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# Teacher Mathematics Learning and Middle School Student Achievement

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TEACHER MATHEMATICS LEARNING AND MIDDLE SCHOOL STUDENT  
ACHIEVEMENT

SALLY MARIE MASCIA

Bachelor of Arts in Education

Notre Dame College of Ohio

May, 1978

Master of Education in Curriculum and Instruction

Cleveland State University

May, 2002

Submitted in partial fulfillment of requirements for the degree

DOCTOR OF PHILOSOPHY IN URBAN EDUCATION:

LEARNING AND DEVELOPMENT

at the

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May, 2010

This dissertation has been approved for  
the Office of Doctoral Studies,  
College of Education  
and the College of Graduate Studies by

---

**Joanne E. Goodell**, Chairperson

Teacher Education

Date

---

**Joshua Bagaka's**, Methodologist

Doctoral Studies in Urban Education

Date

---

**Brian Harper**, Member

Curriculum and Foundations

Date

---

**Carol Phillips-Bey**, Member

Arts and Sciences

Date

---

**Russell Brown**, Member

Cleveland Metropolitan School District

Date

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## **DEDICATION**

This dissertation is dedicated to my family. You have been my support, foundation and encouragement in life.

To my husband, Joe: you carried the load these past years as I followed a dream. You listened to me and encouraged me to keep going. I am sure it was not easy for you, but you never complained. You are my partner in life.

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TEACHER MATHEMATICS LEARNING AND MIDDLE SCHOOL STUDENT  
ACHIEVEMENT

SALLY MARIE MASCIA

ABSTRACT

United States policymakers have taken measures to improve learning for all students emphasizing the use of scientifically based research in choosing educational programs to promote school improvement and student learning. However, educators, researchers and policymakers debate about which factors are most important in affecting student achievement. The *No Child Left Behind Act of 2001* (NCLB) places major emphasis upon teacher quality as a factor in improving achievement for all students. This emphasis grows out of research showing that teachers' mastery of the academic content they teach is critical to engaging students and is a significant factor in raising levels of student achievement. Middle or secondary school teachers must possess the equivalent of an academic major in the core academic area (107th U.S. Congress, 2002).

To meet this need, a key goal of the Cleveland MSP was to increase middle school teacher content knowledge in mathematics through teacher participation in graduate coursework. The primary purpose of this study was to investigate the degree of impact that this program had on middle grades student mathematics achievement. In addition, the stability of teaching assignment was investigated.

A two- level hierarchical linear model was used to explore the relationship between the teacher and student variables. Over 2500 student cases and over 90 teacher cases per grade level were used for analysis. Results indicated that teacher MSP participation, as a main effect, was significantly and negatively associated with student

achievement on the sixth grade OAT-M. In addition, there was a significant positive relationship between teacher MSP participation and student achievement on the OAT-M when students had additional instructional time for sixth and eighth grades. Teacher assignment stability, as a main effect, was significantly and positively associated with sixth grade student achievement on the OAT-M and was significantly and negatively associated with eighth grades student achievement in mathematics when students had additional instructional time. Finally, the main effect of classroom mean prior achievement was significantly and negatively associated with eighth grade mathematics achievement, and classroom mean prior achievement was positively associated with student prior achievement for seventh grade students. As shown in this study, teacher participation in graduate level content coursework can enhance other teacher and student characteristics and thereby contribute to middle grades student achievement in mathematics.



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## **CHAPTER I**

### **INTRODUCTION**

In 1949, W.E.B. Du Bois said, “Of all the civil rights for which the world has struggled and fought for 5,000 years, the right to learn is undoubtedly the most fundamental” (p. 230). The quest for ways to improve opportunities for student learning is one that has been ongoing since the advent of public schools. Numerous programs have been implemented over the years in search of a solution to this dilemma.

In recent years, United States policymakers have taken measures to improve learning for all students. Emphasis has been placed on using scientifically based research in choosing educational programs to promote school improvement and student learning. However, educators, researchers and policymakers debate about which factors are most important in affecting student achievement. One of the most strongly supported initiatives is improving teacher quality, the ability of a teacher to assist students in learning, with the realization that the nation’s higher goals for student learning in mathematics cannot be

reached without improved teacher capacity to deliver consistent and rigorous learning experiences for the students they teach. In essence, teacher quality is identified as imperative to improved student learning. Darling-Hammond and Price (2007) recognized the central impact that high quality teaching has over and above school and district level factors in the quest to educate all students at higher-levels than ever before. Growing evidence suggests that teachers are the single most important variable related to student achievement (Darling-Hammond, 1999, 2005; Haberman, 1991; Hattie, 2003; Haycock, 1998a, 1998b; Singham, 2003; The MacKenzie Group, 1999).

The quality of teachers is an important determinant of school quality, but it is difficult to measure. One traditional indicator is the level of teachers' educational attainment. The type of degree specialization at the undergraduate and graduate levels is another common measure. Researchers have explored the hypothesis that teachers' subject matter knowledge and ability are associated with student learning in the classroom. These studies have found that students learn more from mathematics teachers who majored in mathematics than from teachers who did not and more from mathematics and science teachers who studied teaching methods in the subject they teach than from those who did not (Goldhaber & Brewer, 1997; U.S. Department of Education, Office of Postsecondary Education, & Office of Policy Planning and Innovation, 2002). However, these same studies have shown inconsistencies in their findings across different grade levels with results for middle grades being especially scant and contradictory.

Furthermore, research has found that students in high poverty, high minority schools are more likely to be taught mathematics by out-of field teachers than students in low-poverty, low-minority populations (Haycock, 1998b). This is more likely to occur at

the middle school level than at the high school level (Haycock, 1998a; Seastrom, Gruber, Henke, McGrath, & Cohen, 2002; U.S. Department of Education, Office of Postsecondary Education, & Office of Policy Planning and Innovation, 2002). Since prior research shows a clear link between teacher efficacy, the belief that a teacher has the capacity to affect student learning and performance (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Guskey & Passaro, 1994) and teacher qualifications in mathematics, this inequity for students in poor, urban districts can be especially damaging. When students are exposed to effective teachers, particularly for three or more years in a row, they can effectively narrow the achievement gap for poor and minority students (Haycock, 1998c). Alarming, it also suggests that continual student exposure to ineffective teachers can be so detrimental that even follow-up placement with effective teachers cannot compensate for the damage (Sanders & Horn, 1998; Sanders & Rivers, 1996; Wright, Horn, & Sanders, 1997). According to these studies, it is not surprising that good teachers can make a difference, especially for poor and minority students.

### *Description of the Problem*

The main problem investigated in this study stems from the belief that the content preparation of teachers is enough to increase student learning. Darling-Hammond (2005) argues that to be effective, teachers need to know their subject matter and how to teach it to diverse learners. Research, according to the National School Board Association (2006), indicates that

... teachers' background in the subject matter being taught makes a difference in how well students perform. The presence of a teacher who does not have at least a minor in the subject matter he or she teaches

accounts for around 20% of the variation in the national assessment score (p. 58).

In light of this evidence, the federal *No Child Left Behind Act of 2001* (NCLB) (107th U.S. Congress, 2002), which took effect in January, 2002 and requires that all teachers be highly qualified in the core academic content area(s) they teach, places major emphasis upon teacher quality as a factor for improving achievement for all students. This emphasis grows out of research showing that teachers' mastery of the academic content they teach is critical to engaging students and is a significant factor in raising levels of student achievement. Middle or secondary school teachers must therefore possess the equivalent of an academic major in the core academic area they are teaching (in this case, mathematics) and/or pass a rigorous state and federally approved examination to demonstrate competency in the academic area to thereby achieve Highly Qualified Teacher (HQT) status .

According to the Ohio Department of Education, out of the eight largest districts in Ohio, the Cleveland Metropolitan School District had the highest rate of unqualified teachers in core academic subjects at 22.8% (Ohio Department of Education, 2006). To address this issue, the Cleveland Math/Science Partnership (MSP) initiative began in 2003 and was funded by the National Science Foundation (NSF) with a targeted focus on increasing teacher capacity in mathematics and science, particularly at the middle school level.<sup>1</sup> The Cleveland MSP for middle grades teachers was designed specifically to enhance the content knowledge of teachers formerly certified in elementary education. The Cleveland MSP's vision was to improve student learning and achievement through

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<sup>1</sup> As part of both the U.S. Department of Education and the National Science Foundation, provisions in NCLB committed funding for improving teachers' mathematics and science content knowledge through both university preparation and/or professional development program funding.



high quality mathematics and science teaching within the Cleveland Metropolitan School District classrooms. Two area universities were the primary providers of high-quality continuing professional development through graduate level content coursework in mathematics and science. In turn, the universities held themselves more accountable for improving teaching through the restructuring of their teacher education programs. As a result, the universities created middle grades mathematics and science teacher education programs. District teachers were offered the opportunity to participate in the tuition-paid program, which focused on providing mathematics or science content coursework in preparation for licensure in mathematics or science.<sup>2</sup> By 2007, over 60 teachers had completed the MSP in mathematics and nearly each school with middle grades had a licensed or highly qualified mathematics teacher on staff. Yet, although the ultimate goal of the MSP was teacher content learning to enhance student performance, students still were not achieving at levels that support the theories that middle grades students achieve if the teacher has at least a minor in mathematics.

Thus, the problem explored in this research is multi-faceted. First, this study addressed the assumption that a teacher's content knowledge is in-and-of-itself sufficient in order for students to learn. Few would argue that what a teacher knows and brings to the classroom affects what students learn. Research linking student achievement and teacher subject matter expertise generally agrees that the teachers' knowledge of the mathematical content to be taught is the cornerstone of teaching for student success. However, there is controversy about what kind and how much mathematics is necessary for teachers to be effective. Despite heightened attention to the subject, the research into

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<sup>2</sup> Teacher participation in the MSP initiative was voluntary. Therefore, the sample of MSP teachers in this study representing the treatment is the result of self-selection.

teachers' mathematics preparation and knowledge, particularly for middle school teachers, remains inconsistent.

Second, there is general agreement that teachers, particularly at the elementary and middle school levels, do not know enough of the mathematics deeply enough to provide effective instruction for their students (Ball, 1991; Ball, Hill, & Bass, 2006; Ma, 1999). Therefore, this study explored the assumption that elementary licensed teachers, those who are licensed to teach kindergarten or first through eighth grades, possess little understanding of mathematics and therefore are underprepared to teach this discipline to their students. This was evidenced in the Ohio Revised HQT Plan (Ohio Department of Education, 2006) submitted to the U.S. Department of Education that stated:

The second group of teachers in which Ohio evidenced a significant highly qualified teacher gap was seventh- and eighth-grade teachers teaching core courses with an elementary (K-8) license. While the K-8 licensure has not been available for new teachers since 2002, there are many veteran teachers holding this credential (p. 6).

However, research convincingly linking teacher content knowledge in mathematics to student achievement is inconsistent, scant at the middle grades, and does not support this stance (Hill, 2007; Mewborn, 2001). The majority of studies that resulted in positive effects between teacher content knowledge and student achievement were found at the secondary level (Wayne & Youngs, 2003). Results were mixed at the middle school level with some showing positive results and others showing negative results, but almost all showing insignificant results (Garet et al., 2010). A recent report from the National Mathematics Advisory Panel (2008) states that there is no compelling evidence that students of teachers who are certified to teach mathematics show greater gains than teachers who are not. In addition, when using mathematics coursework as a proxy for

content knowledge, results were mixed regarding the relationship between this teacher measure and student achievement. In fact, the available evidence did not support a relationship below ninth grade. Finally, studies that used tests of teachers' mathematical content knowledge also yielded mixed results; however, the evidence from studies where tests of teacher content knowledge were used suggested a positive relationship between teacher mathematical knowledge and student achievement more than did studies using other proxies for mathematical knowledge.

Although few would argue that teachers need to know and understand the content in order to teach it, more than just the teacher's knowledge of mathematics is needed to increase student learning. Shulman (1986) posited, "Mere content knowledge is likely to be as useless pedagogically as content-free skill" (p. 8). Thus, he proposed that there are other types of specialized knowledge a teacher needs for teaching mathematics. In addition to content knowledge, Shulman's research also identified pedagogical knowledge, that which refers to the elements of the teaching process, and pedagogical content knowledge, which "embodies the aspects of content knowledge most germane to its teachability" (p. 9). In proposing a framework that includes pedagogical content knowledge, Shulman extended the conception of teacher cognition beyond knowledge of content and knowledge of teaching to incorporate the space where these two intersect for student learning.

However, the NCLB requirements for HQT have put almost sole emphasis on teacher content knowledge as a means for identifying teachers as HQT for middle and secondary school teachers. To provide students with "highly qualified" teachers, NCLB requires teachers to demonstrate competency through subject-matter majors, certification,

or other similar means. This definition arises out of educational production function literature and comprises a narrow view of the complexities of teaching. Consequently, middle school teachers who were formerly qualified to teach mathematics through prior licensing requirements as elementary education teachers now were deemed “not good enough.” Their content knowledge was considered insufficient. As a result, districts have rushed to hire teachers with paper credentials. However, Goe (2007) found that teachers who may be considered “high quality” on paper may not perform well in the classroom and those whose credentials do not measure up may actually be more effective in specific contexts.

Finally, Johnson (2002) stated that changing standards and curriculum without changing the ways that teachers teach accomplishes little. Furthermore, research by Sanders and Rivers (1996) found the impact of weak instruction on student achievement to be “additive and cumulative” (p. 6). Similarly, the results of student achievement when they are exposed to a weak program of instruction can be devastating, creating a situation that is almost impossible for students to overcome (U.S. Department of Education, Office of Postsecondary Education, & Office of Policy Planning and Innovation, 2002).

The difficulty stems from identifying the nature of a teacher’s knowledge that is essential in order for students to learn. Hill, Rowan & Ball (2005) assert that “what counts as ‘subject-matter knowledge for teaching’ and how it relates to student achievement has remained inadequately specified in past research” (p. 372). A meta-analysis by Wayne & Youngs (2003) demonstrated that large scale studies connecting teacher content knowledge to student achievement were mixed and noted that studies

leave some uncertainty with respect to whether students learn more from teachers with subject-related degrees.

Therefore, the question remains: what are adequate measures of teacher quality? Does teacher content knowledge relate to student academic achievement? And are not other factors, such as instructional methods courses or teaching internships, essential as well? Teacher quality provisions of NCLB downplay the importance of the latter. Again, the focus of the law is on “content knowledge.”

### *Purpose of the Study*

A key goal of the Cleveland MSP was to increase middle school teacher content knowledge in mathematics through teacher participation in graduate coursework in mathematics. Research by McCaffrey, et al. (2001) found that students of teachers who participated in graduate level training in mathematics or mathematics education scored higher on both multiple choice and open-ended tests. This is relevant when examining the link between teacher participation in graduate coursework in mathematics and student achievement because state tests of student achievement use both multiple choice and open-ended question methods for assessing student learning.

Therefore, the primary purpose of this study was to investigate the degree of impact that enhancing teacher content knowledge through participation in the Cleveland MSP had on middle grades student mathematics achievement as measured by the 2007 Ohio Achievement Test in Mathematics (OAT-M). In addition, the consistency of teaching assignment over a four-year period was investigated as it was considered an important mediating factor that could influence teacher instructional capacity and therefore contribute to differences in student achievement. Thus, this study also sought to

address whether the main effect of teacher participation in the Cleveland MSP could mitigate the impact of other teacher and student level factors. Specifically, this study examined the extent to which the presence or absence of teacher characteristics, such as enhanced content-knowledge in mathematics and teacher assignment stability, defined as the consistency of teaching assignment from year to year, and the presence or absence of student characteristics, such as student attendance, prior achievement, additional mathematics instructional time and enrollment in a higher-level mathematics course (Algebra I) in eighth grade, could predict student mathematics achievement as measured by the state Achievement Test for 2007 for students in grades six, seven and eight.

### *Research Questions*

The results of this study determined if a relationship existed between increased student achievement and teacher participation in additional graduate coursework in mathematics designed to enhance teacher content knowledge for teaching middle grades mathematics, as well as factors related to their teaching assignment. The study compared the main effect of middle grade students' mathematics achievement for teachers who participated in the Cleveland MSP initiative compared to the achievement of middle grades students for teachers who did not participate in the Cleveland MSP initiative. In addition, the main effect of teacher assignment stability and its relationship to student mathematics achievement was also investigated. Furthermore, the study also compared the interaction effects of teacher Cleveland MSP participation with other student and teacher-level factors. The research questions that guided this study were:

1. To what extent do student characteristics, such as prior achievement, attendance, additional instructional time in mathematics and Algebra I course-

taking for grade eight students, predict student achievement in mathematics for sixth, seventh and eighth grades students?

2. To what extent do teacher characteristics, such as participation in the Cleveland MSP initiative and teacher assignment stability, predict the individual classroom average in student achievement in mathematics for sixth, seventh and eighth grade students?
3. To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability moderate the strength of relationship between student prior and current achievement in mathematics for sixth, seventh and eighth grade students?
4. To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability moderate the strength of relationship between students taking Algebra I and those who do not take Algebra I in eighth grade?
5. To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability neutralize the impact of student absenteeism on mathematics achievement for sixth, seventh and eighth grade students?
6. To what extent does teacher participation in the Cleveland MSP initiative, teacher assignment stability moderate the strength of relationship in student achievement for students who have increased instructional time in mathematics for sixth, seventh and eighth grade students?

### *Importance of the Study*

Continued research into the factors that contribute to increased student learning of mathematics in the middle grades, particularly in large urban settings, is important so that these students are afforded equitable educational opportunities in mathematics. First, these schools often serve large populations of students from low socioeconomic backgrounds, and disproportionately African American or Hispanic minorities comprise a large proportion of these populations. Historically students from low socioeconomic backgrounds have been placed at greatest risk of academic failure. Often they have the least prepared teachers and high teacher attrition rates. Moreover, the schools are in poor condition, and classrooms have inadequate educational resources. With regard to those already at-risk, the data have been clear for decades: poor children and children of color are consistently short-changed when it comes to mathematics (Riegle-Crumb, 2006).

Second, more than any other subject, an inadequate mathematics background filters students out of programs leading to scientific and professional careers, and often out of school itself (Aiken, 1970; Lamb, 1998; Livingston, 2009). Robert Moses, founder of the Algebra Project, defines mathematics education as a civil rights issue (Moses & Cobb, 2001). He asserts that children who are not quantitatively literate may be doomed to second-class economic status in an increasingly technological world. According to Moses,

Today . . . the most urgent social issue affecting poor people and people of color is economic access. In today's world, economic access and full citizenship depend crucially on math and science literacy. I believe that the absence of math literacy in urban and rural communities throughout this country is an issue as urgent as the lack of Black voters in Mississippi was in 1961. (p. 5)



Third, students in large urban districts are most in need of highly qualified teachers in mathematics and yet are most likely to be assigned to a teacher who may not be competent in the subject. Yet finding and retaining mathematics teachers is difficult under the best circumstances and is particularly problematic in urban districts. Students in urban districts frequently are taught by inexperienced, under-qualified or under-certified teachers. Studies uncovering these educational inequities for students with the greatest needs note strong biases in assignment of these students to ineffective teachers with inadequate qualifications (Darling-Hammond, 2000). Jordan, Mendro and Weerasinghe (1997) have found that African American students are almost twice as likely to be assigned to the most ineffective teachers. Likewise Sanders and Rivers (1996) have found these students to be half as likely to be assigned to the most effective teachers. Unfortunately, Ohio's own research shows that children in low-performing schools, who need the most experienced, most educated, most skilled teachers, too often get the least effective educators.

Fourth, while students in urban districts do reasonably well in the elementary grades, the achievement chasm widens during the middle grades (Schmidt et al., 2007). In fact, studies have found that the mathematics achievement gap develops most rapidly in grades five through eight, at the crucial moment in which quality preparation is necessary for them to understand critical concepts for high school (Neild, Balfanz, & Herzog, 2007). The ensuing low mathematical proficiency for high concentrations of these students has serious consequences by the end of eighth grade as lifelong opportunities for success depend on the ability to succeed in college preparatory courses (Pelavin & Kane, 1990; Riegle-Crumb, 2006).

Fifth, if the goal is to improve student learning in mathematics, then it is important that those who provide professional development for teachers demonstrate the effectiveness of their programs by establishing links between teacher learning and that of their students. NCLB requires the regular evaluation of professional development programs for impact on teacher effectiveness and student achievement. Yet few programs provide any reliable data to demonstrate the efficacy of their programs in improving student or teacher outcomes beyond superficial measures of reported “enjoyment” of activities (Shaha, Lewis, O’Donnell, & Brown, 2004). Because substantial federal funding is provided to improve teacher quality (e.g., Title II funds), better information and accountability on how professional development programs affect student achievement is an urgent need (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007).

### *Conceptual Framework*

This study uses the framework offered by Goe (2007), which helps focus thought around dimensions of teacher quality (see Table 1). Four dimensions (teacher qualifications, teacher characteristics, teacher practices, and teacher effectiveness) are organized around three categories (inputs, outputs and outcomes) which can be used to analyze teacher quality. The first domain, teacher qualifications, includes teacher education, coursework, certification, experience and other qualities or personal resources that teachers bring with them into the classroom. The second domain, teacher characteristics, encompasses changeable qualities and attitudes as well as characteristics such as race or gender. According to Goe, teacher qualifications and characteristics are inputs because they are the qualities that go into the making of a teacher.

The third domain, teacher practices, are those activities that teachers perform in

the classroom and include interactions with students, planning for instruction, questioning and facilitating discourse, and other qualities that are created by the teacher to facilitate student learning. Teacher practices are categorized as processes because they are those things that teachers can be observed doing in the classroom in the process of teaching. The fourth domain, teacher effectiveness, involved defining teacher quality by looking at student learning gains. Teacher effectiveness is defined as an outcome because it involves student learning as the end result of teaching. For the purpose of this study, teacher qualifications and teacher effectiveness are the domains of interest.

Table 1

*Categories and Dimensions of Teacher Quality as defined by Goe (2007, p. 8)*

Dimensions	Categories		
	Inputs	Processes	Outcomes
Teacher Qualifications	X		
Teacher Characteristics	X		
Teacher Practices		X	
Teacher Effectiveness			X

*Delimitations*

The primary focus of this study was on student achievement in mathematics in grades six through eight in a high poverty urban district and the relationship to teacher participation in advanced graduate content work in mathematics. In order to gain a more complete perspective regarding the relationship of teacher mathematics knowledge to

middle grades student achievement, this research was limited to the use of data for middle grades students (defined as grades six, seven and eight) in a large Midwestern urban school district from traditional public schools. This study did not consider data from nontraditional or nonpublic schools (e.g., charter schools, private schools, alternative schools, schools affiliated with mental health organizations, etc.).

### *Definitions*

- Highly Qualified Teacher (HQT) – in Ohio, this designation consists of three parts: 1) the teachers must hold at least a bachelor’s degree; 2) the teacher must hold certification or licensure appropriate to the grade and subject they are teaching; and 3) the teacher must have demonstrated their subject area expertise through examination in the academic subject they teach.
- Content Major (in mathematics) – coursework preparation in the field of mathematics, which consists of at least thirty semester hours or its equivalent.
- Content Minor (in mathematics) – coursework preparation in the field of mathematics, which consists of at least twenty-four hours or its equivalent but less than thirty hours.
- Generalist – a teacher who has been prepared to teach all of the academic subjects, but lacks a specific major in any of them. Rather, their major, as well as licensure, is usually elementary education or a similar designation.
- Licensure – the credentials issued by the state Board of Education to an individual deemed qualified to teach in the state of Ohio. This was preceded by certification. Under policies for certification, teachers could advance to permanent credentials

that would not require further study or continuing education in their field.

Licensure provisions are more rigorous than those for certification and require teachers to engage in continuing education throughout their careers. In addition, licenses will not become permanent and must be renewed every five years with the attainment of a Master's degree and proof of continuing education.

- Middle grades/middle school – for the purpose of this study, middle grades or middle school is defined as grades 6, 7 and 8.
- MSP – the Mathematics/Science Partnership (MSP) is an initiative funded by the National Science Foundation (NSF). Cleveland was a recipient of this multi-million dollar grant, the purpose of which was to prepare mathematics and science teachers in the Cleveland Metropolitan School District to teach these core academic subjects.
- Teacher Content Knowledge – knowledge of the subject matter, in this case mathematics. For purposes of this paper, this definition does not include the methods or pedagogical practices of teaching mathematics.
- Teacher assignment – refers to the course or courses assigned to a teacher for a school year. This information was used to determine the stability of teaching assignment as a variable for analysis.

### *Assumptions*

This study arises out of the assumption that although teacher content knowledge preparation is important – even essential – for teaching mathematics effectively at the middle school level, by itself it is not enough to increase student achievement. The second assumption is that the strength of the school mathematics program is integral for

student success. This is predicated on the decisions that are made around staffing and teacher assignments with the assumption that instability related to the teacher's work adversely impacts student learning.

### *Organization of Thesis*

Chapter 1 delineated the statement of the problem and the purpose of this study. Included in the chapter was an explanation of the relative importance of the study. The research questions explored through the study were introduced, followed by a description of the delimitations of the study and definitions of terms used in the thesis.

Chapter 2 provides a literature review about the topic of this study. Included in the review are studies, research, government reports and other writings dealing with the relationship between teacher content knowledge in mathematics and its impact on student achievement as well as literature discussing the unique needs for teaching middle grades mathematics and its importance and issues that address teaching assignments and the relationship to student achievement.

Chapter 3 describes the research methods chosen to analyze the data and provides a rationale for choosing these methods. Data collection procedures are described as well as a description of the variables considered in the study. Finally, model specifications and model building procedures are detailed.

Chapter 4 reports the findings from the data analysis, including demographic descriptions, descriptive statistics and results of inferential statistics obtained in the study.

Chapter 5 summarizes the findings, discusses the results and offers conclusions for these results within the context of extant literature. Avenues for future research and exploration are discussed as well as recommendations for policymakers.

## **CHAPTER II**

### **REVIEW OF LITERATURE**

In this chapter, further information is provided regarding the theoretical underpinnings of the study. The chapter is divided into three main sections. The first section examines the literature related to teacher inputs, also known as teacher qualifications especially related to the impact of teacher content knowledge on student achievement through teacher effectiveness research.

The second section examines the literature related to mathematics learning in the middle grades, particularly as the literature relates to students in high poverty urban districts. The literature will present current studies into the crucial middle school to high school connection and examine how learning during the middle grades can impact a student's future ability to access equitable opportunities.

The third section will examine the literature related to the school mathematics program as a whole as it relates to the cumulative effect of school staffing decisions on student learning. The importance of having strong teachers in place for optimal student learning is presented. This section will not examine curricular issues.

## Teacher Qualifications

Research about the importance of good teachers is not new. Schools and the communities they serve seek to find the best teachers in the belief that student success depends on it (Hattie, 2003; Haycock, 1998a; Wenglinsky, 2000). Research shows that teacher quality has influenced differences in student performance more heavily than did race, class, or school of the student (Baker, Gersten, & Lee, 2002; Barth et al., 1999; Bickel & Howley, 2003; Rowe, 2003; Singham, 2005; The MacKenzie Group, 1999; Webster, Young, & Fisher, 1999; Wenglinsky, 2004). Additionally, evidence from research shows that the effects of teacher quality accumulate over the years (Haycock, 1998b; Sanders & Rivers, 1996). Furthermore, it has shown that disadvantaged students, those who attend schools with higher poverty rates, benefited more from good teachers than did advantaged students (Haycock, 1998b; Nye, Konstantopoulos, & Hedges, 2004; Sanders & Rivers, 1996).

However, defining an effective teacher is not easy. What are the characteristics of an effective teacher? How much impact can be expected from teachers given all the factors related to student performance? Finally, if teachers are so important to student learning, how do we assure that all students receive the benefit of good teachers?

There is no single answer. Education, teaching and learning are complex (Killion, 2002). However, research into teacher effectiveness consistently shows that teachers have the greatest potential to impact student learning and achievement (Darling-Hammond, 2005; Darling-Hammond & Youngs, 2002; Hattie, 2003; Hiebert, Morris, Berk, & Jansen, 2007; Nye, Konstantopoulos, & Hedges, 2004; Oakes, Franke, Quartz, & Rogers, 2002; Stronge, 2002; Wayne & Youngs, 2003). Furthermore, this research has shown that



effective teachers have a substantial effect on student achievement, especially when assigned to work with disadvantaged students (Barth et al., 1999; Haberman, 1991, 1995). A study by Sanders and Rivers (1996) has shown that achievement gains from having an effective teacher can be almost three times as large for African American students as for white students, even when comparing students with the same prior school achievement.

Research into teacher effectiveness has shown that there are common characteristics shared by teachers who are outstanding in their craft. The research falls into two main categories: research that has identified common professional preparation backgrounds of effective teachers and research that identifies the behaviors and attributes of effective teachers. Due to the nature of the research questions posed for the current study, which inquires into the relationship between teacher knowledge acquisition in mathematics and the mathematics achievement of their students, this paper will limit its scope to examining the literature on teacher qualifications and professional preparation.

### *Professional Preparation*

Research findings on background and professional preparation are mixed. However, the following four dimensions of professional preparation have been linked consistently to teacher effectiveness. Coursework in teaching and learning, content knowledge, full teacher certification in their field of teaching and teacher years of experience have been determined to account for as much as 40 percent of the variance in students' achievement (Darling-Hammond, 2005; Darling-Hammond, Berry, & Amy, 2001; Darling-Hammond & Youngs, 2002; Hattie, 2003; Hiebert, Gallimore, & Stigler, 2002; Hill, Rowan, & Ball, 2005; Marzano, 2003; Stronge, 2002; Wenglinsky, 2000).

*Educational coursework.* In response to scrutiny of teacher preparation programs, studies indicate that teachers with strong background knowledge of pedagogy are better able to recognize student needs and adapt instruction for diverse learners. In fact, the amount of educational coursework in teaching and learning was a strong predictor of teaching performance (Darling-Hammond, 2001; Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005; Hattie, 2003; Schalock, Schalock, & Myron, 1998; Scherer, 2001; Shelford & Protheroe, 2000; Tell, 2001; Wenglinsky, 2000). Teachers who enter the profession through alternative pathways often have prior careers or preparation in the content area they wish to teach. They are fast-tracked into the classroom and receive little preparation in pedagogy. Although there is no long term evidence for teachers who enter teaching through these pathways, current research indicates that they may have more difficulty than traditionally prepared teachers with strong pedagogical knowledge (Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005; Miller, McKenna, & McKenna, 1998).

*Teacher certification/licensure.* Research indicates that the number of well-qualified and appropriately certified or licensed teachers in a school or district is a consistent and significant predictor of student achievement. Conversely, one of the predictors of low student performance is the number of uncertified teachers or teachers teaching outside their certification area (Clotfelter, Ladd, & Vigdor, 2007; Darling-Hammond, 2001; Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005; Goldhaber & Brewer, 2000; Miller, McKenna, & McKenna, 1998; Scherer, 2001).

*Teaching experience.* Teaching experience, typically five years or more, produces higher student achievement. However, research also suggests that the effect of experience

levels off after eight years. Clotfelter, Ladd & Vigdor (2007) found that teachers with more experience were more effective in raising student achievement than those with less experience. Teachers who are experienced and effective – those who consistently bring about student learning – are experts who know the content and the students they teach. They are able to organize and plan for student learning using a wide range of teaching strategies. (Covino & Iwanicki, 1996; Cruickshank & Haefele, 2001; Darling-Hammond, 1999; Drake, 2002; Hattie, 2003; Kerrins & Cushing, 1998; Scherer, 2001; Tell, 2001). In general, teaching experience can have up to a 30 percent beneficial effect on student achievement.

*Content knowledge.* A background in the subject matter being taught is thought to make a difference in how well students perform. Strong teacher content knowledge consistently has been identified with high student achievement. In fact, the presence of a teacher who does not have at least a minor in the subject matter that he or she teaches accounts for around 20 percent of the variation in the National Assessment of Educational Progress (NAEP) scores (Berliner & Rosenshine, 1977; Hiebert, Gallimore, & Stigler, 2002; Hill, 2007; Hill, Rowan, & Ball, 2005; Ingersoll, 1999; Manouchehri, 1997; Murnane, 1985; National Research Council, 1989; Nye, Konstantopoulos, & Hedges, 2004; Oakes, Franke, Quartz, & Rogers, 2002; Wayne & Youngs, 2003; Wenglinsky, 2000).

Thus, the research discussed so far in this chapter demonstrates that effective teachers have solid background knowledge with either a major or minor in the subject area they teach. Teachers with content knowledge expertise are able to extend beyond the textbook. They are more able to respond to student questions and organize content for

depth and connections. However, it should be noted that the ability to convey the content to students in ways they can grasp is not necessarily related to additional content coursework (Stronge, 2002; Wayne & Youngs, 2003).

However, while teacher content knowledge is thought to impact student achievement, the results are not as strong as might be supposed. When teacher content knowledge was measured by standardized tests of subject matter competency and related to student achievement, no consistent relationship was found. In fact, most studies showed small, statistically insignificant relationships (Andrews, Blackmon, & Mackey, 1980; Byrne, 1983; Ferguson & Womack, 1993; Haney, Madaus, & Kreitzer, 1987). In a review of mathematics teaching, Begle and Geeslin (1972) found that the amount of mathematics coursework was not linearly related to teacher effectiveness with almost all of the positive determinate findings focusing on high school (Wayne & Youngs, 2003). Results are thought to be mixed because knowledge of content is a positive influence up to some level of competence but then becomes less important thereafter. Darling-Hammond (2000) suggests that although knowledge of the subject matter being taught is essential to good teaching, the level necessary grows smaller beyond some level which exceeds the demands of the curriculum taught. Monk's study (1994) showed that teacher content preparation in the subject area of teaching was positively related to student achievement, but the relationship was curvilinear with diminishing returns above a threshold level of five courses in mathematics and with differing effects for high and low achieving students as well as for different grade levels. In addition, Harris and Sass (2007) have identified what they refer to as the lagged effects of professional development. Their research showed that the larger effect of teachers' professional

development on student outcomes do not become apparent until about three years after teachers had completed their courses. According to Wayne and Youngs (2003),

A related concern is lagged effects. Value-added models usually assume that a student's prior test score captures the effects of all previous educational experiences. However, it is likely that the effects of educational experiences may not manifest themselves immediately. To the extent that the sources of lagged effects are in any way connected to the likelihood that students will have certain teachers, estimates of the effect of having teachers with particular characteristics may be biased (p. 93).

Monk and King (1994) found that the greatest advantages of advanced teacher content preparation were gleaned by students taking higher-level mathematics courses.

Finally, concerns that education majors are less well prepared in their subject areas than are academic majors have come under scrutiny. Comparisons of teachers with education degrees versus those with mathematics degrees have found no relationship between degree type and teacher performance (Murnane, 1985). As previously reported, there is no long term evidence for teachers who receive licenses through alternative paths outperforming their counterparts who are licensed through traditional means (Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005; Miller, McKenna, & McKenna, 1998). In general, studies of teacher content preparation have found greater learning gains for teachers who had more formal preparation for teaching their content area (Darling-Hammond, 2000).

### Middle Grades Mathematics Learning

To be successful in today's economy, all students need an education that goes well beyond a high school diploma (National Research Council, 2001). Preparation for post-secondary education and the attainability of good jobs begins well before high school. The middle grades have been identified as vital to the foundation students need

for success not only in secondary education but for education thereafter. And yet among our nation's eighth graders who participated in the 2007 NAEP in mathematics, 29 percent fell below basic, 39 percent reached the basic level and only 32 percent reached the proficient level (Lee, Grigg, & Dion, 2007). And for the 2007 Trial Urban District Assessment (TUDA) for eighth graders, of the eleven participating districts (Charlotte, Austin, Houston, San Diego, New York, Boston, Atlanta, Los Angeles, Cleveland, Chicago, and Washington, DC), all except Austin and Charlotte underperformed at the proficient and advanced levels with most scoring significantly below the nation's average (Lutkus, Grigg, & Dion, 2007). Eighth grade survey data for the 2003 TUDA revealed that factors, such as socioeconomic status, school policies, classroom instructional practices and allocation of resources, may account for performance disparities in mathematics achievement (Strutchens, Lubienski, McGraw, & Westbrook, 2004). This has given pause to the mathematics community, who has become increasingly concerned with the achievement levels and disparities among subgroups.

But why is middle grades learning problematic? As previously stated, the middle grades are pivotal for success in high school and access to higher education. Comparisons of student achievement at the national and international levels show that it is between the fourth and eighth grades when student achievement in the United States rapidly falls behind, especially for minority and high poverty students (Alspaugh, 1998). Balfanz & Legters (2001) posit that weak academic preparation in the middle grades creates secondary schools that function more as "drop out factories" than as the foundation for strong education and upward mobility. One of the reasons offered for the increasing middle school achievement gap in mathematics is a weak, unfocused curriculum

(Schmidt et al., 2007). Another is the shortage of knowledgeable, trained and skilled mathematics teachers (National Commission on Mathematics and Science Teaching for the 21st Century, 2000). Still other reasons offered are the unequal opportunities to learn challenging mathematics (Raudenbush, Fotiu, & Cheong, 1998) and unmotivated students with the turbulence of adolescence (Balfanz & Byrnes, 2006). In addition, student self-concept and motivation also suffers along with achievement, and the negative impact has been found to be most pronounced in mathematics (Eccles et al., 1993). In addition, research shows that instructional time in the middle grades declines as compared to the elementary or high school years, even though Winn, Menlove and Zsiray (1997) stated that the link between time and learning is consistent in findings from educational research (Berliner, 1990; Clark & Linn, 2003; Hossler, Stage, & Gallagher, 1988; Walberg, 1988). Whatever the reasons, reforms that have the power to close the middle grades gap, such as strong instructional programs, better trained and more knowledgeable mathematics teachers, and improved learning climates, have not directly impacted classroom practice (Alspaugh, 1998; Balfanz & Byrnes, 2006).

What is necessary to increase mathematics achievement in the middle grades? Research indicates that a stronger and more focused emphasis on mathematical literacy, particularly for middle grades students, would provide a basis for more rigorous work in high school (Cogan, Schmidt, & Wiley, 2001; National Research Council, 2001; Spielhagen, 2006b). In addition, the middle school mathematics curriculum has been found incoherent with little rigor, and opportunities to learn worthwhile and significant mathematics are greatly variable as a consequence of tracking policies, which seem to accelerate during the middle grades (Schmidt, 2003). Consequently, these policies result

in a “dumbing down” of the curriculum for the majority of middle school students, especially among underrepresented groups.

Research suggests that students who take challenging coursework and work to higher standards in middle school are much more ready to succeed in high school (Alspaugh, 1998). Moreover, increasing the rigor of mathematics curriculum in the intermediate and middle school grades can lead to greater readiness for the study of algebra among more diverse student populations. Livingston (2009) has referred to the position of students to learn “pedagogical capital” and defines it as “a quality that some students possess that enables them to arrive at the academic table better positioned to take advantage of our educational offerings (p, 423).” Therefore, the idea that students bring with them into the classroom the sum of their prior experiences – or lack of experiences – emphasizes the importance of providing more rigorous and relevant educational experiences in mathematics for students.

However, studies such as the Trends in International Mathematics and Science Study (TIMSS) and Trends in International Mathematics and Science Study – Repeat (TIMSS-R) have called into question the rigor of the middle school mathematics curriculum (Schmidt, 2003), concluding that “The 8th-grade mathematics curriculum in the U.S. seems comparable to the average 7th-grade curriculum for other participating countries, putting U.S. students a full year behind their global counterparts at age thirteen” (Greene, Herman, & Haury, 2000, p. 2). They also conclude that a more rigorous middle school curriculum, including the study of algebra in eighth grade, could potentially address the issue of mathematical literacy in the United States.



The study of algebra in eighth grade provides both rigor and opportunity. Since algebra is widely recognized as a “gateway” course, students who take it by the end of eighth grade are much more likely to take rigorous courses in high school that lead to a college degree (Riegle-Crumb, 2006; Spielhagen, 2006a, 2006b). Curricular policies that encourage participation in more rigorous courses should take into account the needs of advanced learners but also encourage participation among underrepresented populations (VanTassel-Baska, 2000). Therefore, providing opportunities for a greater number of eighth-grade students to study algebra may improve the overall mathematics literacy of all students.

#### Cumulative Effects of Teacher Assignment

Finally, the strength of the overall quality of mathematics instruction in a school as students move through the grades is integral to student learning. Staffing teachers for this work is largely the result of managerial decisions. Ingersoll (2005) reports that decisions concerning hiring and selection of teachers as well as the allocation of teachers to course and program assignments are primarily the responsibility and prerogative of principals and other school administrators, and principals usually have a large degree of discretion in these decisions, even given state requirements for HQT. Thus, there is little regulation about how teachers are assigned once on the job. Ingersoll (2003) states that “Teachers assigned by principals to teach subjects that do not match their expertise is widespread in the United States” (p. 85). In urban schools, teachers often change teaching assignments yearly and sometimes within a school year. It is not uncommon for a second grade teacher to be assigned to an eighth grade classroom the following school year. Koehler & Grouws (1992) point out, “experts become in some ways like novices when

teaching new content" (p. 121). This instability weakens the quality of the school's academic program and ultimately impacts student learning in detrimental ways.

Early work by Hanushek (1992) indicated that the difference between being taught by a strong teacher and a weak teacher can translate into a full grade level of achievement in a school year. Beyond short term impact, studies have shown that teacher effects of strong or weak teachers are cumulative and enduring, whether those effects are positive, advancing student achievement, or negative, leaving students behind (Borman & Kimball, 2005). Value added research by Sanders and Rivers (1996) has shown that student performance was still affected by a teacher two years after leaving that teacher's classroom. Their study followed two sets of students as they progressed from third grade through fifth grade. By the end of fifth grade, the set of students with the least effective teachers for three years in a row posted academic achievement gains of 29 percent as compared to gains of 83 percent for students assigned to the most effective teachers. This represented a gap of more than 50 percent. Furthermore, in many cases, students with initially comparable achievement demonstrated greatly different academic outcomes as a result of the sequence of teachers to whom the student was assigned. Their study indicated that the effect was both additive and cumulative, denying students the full opportunities they might have had to acquire an excellent education.

Recently, the increased application of value-added measures has permitted researchers to examine these cumulative effects and have confirmed the findings (Borman & Kimball, 2005; Borman et al., 2000; Milanowski, 2004; Odden, Borman, & Fermanich, 2004; Sanders & Horn, 1998). These studies have estimated that the growth in academic achievement between having a strong or weak teacher can be more than one

grade level. The U.S. Department of Education (2002) has stated that "...students unfortunate enough to face several bad teachers in a row face devastating odds against success" (p. 7). Thus the research shows that a student can learn more from one teacher than another and that teachers and schools matter. This would suggest that not only is the quality of the individual teacher important for student academic growth, so is the vertical quality of the instructional program (Bracey, 2004).

### Summary of Chapter

The literature presented has demonstrated that teachers make a difference – and in urban districts it is imperative that students have access to highly qualified teachers. But the current requirements for determining this classification for teachers are nebulous and vary from state to state. Although NCLB places almost full emphasis on subject-matter knowledge, the research does not convincingly demonstrate that this should be the predominant criterion for making staffing decisions or qualifying teachers as HQT, at least for grades below high school.

In addition, the research examined has shown that schooling in the middle grades presents a unique challenge for teaching mathematics. It is a pivotal age upon which further success rests. Furthermore, stratification of the curriculum becomes particularly prevalent during the middle grades resulting in inequitable opportunities for students. Opportunities to study algebra in the 8<sup>th</sup> grade have been well documented, and these opportunities are still open to select students. Since evidence for increased student learning based on teacher content knowledge for middle grades students is inconclusive, more evidence is needed before assertions can be made that the problems in mathematics

learning for middle grades students is attributable primarily to lack of teacher content knowledge.

Finally, the case has been made for the necessity to have strong mathematics teachers year after year in order to optimize students' chances for academic success in mathematics. These positions should be staffed by teachers who are knowledgeable about mathematics and student learning of mathematics. Furthermore, efforts should be made to assure that these positions are stable. This again indicates that teacher deficit should not be the main attribution of problems with increasing student achievement.

The next chapter outlines the methods for investigating the research questions that examine the relationship of a program aimed at enhancing teacher content knowledge for middle grades teachers in mathematics and teacher assignment stability on student mathematics achievement.

## **CHAPTER III**

### **METHODS**

The literature review in chapter two provided evidence that a large body of research has been conducted on the relationship between teacher content knowledge and student achievement and that the results from studies have been mixed across grade levels and scant in the middle grades. In addition, the literature that was cited in chapter two highlighted the importance and particular challenges of providing mathematics instruction for middle grades students. Furthermore, prior research was reported that examined the impact of teacher working conditions related to teaching assignment. In an attempt to add to the body of research, this study examined interactions between student characteristics, such as attendance, prior achievement, additional mathematics instructional time, and for eighth grade students, enrollment in higher-level mathematics courses, as well as teacher characteristics, such as participation in the Cleveland MSP initiative and stability of teaching assignment, to examine if these factors were predictors of student achievement in mathematics.

The purpose of this quasi-experimental research study was to examine the level of impact that middle school teacher participation in graduate coursework in mathematics

had on student achievement, over and above what would normally occur, as measured by the 2007 Ohio Achievement Test in Mathematics for grades six, seven and eight. Simple descriptive statistics were utilized to explore demographic data and to reflect the context of the study, and inferential statistics were used to explore the extent to which teacher learning impacts student achievement.

### *Setting*

The study was situated in a large, Midwestern urban public school district. At the time of the study, the student population was 52,769 students in grades kindergarten through twelve. The district participation in the free and reduced lunch program was 100%. The overall district mobility rate was 34.2%, although some schools had mobility rates closer to 38.2%. Approximately 67% of the students were African-American, about 14% were Hispanic and about 16% were white. Less than 3% of the student population was reported as Asian-American, American Indian, or other. The median household income for 2006 – just above \$24,000 – was the lowest of any big city in the country, according to figures released by the U.S. Census Bureau. This was just a little more than half the national average.

The school district has had a history of academic underperformance and consistently received academic ratings of Academic Watch or Academic Emergency during the last ten years of reporting. These ratings are the two lowest designations given by the state Education Department. Mathematics has been a particular problem for the school district at all grade levels. To illustrate further, the school district has been one of eleven urban districts to participate voluntarily in the Trial Urban District Assessment

(TUDA), a NAEP mathematics assessment, since 2003<sup>3</sup>. The NAEP assessment, also known as the Nation's Report Card, is a congressionally authorized project of the U.S. Department of Education and is intended to inform the public about the progress of student academic achievement in the United States over time. The TUDA is a subset of the NAEP and allows comparison of student performance "in participating urban school districts to those of public school students in the nation, in large central cities and to each other" (Lutkus, Grigg, & Dion, 2007, p. 2). In 2007, the district's average score for eighth grade students was lower than that of other public schools in large central cities and not significantly different from past performance.

#### *Data Sources and Sample*

Permission to conduct this study was obtained from the Cleveland State University Human Subjects Review Board and the Cleveland Metropolitan School District's Office of Research and Assessment. The school district's Office of Research and Assessment provided the student and teacher data for this study. The sample for this study included the original student data set for 79 schools that have grades six, seven and eight in the school district. Student test scores used as outcomes in this study were from the sixth, seventh and eighth grade state Achievement Tests in mathematics for the academic year 2006-2007 (sixth grade, N= 2445; seventh grade , N=2764; eighth grade, N=3006). The study sample also included teacher data for nearly 115 middle school mathematics teachers at each grade level (sixth grade, N=114; seventh grade, N=105; eighth grade, N=112). In most cases, teachers were assigned to teach multiple grade levels. Teacher and student data were linked using TEACHERID as the linkage variable.

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<sup>3</sup> The TUDA assessment tests only grades 4 and 8 in reading and mathematics. Cleveland has been participating since 2003, the first year of this test.

## *Research Design*

According to Shaha, Lewis, O'Donnell & Brown (2004), excellence in inquiry reflects "...systematic adherence to proven research methods, wherever and whenever possible, knowing that very often, due to circumstances, we must use whatever data we can get" (p. 4). The quantitative research design of this study incorporated three aspects of good research methods:

- Test Occasions – pretest and posttest designs provide the ability to assess change or improvement as well as the ability to adjust for pre-existing differences. In addition, multiple test occasions should be used as often as possible (Shaha, Lewis, O'Donnell, & Brown, 2004). This study used two years of student test data in mathematics in a pretest-posttest design. Research also supports the use of prior achievement test scores in order to minimally reduce the potential for alternative explanations for student differences (Wayne & Youngs, 2003). For this study, data from the OAT-M for 2006 was used as the pretest variable, and data from the OAT-M for 2007 was used as the posttest variable.
- Experimental/Quasi-Experimental Design – contrasting results for a control group with those for a treatment group enables the study to interpret results with more confidence rather than mere chance. In this quasi-experimental study, the treatment was defined as those middle school mathematics teachers who participated in a program of graduate coursework in mathematics and the students of those who participated. These results were contrasted with middle



school mathematics teachers who did not participate in the graduate coursework program and their respective students.

- Demographic Analysis – describing the nature of schools, teachers and students whose data is reflected in the study adds generalizability to the results beyond the current situation (Neuman, 2005). A demographic analysis of study participants reflects an overview of study subjects' characteristics. Descriptive statistics for teachers and students were used to situate the study and reflect unique conditions associated with the study.

These three aspects of research design provided a framework for this study.

#### *Operational Definitions of Independent and Dependent Variables*

This study considered two nested levels of variables: teacher-level and student-level variables.

*Student-level variables.* Individual student data were linked to the student's 2006-2007 mathematics teacher of record by using blind student and teacher identification numbers.

Data on four student-level variables thought to be determinants of student achievement were used to address the research questions for this study. A fifth variable also was used to address the research questions related to eighth grade student achievement. Table 2 presents a description of the student level variables used in this study.

Table 2

*Description of Level-1 (Student Level) Variables*


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Variable Name	Variable Description	Type of Variable
TEACHERID	Teacher identification number; the linkage variable occurring in both the teacher and student data sets. The linkage variable allowed data for each student to be associated with one teacher primarily responsible for their mathematics learning during the 2006-2007 school year.	Linkage variable between Level-1 and Level-2 data sets.
OATM07	2006-2007 OAT-M standardized scores for grades six, seven and eight; Level-1 Outcome variable	Dependent variable; Scale
OATM06	2005-2006 OAT-M standardized scores; used as a Level-1 predictor to control for prior student achievement	Independent variable; Scale
ATTEND	Student attendance; number of attended days in the school district	Independent variable; Scale

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Variable Name	Variable Description	Type of Variable
DBL_MTH	Constructed variable to reflect whether students were scheduled for a single or double period of mathematics instruction daily; dummy-coded (Single period=0; double period=1); Level-1 predictor	Independent variable; Categorical; Dichotomous
ALG1	Algebra 1 course membership; dummy-coded (General Math=0; Algebra 1 course=1); variable only used for eighth grade analysis and refers to students who took Algebra I in eighth grade for high school credit; Level-1 predictor	Independent variable; Categorical; Dichotomous

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It is important to include theory-based student background variables since students are not assigned randomly to schools. These variables are confounded with those occurring within classrooms and schools. The specified model attempted to statistically control for this confounding by using these characteristics as covariates. One important covariate was student prior achievement because it can be seen as summarizing the cumulative academic effects of individual background, including prior educational experiences, up to that time (Gottfried, 2009; Nye, Konstantopoulos, & Hedges, 2004).

Hedges and Hedberg (2007) recommend introducing covariates into a model, especially pretest and demographic variables, as they can substantially increase statistical power by explaining between- and within-group variance. Wayne and Youngs (2003) suggest that accounting for both prior student achievement and socioeconomic status enhances a study's evidence and provides more support for causal evidence that would allow attribution of observed student achievement to teacher characteristics while ruling out alternative explanations. It should be noted that in this study, socioeconomic status was not included as a student variable since 100% of the students in the school system were eligible for free and reduced lunch, a common proxy used to determine students from low income families. Therefore, the socioeconomic status of students in this study was homogeneous and would not contribute information to the model. In addition, through preliminary analysis in model building, differences in student performance by gender were not statistically significant and therefore did not contribute information. In fact, student mathematics performance for males and females was virtually identical. Therefore, student gender was not included as a variable for examination.

*Teacher-level variables.* Wayne & Youngs (2003) suggest that “studies that assess multiple teacher characteristics simultaneously are therefore more readily interpretable” (p. 93). Individual teacher data were assigned to the mathematics teacher of record for 2006-2007 by using blind teacher identification numbers. Data on three teacher-level variables were used for this study. Table 3 presents a description of the teacher-level variables used in this study.

Table 3

*Description of Level-2 (Teacher-level) Variables*

Variable Name	Variable Description	Type of Variable
TEACHERID	(See description in Table 1)	Linkage variable
TMSP	MSP membership; dummy-coded (0=non-MSP; 1=MSP); used as Level-2 predictor	Independent variable; Categorical; Dichotomous
TSTAB	This is a synthetic variable created to reflect the teaching assignment stability in middle grades math (2003-2007) by linking four years of teaching assignment data. <sup>4</sup> The assignment for each year was coded as Middle Grade Math=1; Other=0. These indicators were summed for the four years of linked data and one was subtracted from the result to give a range of assignment stability from 0 – 3. A score of 3 reflects the most consistent and stable	Independent variable; Scale

<sup>4</sup> Although this variable assigns a score for teaching middle grades mathematics during a particular year, due to peculiarities in the data set, it does not specify whether the mathematics course was a singular preparation or included different preparations. As a result, teachers could have taught the same course for all classes, different mathematics courses for their classes, or different content courses in addition to mathematics for their classes.

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Variable Name	Variable Description	Type of Variable
MNPRIOR	assignment in middle grades mathematics over four years. A score of 0 reflects the least consistent and stable assignment over four years.	Independent variable; Continuous

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*Goals of Research and Hypotheses*

For this study of the possible differential effects of student characteristics, such as prior achievement in mathematics, attendance, additional instructional time in mathematics and for eighth grade students, enrollment in Algebra I, and teacher characteristics, such as MSP participation, stability of teaching assignment and mean prior student achievement, on sixth, seventh and eighth grade student mathematics achievement were explored. Specifically, the following goals and hypotheses of the study guided the research.

1. The first goal was to determine the extent to which student characteristics, such as individual prior student achievement, attendance, additional mathematics instructional time and Algebra I course-taking for grade eight students were predictors of mathematics achievement for students in sixth, seventh grade and eighth grades.

Research Null Hypothesis 1: Student prior knowledge in mathematics, attendance, additional mathematics instructional time and Algebra I course-taking for grade eight students are not significant predictors of mathematics achievement for students in sixth, seventh grade and eighth grades. The terms for level-1 slopes were used to answer this question.

2. The second goal was to determine the extent to which teacher participation in the Cleveland MSP initiative and teacher assignment stability were predictors of mathematics achievement for students in sixth, seventh grade and eighth grades.

Research Null Hypothesis 2: Teacher participation in the Cleveland MSP initiative and teacher assignment stability are not significant predictors of mathematics achievement for students in sixth, seventh grade and eighth grades. The level-2 terms for the level-1 intercept were used to answer this question.

3. The third goal was to determine the extent to which teacher participation in the Cleveland MSP initiative and teacher assignment stability could moderate the strength of relationship between student prior and current achievement in mathematics for sixth, seventh and eighth grade students.

Research Null Hypothesis 3: Teacher participation in the Cleveland MSP initiative and teacher assignment stability do not moderate significantly the strength of relationship between student prior and current achievement in mathematics for sixth, seventh and eighth grade students. The level-2 terms for the level-1 OATM06 slope were used to answer this question.

4. The fourth goal was to determine the extent to which teacher participation in the Cleveland MSP initiative and teacher assignment stability could moderate the strength or relationship between students taking Algebra I in eighth grade and those who take a general mathematics course in eighth grade.

Research Null Hypothesis 4: Teacher participation in the Cleveland MSP initiative and teacher assignment stability do not moderate significantly the strength of relationship for students taking Algebra I in eighth grade than for those who take a general mathematics course in eighth grade. The level-2 terms for the level 1 ALG1 slope were used to answer this question in the eighth grade data set.

5. The fifth goal was to determine the extent to which teacher participation in the Cleveland MSP initiative and teacher assignment stability could neutralize the impact of student absenteeism on mathematics achievement for sixth, seventh and eighth grade students.

Research Null Hypothesis 5: Teacher participation in the Cleveland MSP initiative and teacher assignment stability do not neutralize significantly the impact of student absenteeism on mathematics achievement for sixth, seventh and eighth grade students. The level-2 terms for the level-1 ATTEND slope were used to answer this question.

6. The sixth goal was to determine the extent to which teacher participation in the Cleveland MSP initiative and teacher assignment stability could moderate the strength of relationship in student achievement for students who have



increased instructional time in mathematics compared to those who do not have increased instructional time.

Research Null Hypothesis 6: Teacher participation in the Cleveland MSP initiative and teacher assignment stability do not moderate significantly the strength of relationship in student achievement for students who have increased instructional time in mathematics compared to those who do not have increased instructional time. The level-2 terms for the level-1 DBL\_MTH slope were used to answer this question.

### *Data Preparation*

Using the statistical software SPSS 12.0 (Nie, Hull, & Bent, 2003), two separate data files were created for each grade level being examined – one for student level data and one for teacher-level data. Teacher and student data files were linked using the string variable TEACHERID and then sorted in ascending order in both files.

The sixth grade data set originally contained 2445 student cases and 115 teacher cases. During data preparation, one teacher case and the corresponding 23 student cases were deleted due to missing data. This resulted in 2422 student cases ( $n = 2422$ ) and 114 teacher cases ( $n = 114$ ) for analysis. The original seventh grade data set contained 2764 student cases and 105 teacher cases. The seventh grade file contained all data necessary for analysis so no information was lost. The original eighth grade data set included 3006 original student cases and 112 teacher cases, and again, due to missing data, 5 teacher cases and the corresponding 128 student cases were deleted. This resulted in 2878 student cases ( $n = 2878$ ) and 107 teacher cases ( $n = 107$ ) for analysis. Although some cases were lost for analysis, the sample size still conformed to the rule of thumb guidelines

(approximately 20 teacher-level/30 student-level) for adequate statistical power in multilevel modeling (Bickel, 2007).

Student test scores for 2006 and 2007 were standardized for analytical purposes of this study to account for the different scales upon which scores are measured from year to year. The standard score determines the distance from the mean for a set of particular scores in terms of standard deviations. That is, the standard score indicates how many standard deviation units a particular case might be above or below the mean, which serves as a reference point for comparing values. The use of standard scores made it possible to compare scores and put the values in perspective when they are reported on different scales with different means and standard deviations.

The scaled score for each student from the OAT-M for 2006 and 2007 was converted to a standard score by taking the individual scaled score, subtracting the mean of the scaled scores for all Ohio students tested during that test administration, then dividing this by the standard deviation of the data set of scaled scores for the whole population tested in Ohio that year. This conversion process normalized the scores to facilitate comparisons and analyses by standardizing the student sample. Student standard scores for the OAT-M 2007 served as the outcome variable in the HLM analysis for each grade level. Each student's standard score on the OAT-M 2006 was used as an independent variable to control for prior achievement.

Unequal frequencies of occurrence in the teacher file were observed for teacher MSP participation with nonMSP teachers occurring at least three times more frequently than MSP teachers. In order to correct for this uneven representation, the variable TMSP was weighted to simulate equal representation in the data. Raudenbush and Bryk (2002)

recommend weighting cases when known but unequal probabilities arise from natural data sampling. They state that observations should be weighted to produce unbiased estimates of the population parameters and that the units should be weighted inversely proportional to its probability of selection. Without weighting, the over-sampled groups would exert undue influence. Therefore, weights were calculated and applied in the teacher file to simulate equal chance of selection.

Finally, upon preliminary examination of the data, it was found that the students of MSP teachers had lower mean achievement scores and lower minimum and maximum scores than students of nonMSP teachers. In fact, the mean score for students of MSP teachers was in the basic achievement range, while the mean score for students of nonMSP teachers was in the proficient achievement range. In order to control for the unequal variability, and since students are not randomly assigned to teachers, the variable MNPRIOR was entered as a level-2 predictor in order to account for the incoming achievement levels of students in each teacher's classes. This variable was created to accommodate for discrepancies in means and variability between students of MSP and nonMSP teachers. Raudenbush and Willms (1995) suggest the introduction of mean pretest scores in such situations. Ballou, Sanders and Wright (2004) note that if the mean prior test score is not orthogonal to the random school effect (i.e., if students are not randomly assigned to the school), the coefficient on the context variable (i.e., the mean pretest variable) will pick up the correlation between the mean score and the true school effects. This same idea was applied to the level-2 teacher effects in order to control for variability in student prior achievement scores. Therefore, the mean pretest score (MNPRIOR) was calculated for each teacher's set of students and then aggregated to the

teacher level. Again, standard scores were used to indicate the distance from the mean in terms of standard deviation units for each teacher's students prior to instruction.

### *Data Analysis*

As a first step, frequencies and percents for demographic information and simple descriptive statistics were used to summarize data. The demographic profile provided contextual information for student level data and included the frequencies and percent for each grade level sample such as gender, ethnicity, participation in free-and-reduced-lunch program (FRPL), number of Limited English Proficient (LEP) students and students with an individual educational plan (IEP). Demographic information for the teacher-level data included the frequencies and percent of sample such as gender, ethnicity, participation in the Cleveland MSP initiative and number of years teaching in the school district. Descriptive statistics for the student data reported the mean and standard error for the student data.<sup>5</sup>

The second phase of analysis included model building and hypothesis testing. Due to the nested nature of the data, two-level hierarchical linear modeling (HLM) was used at each grade level for grades six, seven and eight in order to analyze the quantitative data and test the research questions.<sup>6</sup> HLM has a nested structure that allows regression coefficients to vary from one context to another and provides information about within-group and between-group variation. HLM is based on the assumptions of

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<sup>5</sup> Demographic information and descriptive statistics are reported in section four of this paper.

<sup>6</sup> The decision to use a two-level model rather than a three-level model was necessitated by the required number of teachers (level-2) within schools (level-3) to provide adequate statistical power. In order for a three-level model to have adequate power, the sample would require at least twenty teachers at each grade level per school. For this study this was not the case since most schools were neighborhood schools with at most three teachers per grade level. Therefore, the two-level model was used, and building level variance was accounted for by using mean prior achievement by teacher as a level-2 predictor.

linearity and normality. The use of this procedure allowed the study of relationships between variables at both levels using a single analysis that accounted for the variability associated with each distinct level of the hierarchy.

According to Raudenbush and Bryk (2002), research on instruction can be troublesome due to interactions that occur between students and teachers around curricular materials. Because interactions typically occur within a single school year and within a classroom setting, research data often have a hierarchical structure. Given that individual student characteristics influence learning, the students are situated in groups (in this case as students assigned to teachers), which then take on group characteristics that also influence learning. In this study, the mathematics teacher of record was used as the level-2 unit of analysis because the same curriculum was used with the students they taught even though they were organized into different classrooms. Furthermore, Snijders (2003) suggests that, “In educational research, the largest contributions to achievement outcomes usually are determined by the pupil and the teacher...” (p. 676). In this study, students are nested within teachers, and the model permits the investigation of the relationship between student level variables and math achievement, by teacher, and allows the investigation of teacher-level factors that affect this relationship.

This hierarchically structured data, when aggregated to its highest level and treated with single-level techniques, have been found to violate standard linear regression assumptions, such as the assumption of independence of observations, and “may result in incorrect standard error estimation and flawed hypothesis tests” (Mullens, Murnane, & Willett, 1996, p. 143). In addition, important interactions between students and teachers might be overlooked due to aggregation bias. The technique of hierarchical linear

modeling has been shown to be particularly effective in controlling for many of these types of effects (Raudenbush & Bryk, 2002). Since students are grouped within classrooms, the errors from the observations are not independent of one another and therefore will result in underestimation of standard errors. Traditional multivariate analysis of variance cannot handle this nested data structure. HLM allows the analysis of hierarchical data. Therefore, HLM was used as the analytical method in this research to address lack of independence among observations and cross-level relationships.

Data were analyzed using HLM 6 software (Raudenbush, Bryk, & Congdon, 2007). HLM 6 is an established program for HLM analyses and is used commonly in educational research due to the hierarchical structures in the data. This procedure allows for the study of complex relationships at any level in a single analysis while accounting for the variability associated with each level of the hierarchy.

For this research, the students were chosen as the level-1 units of study. This represented the within-group level since students assigned to a teacher are hypothesized to be more homogeneous than students assigned to different teachers. Further, students were grouped according to their respective mathematics teachers. The teachers were the level-2 units and represented between-group levels. Teachers were used as the second level of analysis rather than classrooms because the treatment of graduate coursework in mathematics occurred at the teacher-level rather than at the classroom level. In addition, students in the middle grades were not grouped into self-contained classrooms but rather were assigned to teachers for their mathematics classes.

### *Model Specifications*

Following the recommendations for steps in model building, a two-level hierarchical linear model used known values of the independent variables to predict the dependent variable – standardized achievement test scores in middle grades mathematics for 2007. The models were comprised of equations with student level predictors at level-1 and equations with teacher-level predictors at level-2.

*Unconditional Model.* (Null or Intercept-as-Outcome model) The null or unconditional model was fit to the data for each grade level examined. This model is similar to the one-way ANOVA with random effects and provides a baseline to which other models were compared. This model also provides useful preliminary information about the amount of variance that lies within and between levels, as well as providing information about the reliability of the level-2 sample mean as an estimate of the true population mean (Raudenbush & Bryk, 2002).

The only parameter estimated in this model was the intercept or mean for the students of each teacher ( $\beta_{0j}$ ) with a random error term ( $r_{ij}$ ) and the overall mean across all teachers' students ( $\gamma_{00}$ ) with a random error term ( $u_{0j}$ ). The unconditional model was specified by the equations

$$\text{Level 1: } Y_{ij} = \beta_{0j} + r_{ij} \quad (1)$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + u_{0j} \quad (2)$$

where

$Y_{ij}$  = the individual student standardized score for the 2007 Ohio Achievement Test in mathematics (OAT-M) for student  $i$  of teacher  $j$ ;

$\beta_{0j}$  = the intercept (adjusted mean OAT-M score) for students of teacher  $j$ ;

$r_{ij}$  = the level-1 residual error for student  $i$  of teacher  $j$ . It is assumed that  $r_{ij}$  is distributed normally with a mean of zero and variance of  $\sigma^2$ .

$\gamma_{00}$  = the intercept (adjusted mean OAT-M) in modeling the teacher effect;

$u_{0j}$  = the level-2 residual error for students of teacher  $j$ . These are the unique teacher effects. It is assumed that  $u_{0j}$  is independently normally distributed with a mean of zero and variance of  $\tau_{00}$ .

This model was used to predict the outcome variable based on the intercept and an error term alone and allowed examination of the intraclass correlation (ICC), which shows the proportion of between-teacher variability in student achievement scores. The ICC was calculated using the equation

$$\hat{\rho} = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} \quad (3)$$

where

$\hat{\rho}$  = the ICC for the null model;

$\tau_{00}$  = the amount of level-2 variance, or the amount of variance between teachers; and,

$\sigma^2$  = the amount of level-1 variance, or the amount of student level variance within teachers.



*Conditional Model.* (Full or Intercepts-and Slopes-as-Outcomes Model.) The full model for student data (level-1) and teacher data (level-2) included all predictors being examined in the study at both student and teacher-levels.

*Student-Level Model (Level 1).* Student achievement was modeled as a function of student-level predictors plus a random student-level error. For students in grades six and seven, attendance and prior achievement were grand mean centered before the variables were added to the model (Equation 4).

$$\begin{aligned} ATTEND_{ij}^* &= (ATTEND_{ij} - \overline{ATTEND_{..}}) \\ OATM06_{ij}^* &= (OATM06_{ij} - \overline{OATM06_{..}}) \end{aligned} \quad (4)$$

Therefore, the specified model was

$$\begin{aligned} Y_{ij} &= \beta_{0j} + \beta_{1j}(ATTEND_{ij} - \overline{ATTEND_{..}}) \\ &+ \beta_{2j}(OATM06_{ij} - \overline{OATM06_{..}}) + \beta_{3j}(DBL\_MTH) + r_{ij} \end{aligned} \quad (5)$$

where

$Y_{ij}$  = the individual student standardized score for the 2007 OAT-M for student  $i$  in a class for teacher  $j$ ;

$\beta_{0j}$  = the intercept (adjusted mean OAT-M score) for the class of teacher  $j$ ;

$\beta_{1j}$  = the effect of student attendance on student  $i$  standardized scores (grand mean centered) in a class of teacher  $j$ ;

$\beta_{2j}$  = the individual student standardized score for the 2006 Ohio Achievement test in mathematics (grand mean centered) for student  $i$  in a class for teacher  $j$ ;

$\beta_{3j}$  = the effect of additional instructional time in mathematics (uncentered) for student  $i$  in a class for teacher  $j$ ; and

$r_{ij}$  = the level-1 residual error for student  $i$  in a class for teacher  $j$ . It is assumed that  $r_{ij}$  is distributed normally with a mean of zero and variance the same across teachers and schools. In the Level-1 model for sixth and seventh grade data, student test scores will be regressed against the student level covariates of prior achievement, gender, and attendance.

For students in grade eight, the specified model was similar to that for sixth and seventh grade with the addition of a variable for membership in a higher-level mathematics course. As in the student level model for sixth and seventh grades, attendance and prior achievement were grand mean centered before adding to the model (Equation 6).

$$\begin{aligned} ATTEND_{ij}^* &= (ATTEND_{ij} - \overline{ATTEND_{..}}) \\ OATM06_{ij}^* &= (OATM06_{ij} - \overline{OATM06_{..}}) \end{aligned} \quad (6)$$

Therefore, the specified model for eighth grade level-1 data was

$$\begin{aligned} Y_{ij} &= \beta_{0j} + \beta_{1j}(ATTEND_{ij} - \overline{ATTEND_{..}}) + \beta_{2j}(OATM06_{ij} - \overline{OATM06_{..}}) \\ &+ \beta_{3j}(DBL\_MTH_{ij}) + \beta_{4j}(ALGI_{ij}) + r_{ij} \end{aligned} \quad (7)$$

where

$Y_{ij}$  = the individual student standardized score for the 2007 OAT-M for student  $i$  in a class for teacher  $j$ ;

$\beta_{0j}$  = the intercept (adjusted mean OAT-M score) for the class of teacher  $j$ ;

$\beta_{1j}$  = the effect of student attendance (grand mean centered) on student  $i$  standardized scores in a class of teacher  $j$ ;

$\beta_{2j}$  = the individual student standardized score for the 2006 Ohio Achievement test in mathematics for student  $i$  in a class for teacher  $j$ ;

$\beta_{3j}$  = the effect of additional instructional time in mathematics for student  $i$  in a class for teacher  $j$ ;

$\beta_{4j}$  = the effect of student enrollment in Algebra I on student standardized scores for student  $i$  in a class for teacher  $j$ ; and

$r_{ij}$  = the level-1 residual error for student  $i$  in a class for teacher  $j$ . It is assumed that  $r_{ij}$  is distributed normally with a mean of zero and variance the same across teachers. In the level-1 model for eighth grade data, student test scores will be regressed against the student level covariates of prior achievement, gender, attendance and participation in higher-level mathematics courses.

*Teacher-Level Model (Level 2).* Variation among classes for teachers within schools was modeled as a function of teacher-level predictors plus a random teacher-level error. The mean prior achievement for each teacher was grand mean centered prior to adding this variable to the model (Equation 8).

$$MNPRIOR_{ij}^* = (MNPRIOR_{ij} - \overline{MNPRIOR_{..}}) \quad (8)$$

For each teacher effect,

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + \gamma_{01}(TMSP_j) + \gamma_{02}(TSTAB_j) + \gamma_{03}(MNPRIOR_j - \overline{MNPRIOR_{..}}) + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11}(TMSP_j) + \gamma_{12}(TSTAB_j) + \gamma_{13}(MNPRIOR_j - \overline{MNPRIOR_{..}}) \\ \beta_{2j} &= \gamma_{20} + \gamma_{21}(TMSP_j) + \gamma_{22}(TSTAB_j) + \gamma_{23}(MNPRIOR_j - \overline{MNPRIOR_{..}}) + u_{2j} \\ \beta_{3j} &= \gamma_{30} + \gamma_{31}(TMSP_j) + \gamma_{32}(TSTAB_j) + \gamma_{33}(MNPRIOR_j - \overline{MNPRIOR_{..}}) \\ \beta_{4j} &= \gamma_{40} + \gamma_{41}(TMSP_j) + \gamma_{42}(TSTAB_j) + \gamma_{43}(MNPRIOR_j - \overline{MNPRIOR_{..}}) \end{aligned} \quad (9)$$

where

$\beta_{0j}$  = the intercept (adjusted mean OAT-M score) for the class of teacher  $j$ ;

$\beta_{1j}$  = the effect of student attendance on student standardized scores in a class of teacher  $j$ ;

$\beta_{2j}$  = the individual student standardized score for the 2006 OAT-M for student  $i$  in a class for teacher  $j$ ;

$\beta_{3j}$  = the effect of additional instructional time in mathematics for students;

$\beta_{4j}$  = the effect of student enrollment in Algebra I on student standardized scores in a class of teacher  $j$  (this parameter is not included in the models for sixth and seventh grade);

$\gamma_{00}$  = the intercept (adjusted mean OAT-M) in modeling the classroom (teacher) effect;

$\gamma_{10}$  = the effect of teacher MSP participation (uncentered) on student standardized scores;

$\gamma_{20}$  = the effect of teacher assignment stability (uncentered) on student standardized scores;

$\gamma_{30}$  = the effect of mean prior mathematics achievement (grand centered) on student standardized scores;

$u_{0j}$  = is the level-2 residual error for teacher  $j$  in a class for the intercept. These are the unique teacher effects. It is assumed that  $u_{0j}$  is distributed normally.

$u_{2j}$  = is the level-2 residual error for teacher  $j$  in a class for the prior achievement slope. These are the unique teacher effects. It is assumed that  $u_{2j}$  is distributed normally also.

Teacher-level models were specified for each student-level parameter in the level-1 model. In the level-2 model, student test scores (the outcome variable from level-1) were regressed against each of the teacher-level covariates of MSP participation and teacher assignment stability.

The proportion reduction in variance based on the level-1 predictors was calculated in order to provide a conditional ICC statistic, sometimes called the pseudo- $R^2$  statistic and denoted as the  $R_j^2$  summary statistic. The  $R_j^2$  was found by first calculating the ICC for the unconditional (null) model (see equation 3) which gave the variance between groups with no predictors entered into the model. After predictors were included in the conditional model, the  $R_j^2$  was calculated using the equation

$$R_1^2 = 1 - \frac{(\tau_{conditional} + \sigma_{conditional}^2)}{(\tau_{null} + \sigma_{null}^2)} \quad (10)$$

where

$R_j^2$  = the proportion reduction in variance for the conditional model;

$\tau_{conditional}$  = the amount of level-2 variance, or the amount of variance between teachers for the conditional model;

$\sigma^2_{conditional}$  = the amount of level-1 variance, or the amount of student level variance within teachers for the conditional model;

$\tau_{null}$  = the amount of level-2 variance, or the amount of variance between teachers for the null model; and

$\sigma^2_{null}$  = the amount of level-1 variance, or the amount of student level variance within teachers for the null model.

This gave the amount of variance in the adjusted mean student mathematics achievement that was explained by the level-2 predictors on the level-1 intercept and slopes. It should be noted that in the conditional model, all slopes were temporarily fixed in order to calculate the  $R_j^2$  statistic (Bickel, 2007).

#### Summary of Chapter

This chapter outlined the methods that were used to conduct the study. Discussion included the context of the study, description of study participants, descriptions of data included in the study and its preparation, the teacher and student variables considered for analysis, and the procedures utilized for analyzing the data. Chapter 4 examines and presents the results of this empirical investigation.

## CHAPTER IV

### RESULTS

The main purpose of this research was to study the relationship between the MSP initiative for middle grades mathematics teachers and student achievement. Student achievement was measured by the 2007 Ohio Achievement Test in Mathematics. A secondary purpose of this study was to examine the relationship between mediating teacher variables of stability of teaching assignment, and mediating student variables, such as attendance, additional instructional time in mathematics and participation in higher-level course taking. This chapter provides a summary of findings from this study, including demographic information and descriptive statistics for the sample of students and their teachers, as well as findings related to the research questions.

#### Descriptive Information

##### *Student Demographics and Descriptive Statistics*

*Demographic Data.* A summary of the student demographic data for the sample included in this study are reported in Table 4. Frequencies and percents of occurrence in

the data provide the reader with a contextual overview of the middle school student population included in this study.

Student gender was almost evenly divided at all three grade levels (sixth grade: 48.4% males, 51.6% females; seventh grade: 48.6% males, 51.4% females; eighth grade: 47% males, 53% females). Preliminary examination of this variable indicated no statistically significant difference in achievement between males and females at the three grade levels; therefore, this variable was not included in the HLM analysis because it would not contribute information to the study. Furthermore, at all three grade levels, the majority of student cases included in the study were minority with the largest category being African-American (sixth grade: 71.7%; seventh grade: 65%; eighth grade: 73.1%). This variable also was not included in the HLM analysis for this study due to the large disparity in group membership, which would have reported biased estimates. In addition, few students were classified as Limited English Proficient (LEP) (sixth grade: 1.7%; seventh grade: 3.1%; eighth grade: 3.3%) or as having a valid Individualized Education Plan (IEP) (sixth grade: 3.8%; seventh grade: 3.4%; eighth grade: 7.4% respectively). These variables also were not used in the analysis due to their low statistical power.<sup>7</sup> Additionally, during the 2006-2007 school year, all students (100%) in the district qualified for participation in the free-and-reduced-price-lunch program (FRPL), which is commonly used as a proxy for economical disadvantage and an indicator of poverty levels and socioeconomic status (SES). Because there was full student participation in FRPL, SES was not examined in this study as a student level predictor.

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<sup>7</sup> Variables for SLD and LEP students might not be reliably reported as the state guidelines for documenting students with IEP's or who are LEP were limited to about 3% in 2007. Therefore, it is entirely possible that a school district could have had higher occurrences of students whose native language was not English or who participated in special education services but were not reported due to these guideline restrictions.



Table 4

*Frequencies and Percents for Middle Grades Students' Demographic Data for Gender, Ethnicity, SLD and LEP Qualifications, Free and Reduced Lunch Participation, and Course Enrollment*

		Sixth Grade (n = 2422)		Seventh Grade (n = 2764)		Eighth Grade (n = 2878)	
Demographic Category		Frequency (f)	Percent (P)	Frequency (f)	Percent (P)	Frequency (f)	Percent (P)
Gender	Male	1170	48.3	1343	48.6	1353	47
	Female	1252	51.7	1421	51.4	1525	53
Ethnicity	African-American	1737	71.7	1797	65	2104	73.1
	Hispanic	227	9.4	276	10	282	9.8
	White	397	16.4	404	14.6	432	15
	Other	61	2.5	287	10.4	60	2.1
Students with IEP		92	3.8	94	3.4	213	7.4
LEP Students		41	1.7	86	3.1	95	3.3
FRPL (SES indicator)		2422	100	2764	100	2878	100
Course Enrollment	General Math	2422	100	2764	100	2107	73.2
	Algebra I					771	26.8

Finally, mathematics course enrollment is reported for eighth grade students. This is not reported for sixth and seventh grade students since the only mathematics course option at those grade levels was general mathematics. The majority of eighth grade students (73.2%) were enrolled in general mathematics during the 2006-2007 school year. A little over one fourth (26.8%) of district eighth graders were enrolled in Algebra I during the 2006-2007 school year. This accelerated course allowed students to qualify for high school credit while in middle school. The course was taught by a state licensed mathematics teacher. MSP teachers were responsible for teaching the majority of the eighth grade Algebra I courses (65.2%) since they were able to attain licensure in middle grades mathematics through the MSP initiative. The remainder of these courses (34.8%) was either taught by high school licensed teachers or middle grades mathematics licensed teachers who did not obtain licensure through the MSP.

*Descriptive Statistics.* The original data sets for this study included 2445 sixth grade student cases, 2764 seventh grade student cases and 3006 eighth grade student cases. After deletion of cases due to missing data, 98% of sixth grade student cases ( $n = 2422$ ), 100% of seventh grade student cases ( $n = 2764$ ) and 96% of eighth grade student cases ( $n = 2878$ ) were included in the study.<sup>8</sup>

Descriptive statistics of student standardized performance scores, attendance and additional mathematics instructional time (reported as “double math”) for participants in this study are reported in Table 5. In addition, participation in Algebra I in the eighth grade is also reported in this table. The means and standard deviations as well as

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<sup>8</sup> As previously reported, cases were deleted due to missing teacher data, which then necessitated the deletion of corresponding student data. Test occasions for both prior achievement (2005-2006) and outcome measures (2006-2007) were present in the data sets for all student cases in the study.

minimum and maximum values are reported. Students who were assigned to middle school mathematics teachers during the 2006-2007 school year are the unit of analysis.

Table 5  
*Descriptive Statistics for Middle Grades Students for Achievement, Attendance, Additional Instructional Time and Algebra I in Eighth Grade*

Variable Name	<i>n</i>	<i>M</i>	<i>SD</i>	Minimum	Maximum
OAT-M 2006					
Grade 6	2422	-0.76	0.81	-4.44	2.67
Grade 7	2764	-0.71	0.80	-3.66	2.74
Grade 8	2878	-0.64	0.73	-3.10	2.29
OAT-M 2007					
Grade 6	2422	-0.82	0.76	-2.80	2.51
Grade 7	2764	-0.69	0.74	-4.36	2.14
Grade 8	2878	-0.64	0.80	-5.26	2.94
Student Attendance					
Grade 6	2422	159.49	13.59	77	184
Grade 7	2584	155.90	16.50	48	182
Grade 8	2878	156.58	16.43	52	184
Double Math					
Grade 6	2242	0.39	0.49	0	1
Grade 7	2584	0.30	0.46	0	1
Grade 8	2878	0.38	0.48	0	1
Algebra 1 (Grade 8)	2878	0.28	0.45	0	1

As can be seen in Table 5, student achievement for both years of testing included in this study was well below the state mean. On average, middle grades students in the district performed about 0.6 to 0.8 of a standard deviation below the state mean. Furthermore, mean standardized achievement test scores did not change between the two years of testing used in this study.

Finally, average daily attendance during the 2006-2007 school year was between 155 – 160 days. The school year consists of 174 days that students are to be in attendance. This does not include days for teacher professional development, parent-teacher conferences and compensatory days. At the time of this study, one school in the district was a year round school, and the number of student attendance days was 184 days – ten more days than expected at the traditional calendar schools. This is reflected in the maximum values for grades 6, 7 and 8 shown in the table.<sup>9</sup>

### *Teacher Demographics and Descriptive Statistics*

Demographic data for the middle grades teachers included in the sample for this study are reported in Table 6.

The original data sets for this study included 114 sixth grade teacher cases, 105 seventh grade teacher cases and 112 eighth grade teacher cases. After deletion of cases due to missing data, 100% of sixth grade teacher cases (n = 114), 100% of seventh grade teacher cases (n = 105) and 96% of eighth grade teacher cases (n = 107) were included in the study. The overwhelming majority of teachers at all three grade levels were female (sixth grade: 17.5% males, 77.2% females; seventh grade: 21.9% males, 70.5% females; eighth grade: 21.6% males, 64% females). In addition, at all three grade levels, the

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<sup>9</sup> This school has now converted to the same calendar of instructional days as other schools in the district.

majority of teacher cases included in the study were nonminority with the largest category being White (sixth grade: 66.4%; seventh grade: 60.9%; eighth grade: 57.6%). Since student gender and ethnicity were not included as level-1 variables, and since cross interaction between teacher and student race and gender were not foci of this study, these teacher variables were not included in the analysis.

At all three grade levels more than half of the teachers included in the study had 10 or fewer years of district experience (sixth grade: 57.4%  $\leq$  10 years; 42.6%  $\geq$  11 years; seventh grade: 59.9%  $\leq$  10 years; 40.1%  $\geq$  11 years; eighth grade: 55.9 %  $\leq$  10 years; 44.1 %  $\geq$  11 years). A few factors contributed to the decision not to include this variable in the analysis. First, teachers could have had prior teaching experience before working in the school district, and the data set does not include information about work experience prior to employment in CMSD. Thus, teacher experience data unreliably reflects true teacher experience. Second, teacher experience information in the data set does not indicate if the teacher's experience was in mathematics or other content areas during their years of employment. Third, according to extant literature, teacher experience has a curvilinear relationship with student achievement. These studies indicate that achievement rises with experience up to about eight years, then levels off (Darling-Hammond, 2000; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004). Third, teacher experience was initially included in the full model but did not enhance the findings and partitioned variance from other contributing variables. Therefore, in order to create the most parsimonious model, this variable also was eliminated from the model.

Table 6

*Frequencies and Percents for Middle Grades Teachers' Demographic Data for Gender, Ethnicity, MSP Participation, and Years of District Experience*

		Sixth Grade (n = 114)		Seventh Grade (n = 105)		Eighth Grade (n = 107)	
Demographic Category		Frequency ( <i>f</i> )	Percent ( <i>P</i> )	Frequency ( <i>f</i> )	Percent ( <i>P</i> )	Frequency ( <i>f</i> )	Percent ( <i>P</i> )
Gender	Male	20	17.5	23	21.9	23	21.6
	Female	88	77.2	74	70.5	69	64
	Unreported	6	5.3	8	7.6	15	14.4
Ethnicity	African-American	27	23.7	26	24.8	23	21.6
	Hispanic	4	3.5	6	5.7	5	4.8
	White	76	66.4	64	60.9	62	57.6
	Other	7	6.4	9	8.6	17	16
MSP	MSP	15	13.2	33	31.4	37	34.4
	nonMSP	99	86.8	72	68.6	70	65.6

Table 6 (continued)

*Frequencies and Percents for Middle Grades Teachers' Demographic Data for Gender, Ethnicity, MSP Participation, and Years of District Experience*

Demographic Category		Sixth Grade (n = 114)		Seventh Grade (n = 105)		Eighth Grade (n = 107)	
		Frequency ( <i>f</i> )	Percent ( <i>P</i> )	Frequency ( <i>f</i> )	Percent ( <i>P</i> )	Frequency ( <i>f</i> )	Percent ( <i>P</i> )
District Experience	≤ 5 yrs.	19	16.7	15	14.4	25	23.6
	6-10 yrs.	46	40.7	48	45.5	35	32.3
	11-15 yrs.	19	16.8	21	19.6	23	21.8
	16-20 yrs.	19	16.7	13	12.5	16	15
	21-25 yrs.	1	.9	2	2	4	3.7
	> 25 yrs.	9	8.2	6	6	4	3.6

Teacher membership in the MSP (the study treatment) and stability of teacher assignment were variables of interest in the study. Both Tables 6 and 7 show information regarding teacher MSP participation. At all three grade levels, the majority of teachers had not participated in the MSP initiative (sixth grade:  $M = .16$ ; 13.2% MSP, 86.8% nonMSP; seventh grade:  $M = .37$ , 31.4% MSP, 68.6% nonMSP; eighth grade:  $M = .38$ , 34.4% MSP, 65.6% non MSP). Furthermore, the number of MSP teachers placed at the upper middle grade levels is more than double the number of MSP teachers at the sixth grade. Because of the unequal representation of MSP teachers in the control group, this variable was weighted to simulate equal groups between the control and treatment.

Table 7 also includes information about the teachers' assignment stability. A zero for this variable indicated that the teacher had not taught mathematics at that grade level over a four year span of time from the 2003-2004 academic year to the 2006-2007 academic year. Likewise, a three for this variable indicated that the teacher had taught mathematics at the grade level all years over the four year span of time. For sixth grade teachers, the average assignment was about 2 years ( $M = 1.08$ ;  $SD = 1.03$ ). The stability of assignment increases with the grade level. Eighth grade teachers had the most stable assignment ( $M = 1.77$ ;  $SD = 1.11$ ) indicating that the average assignment was about three out of the four years included in the data.

Finally, the variable MNPRIOR was included as a level-two predictor. This variable was created by aggregating the prior achievement scores of each teachers' students (for the 2005-2006 school year) and was included to control for the variability found between the prior achievement between MSP and non-MSP teachers' students (Ballou, Sanders, & Wright, 2004; Raudenbush & Willms, 1995). The variability was



determined through a preliminary analysis of the data, which showed that on average, MSP teachers' students scored below proficient compared to non-MSP teachers' students at all three grade levels and was previously discussed in chapter 3 under data preparation. As can be seen in table 7, most students' prior achievement was about three-fourths below grade level for all three years.

Table 7

*Descriptive Statistics for Middle Grades Teachers for MSP Participation, Teacher Assignment Stability and Mean Prior Achievement*

Variable Name	<i>n</i>	<i>Mean</i>	<i>SD</i>	Minimum	Maximum
<b>TMSP (MSP Participation)</b>					
Grade 6	114	.16	.37	0	1
Grade 7	105	.37	.49	0	1
Grade 8	107	.38	.49	0	1
<b>TSTAB (Assignment Stability)</b>					
Grade 6	114	1.08	1.03	0	3
Grade 7	105	1.46	1.12	0	3
Grade 8	107	1.77	1.11	0	3
<b>MNPRIOR (Mean prior achievement)</b>					
Grade 6	114	-0.83	0.46	-2.32	0.57
Grade 7	105	-0.75	0.38	-1.75	0.23
Grade 8	107	-0.70	0.36	-1.61	0.62

## Research Findings

### *Intraclass Correlation and Reliability Estimates*

One of the purposes of estimating the null model is to assess the degree of between group variance in the dependent variable by partitioning variance into its within and between components. The null, or unconditional model was used to determine the intraclass correlations (ICC's) and reliability of the level-1 ( $\beta_0$ ) intercept for sixth, seventh and eighth grade data. This information is reported in Table 8. Most of the variance in student achievement is associated with student characteristics. The remaining variance in this model can be associated with teacher characteristics. These models indicate that teacher characteristics account for roughly 13 – 22% of variance in student mathematics achievement. Hedges and Hedberg (2007) report that the ICC's for low socioeconomic schools and low achievement schools are about .09 to .22. This study findings are consistent with extant literature, which suggests that teacher characteristics account for between one sixth to one third of student achievement (Harwell et al., 2007; Hattie, 2003; Marzano, 2003). Furthermore, the  $R_1^2$  statistic, which is reported in Table 8, indicates that the addition of the predictors to the model now accounts for about 40% of the variance, an increase of between 17 – 27%. In addition, the chi-square goodness-of-fit statistics reported in Table 8 indicate that the hierarchical models for each grade were justified because the variance components were significantly different from zero.

Table 8

*Intraclass Correlations, Chi-Square and Reliability Estimates for Sixth, Seventh and Eighth Grade Mathematic Achievement*

	Grade Level		
	Six	Seven	Eight
Intraclass Correlation (Unconditional), $\rho$	.17	.13	.22
Intraclass Correlation (Conditional), $R_1^2$	.39	.40	.39
$\chi^2$	666.26 ***	494.72 ***	913.80 ***
Reliability estimates (Null Model)	0.762	0.736	0.818

\*\*\*  $p < .001$

The reliability estimate, which is a ratio of expected parameter variance to observed parameter variance, represents the proportion of variance in the level-1 group (students) that is parameter variance. Reliability estimates of .70 or greater are considered high and indicate that the intercepts are reliable predictors (Snijders & Bosker, 1999). The estimates for grades six, seven and eight are reported in Table 7 and are adequate for multilevel modeling. They show that the intercept is reliable in its ability to discriminate the average student achievement among the level-2 groups (teachers).

*Findings Related to Research Questions*

A two level HLM for each grade level was used to examine the data for sixth seventh and eighth grade students and their mathematics teachers using the conditional, or full model. The full model was used to answer each of the research questions for each grade level.

**Research Question 1:** To what extent do student characteristics, such as prior achievement, attendance, additional instructional time in mathematics and Algebra I course taking for eighth grade students, predict student achievement in mathematics for sixth, seventh and eighth grades students?

Findings for middle school students are reported in Table 9. For all three grades, the standardized adjusted classroom average on the OAT-M for 2007 was more than one-half standard deviation below the mean, and the results were statistically significant at  $p < .001$ . For sixth grade, the adjusted average ( $\beta_0 = -0.88, p < .001$ ) indicates that a sixth grade student taking a single period general mathematics course with average district attendance (159.49 days) and average prior mathematics achievement could be predicted to score between nearly nine-tenths of a standard deviation below the mean on the 2007 OAT-M state achievement test. Similarly, the findings for seventh grade students indicate that the adjusted classroom average ( $\beta_0 = -0.68, p < .001$ ) on the OAT-M for 2007 means that a student with average attendance (155.90 days) and average prior mathematics achievement could be predicted to score almost seven-tenths of a standard deviation below the mean on the 2007 OAT-M state achievement test. Finally, the findings for eighth grade students show that the standardized adjusted classroom average ( $\beta_0 = -0.52, p = .001$ ) on the OAT-M for 2007 was about one-half of a standard deviation below the mean when considering student average attendance (156.58 days) and prior average mathematics achievement.

Student attendance was a statistically significant predictor of student mathematics achievement on the 2007 OAT-M. For all three grade levels, average student achievement was predicted to increase about one-hundredth of a standard deviation for

each additional day of student attendance ( $\beta_1 = 0.01$ ;  $p < .01$ ) above the grade level mean attendance.

Table 9

*HLM Results for Middle School Student-Level Predictors and Student Performance on the 2007 OAT-M (Standardized Scores) by Grade Level*

Student Characteristic	Coefficient	SE	t	p
<b>Grade 6</b>				
Adjusted Average Score, $\beta_0$	-0.88	0.05	-17.377	.000 ***
Student Attendance, $\beta_1$	0.01	0.00	3.035	.003 **
Prior Mathematics Achievement, $\beta_2$	0.53	0.04	14.098	.000 ***
Additional Math Instructional Time, $\beta_3$	-0.01	0.07	-0.092	.927
<b>Grade 7</b>				
Adjusted Average Score, $\beta_0$	-0.68	0.09	-7.608	.000 ***
Student Attendance, $\beta_1$	0.01	0.00	2.811	.005 **
Prior Mathematics Achievement, $\beta_2$	0.57	0.07	8.383	.000 ***
Additional Math Instructional Time, $\beta_3$	-0.03	0.13	-0.256	.798
<b>Grade 8</b>				
Adjusted Average Score, $\beta_0$	-0.52	0.14	-3.649	.001 ***
Student Attendance, $\beta_1$	0.01	0.00	2.777	.007 **
Prior Mathematics Achievement, $\beta_2$	0.54	0.10	5.356	.000 ***
Additional Math Instructional Time, $\beta_3$	-0.35	0.22	-1.592	.114
Algebra I Course (Eighth Grade), $\beta_4$	0.28	0.25	1.147	.252

\*\* $p < .01$ , \*\*\* $p < .001$

Student prior achievement was also a significant predictor of the adjusted mean at all three grade levels. For the sixth grade, the fifth grade OAT-M for 2006 was a statistically significant predictor of student mathematics achievement on the sixth grade OAT-M for 2007 ( $\beta_2 = 0.53$ ;  $p < .001$ ) and indicates that for every one standard deviation increase on the 2006 fifth grade OAT-M, a student is predicted to increase about one-half of a standard deviation on the 2007 sixth grade OAT-M. For seventh grade students, prior achievement on the sixth grade OAT-M for 2006 was a statistically significant predictor of student mathematics achievement on the seventh grade OAT-M for 2007 ( $\beta_2 = 0.57$ ;  $p < .001$ ) and indicates that for every one standard deviation increase on the 2006 sixth grade OAT-M, a student is predicted to increase almost half of a standard deviation on the 2007 seventh grade OAT-M. Likewise, student prior achievement on the seventh grade OAT-M for 2006 was a statistically significant predictor of student mathematics achievement on the eighth grade OAT-M for 2007 ( $\beta_2 = 0.54$ ;  $p < .001$ ) and indicates that for every one standard deviation score increase on the 2006 seventh grade OAT-M, a student is predicted to increase about one-half of a standard deviation on the 2007 eighth grade OAT-M.

As a student level variable, additional instructional time in mathematics for all three middle grades had a negative relationship to predicted student achievement on the OAT-M for 2007, although the results were not statistically significant. Likewise, Algebra I course taking in eighth grade did not have a statistically significant relationship to student achievement, although the relationship was positive.

For this research question, student prior knowledge in mathematics and student attendance were significant positive predictors of the adjusted average mathematics

achievement, but additional instructional time in mathematics and Algebra I course taking for eighth grade students were not significant predictors of student mathematics achievement.

**Research Question 2:** To what extent do teacher characteristics, such as participation in the MSP initiative and teacher assignment stability, predict the adjusted classroom average in student achievement in mathematics for sixth, seventh and eighth grade students?

Table 10 shows the findings for teacher-level variables and their relationship to student mathematics achievement.<sup>10</sup> Teacher MSP participation was found to be a statistically significant and negative predictor of mathematics achievement for sixth grade students ( $\gamma_{01} = -0.07, p < .05$ ). This indicates that students of an MSP teacher could be expected to score about seven-tenths of a standard deviation below the mean on the OAT-M for 2007 than students who had a nonMSP teacher. Results for MSP participation were not statistically significant for seventh or eighth grade students.

The results also indicate that teacher assignment stability was a statistically significant predictor of sixth grade student achievement on the OAT-M for 2007 ( $\gamma_{02} = 0.07, p < .05$ ). These results indicate that for every year that a teacher's assignment in mathematics remained consistent over a four-year period, student achievement scores could be predicted to increase about seven-tenths of a standard deviation. This was not the case for seventh and eighth grade results as teacher assignment stability was not a significant predictor at those grade levels.

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<sup>10</sup> As previously stated, the variable for mean prior achievement (MNPRIOR) was included in the model to correct for the inequitable distributions in prior student achievement between groups of teachers (MSP and non-MSP). However, this variable is not a variable of interest in this study.

Table 10

*HLM Results for Teacher-Level Variables and Middle Grade Student Performance on the 2007 OAT-M*

Teacher Characteristic	Coefficient	SE	<i>t</i>	<i>p</i>
Grade 6				
MSP Participation, $\gamma_{01}$	-0.07	0.03	-2.49	.015 *
Assignment Stability, $\gamma_{02}$	0.07	0.03	2.045	.043 *
Mean Prior Achievement, $\gamma_{03}$	-0.06	0.08	-0.753	.453
Grade 7				
MSP Participation, $\gamma_{01}$	-0.03	0.10	-0.318	.751
Assignment Stability, $\gamma_{02}$	-0.01	0.03	-0.426	.671
Mean Prior Achievement, $\gamma_{03}$	-0.01	0.06	-0.184	.854
Grade 8				
MSP Participation, $\gamma_{01}$	-0.22	0.15	-1.456	.148
Assignment Stability, $\gamma_{02}$	0.01	0.03	0.345	.730
Mean Prior Achievement, $\gamma_{03}$	0.26	0.11	2.406	.018 *

\* $p < .05$ 

Finally, mean prior achievement, when aggregated to the teacher level, was shown to be a significant predictor of student mathematics achievement for the eighth grade ( $\gamma_{03} = 0.26, p > .05$ ). This would indicate that for every one standard deviation increase in classroom prior achievement, individual student achievement could be



predicted to increase by about one-fourth of a standard deviation. This was not the case for sixth and seventh grade students.<sup>11</sup>

For this research question, teacher participation in the Cleveland MSP initiative was significant and negatively associated with student mathematics achievement for sixth grade. Teacher assignment stability was significant and positively associated with mathematics achievement for sixth grade. They were not significant predictors for seventh grade and eighth grades. In addition, mean prior achievement was a significant positive predictor of eighth grade mathematics achievement.

**Research Question 3:** To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability moderate the strength of relationship between student prior and current achievement in mathematics for sixth, seventh and eighth grade students?

Table 11 shows the results for the interaction effects between teacher participation in the MSP, teacher assignment stability and mean prior achievement aggregated to the teacher level and the relationship to student achievement on the 2007 OAT-M. For all three grade levels, the results indicate that there is a negative but non-significant relationship for students who had an MSP teacher and the students' prior achievement. Results also show that teacher assignment stability was not a significant predictor of student mathematics achievement although the relationship is positive for sixth and seventh grade. Finally, mean prior achievement was not a statistically significant predictor of student mathematics achievement for grades six and eight when regressed on the individual student's prior achievement. Only mean prior achievement for seventh

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<sup>11</sup> Although mean prior achievement (MNPRIOR) was included as a variable to control for disparities between the prior mean achievement of groups of students assigned to a teacher and not necessarily of variable of interest in this study, the results are reported.

grade yielded a statistically significant result when examined against individual student prior achievement ( $\gamma_{33} = 0.12, p < .05$ ). This indicates that for every one standard deviation increase in classroom mean prior achievement, individual student achievement could be expected to increase additionally about one-tenth of a standard deviation.

Table 11

*HLM Results for Interaction between Teacher-Level Variables and Middle Grades Student Prior Achievement (Standardized Scores)*

Teacher Characteristic	Coefficient	SE	t	p
<b>Grade 6</b>				
MSP Participation, $\gamma_{21}$	-0.06	0.04	-1.327	.187
Assignment Stability, $\gamma_{22}$	0.08	0.04	1.893	.060
Mean Prior Achievement, $\gamma_{23}$	0.08	0.12	0.657	.512
<b>Grade 7</b>				
MSP Participation, $\gamma_{21}$	-0.08	0.08	-0.986	.327
Assignment Stability, $\gamma_{22}$	0.03	0.02	1.325	.188
Mean Prior Achievement, $\gamma_{23}$	0.12	0.05	2.425	.017 *
<b>Grade 8</b>				
MSP Participation, $\gamma_{21}$	-0.01	0.10	-0.123	.903
Assignment Stability, $\gamma_{22}$	0.00	0.02	-0.062	.951
Mean Prior Achievement, $\gamma_{23}$	0.10	0.07	1.411	.161

\* $p < .05$

For this research question, teacher participation in the Cleveland MSP initiative and teacher assignment stability did not moderate significantly the strength of relationship between student prior and current achievement in mathematics for sixth, seventh and eighth grade students. However, mean prior achievement was significantly and positively associated with seventh grade mathematics achievement.

**Research Question 4:** To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability moderate the strength of relationship between students taking Algebra I in eighth grade and those who do not take Algebra I?

Findings for cross-level interactions of teacher-level characteristics and student Algebra I course taking in eighth grade are reported in Table 12. The results for student level predictors given in Table 9 have already shown that Algebra I students could be predicted to score 0.17 standard deviations higher than students taking a general mathematics course. These findings of cross-level interaction between teacher variables and student enrollment in Algebra I suggest that any benefit students received from participation in an Algebra I course as an eighth grader was negated when the course was taught by an MSP teacher ( $\gamma_{41} = -0.12, p > .05$ ) although the results are not statistically significant. Furthermore, the cross-level interaction between teacher assignment stability and student participation in eighth grade Algebra I indicates that student achievement is slightly enhanced for every year that a teacher's assignment is consistent ( $\gamma_{42} = 0.06, p > .05$ ), although again these results are not statistically significant.

For this research question, teacher participation in the Cleveland MSP initiative and teacher assignment stability did not moderate significantly the achievement gap in

mathematics of students taking Algebra I in eighth grade than for those who take a general mathematics course in eighth grade.

Table 12

*HLM Results for Interaction between Teacher-Level Variables and Eighth Grade Student Algebra I Course Participation*

Teacher Characteristic	Coefficient	SE	t	p
Teacher MSP Participation, $\gamma_{41}$	-0.12	0.21	-0.562	.573
Assignment Stability, $\gamma_{42}$	0.06	0.04	1.630	.103
Mean Prior Achievement, $\gamma_{43}$	-0.18	0.13	-1.393	.164

\* $p < .05$

**Research Question 5:** To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability neutralize the impact of student absenteeism on mathematics achievement for sixth, seventh and eighth grade students?

The results for cross-level interactions of teacher-level variables and student attendance are reported in Table 13. None of the teacher level variables were statistically significant predictors of student mathematics achievement for grades six, seven or eight.

For this research question, teacher participation in the Cleveland MSP initiative and teacher assignment stability did not neutralize significantly the impact of student absenteeism on mathematics achievement for sixth, seventh and eighth grade students.

Table 13

*HLM Results for Interaction between Teacher-Level Variables and Middle Grades Student Absenteeism*

Teacher Characteristic	Coefficient	SE	t	p
Grade 6				
Teacher MSP Participation, $\gamma_{11}$	0.00	0.00	0.450	.652
Assignment Stability, $\gamma_{12}$	-0.00	0.00	-1.244	.214
Mean Prior Achievement, $\gamma_{13}$	0.00	0.00	0.047	.963
Grade 7				
Teacher MSP Participation, $\gamma_{11}$	-0.03	0.10	-0.318	.751
Assignment Stability, $\gamma_{12}$	-0.01	0.03	-0.426	.671
Mean Prior Achievement, $\gamma_{13}$	-0.01	0.06	-0.184	.854
Grade 8				
Teacher MSP Participation, $\gamma_{11}$	-0.01	0.00	-1.267	.208
Assignment Stability, $\gamma_{12}$	0.00	0.00	1.306	.195
Mean Prior Achievement, $\gamma_{13}$	-0.00	0.00	-0.929	.355

\* $p < .05$

**Research Question 6:** To what extent does teacher participation in the Cleveland MSP initiative and teacher assignment stability moderate the strength of relationship in student achievement for students who have increased instructional time in mathematics for sixth, seventh and eighth grade students?

Increasing instructional time in mathematics was examined against the teacher-level variables of teacher MSP participation and teacher assignment stability (see Table

14). Results indicate a statistically significant and positive relationship for teacher participation in the MSP and increased mathematics instructional time for sixth grade students ( $\gamma_{31} = 0.09, p < .05$ ).

Table 14

*HLM Results for Interaction between Teacher-Level and Increased Mathematics Instructional Time*

Teacher Characteristic	Coefficient	SE	t	p
<b>Grade 6</b>				
Teacher MSP Participation, $\gamma_{31}$	0.09	0.04	2.000	.045 *
Assignment Stability, $\gamma_{32}$	-0.04	0.05	-0.869	.385
Mean Prior Achievement, $\gamma_{33}$	0.05	0.13	0.386	.699
<b>Grade 7</b>				
Teacher MSP Participation, $\gamma_{31}$	0.23	0.13	1.696	.090
Assignment Stability, $\gamma_{32}$	-0.09	0.05	-1.818	.069
Mean Prior Achievement, $\gamma_{33}$	0.20	0.14	1.400	.162
<b>Grade 8</b>				
Teacher MSP Participation, $\gamma_{31}$	0.51	0.23	2.222	.028 *
Assignment Stability, $\gamma_{32}$	-0.09	0.05	-1.954	.053
Mean Prior Achievement, $\gamma_{33}$	-0.08	0.15	-0.515	.607

\* $p < .05$

Similarly, a statistically significant and positive relationship was found between teacher MSP participation and increase instructional time for eighth grade students ( $\gamma_{31} = 0.51, p < .05$ ). Therefore, it would seem that MSP teachers capitalized on increased instructional

time in mathematics for students than did non-MSP teachers. In addition, a negative, though not statistically significant relationship, was found for teacher assignment stability and additional instructional time in mathematics for eighth grade students ( $\gamma_{32} = -0.09, p = .053$ ). Neither of these variables was found to be statistically significant predictors at the seventh grade level.

For this research question, teacher participation in the Cleveland MSP initiative significantly and positively moderated the strength of relationship in student achievement for students who have increased instructional time in mathematics for grades six and eight but not for grade seven. Teacher assignment stability was significantly and negatively associated with student mathematics achievement in eighth grade for students who received additional instructional time.

#### Summary

This chapter served to present results for the empirical investigation. It included an examination of student level and teacher level variables to determine if certain characteristics were predictors of middle grades student mathematics achievement. This study also presented findings related to the presence or absence of interaction effects between student-level and teacher-level variables. Chapter 5 will discuss these findings and limitations of the investigation. It will also provide recommendations for further research.

## **CHAPTER V**

### **CONCLUSION**

This study sought to investigate the two factors of teacher participation in graduate level course taking in mathematics as well as the stability of teaching assignment and their relationship to student mathematics achievement. Its general aims explored the relationship between the student level variables, such as attendance, prior achievement, additional instructional time in mathematics and Algebra I course taking and the extent to which these factors were impacted in any way by the teachers' additional course taking in mathematics and the stability of their teaching assignment. This chapter will summarize the findings presented in chapter 4. This is followed by a discussion of the relationship between the two teacher factors of teacher content knowledge and stability of teaching assignment and middle grades student achievement in mathematics. In addition, limitations of the study and implications and recommendations for future research are outlined. Finally, concluding remarks are given.



## Summary of Findings

Heightened concerns over lower than expected student mathematics achievement have been at the forefront of educational policy in the United States for many years as international testing and reports from the National Research Council (2001) and the National Mathematics Advisory Panel (2008) have focused attention on the need for improving mathematics instruction. One source of poor student performance has been linked to deficits in the teachers' mathematical knowledge (Garet et al., 2010). As a result, teacher professional development focused on developing content knowledge has become an essential component for improving student mathematics achievement in the belief that it will lead to enhanced learning. To this end, the federal government has committed substantial funding for teacher professional development, particularly for teachers in mathematics and science. The MSP was one such initiative and received funding through the National Science Foundation for the purpose of teacher content knowledge enhancement in mathematics and science.

Furthermore, Marzano (2003) paints a picture of the relative impact of achievement differences by likening standard deviations in achievement scores to student learning time. This might provide a useful gauge when viewing the results of this study by offering practical benchmarks for interpretation. For example, according to Marzano, one standard deviation is roughly equivalent to about one calendar year of learning, and .4 of a standard deviation is equivalent to about five months of school. Contrast this with one year of normal maturation, holding all other factors constant, which has been benchmarked at about .17 of a standard deviation. On the surface one-tenth of a standard deviation might seem inconsequential until it is understood that this is roughly equivalent

to about five weeks, or 25 days of learning, and .7 of a standard deviation has been likened to one full academic year. Therefore, in examining the impact of teacher learning and the stability of teaching assignment, these factors can have a very large and real practical impact on student learning and achievement. Using these benchmarks, the findings of this study might not have statistical significance in many cases, but the practical implications cannot be ignored. Since findings from this study are in terms of standard deviations, the results also can be viewed for their practical significance in terms of Marzano's benchmarks.

The purpose of this study was to investigate the relationship between enhancing teacher content knowledge through participation in the Cleveland MSP and middle grades student mathematics achievement as measured by the Ohio Achievement Test in Mathematics (OAT-M) for 2007 using a multilevel analysis. In addition, the consistency of teaching assignment over a four-year period and the relationship to middle grades student mathematics achievement was investigated as it was considered an important mediating factor that influenced teacher instructional capacity and might have contributed to differences in student achievement. Thus, this study sought to address whether the main effect of teacher participation in the Cleveland MSP and teacher assignment stability could mitigate the impact of other teacher and student level factors.

### *Descriptive Summary*

Student-level data for this study included demographic information, descriptive statistics and test histories for over 7,000 middle grade students in the Cleveland Metropolitan School District in during the 2006-2007 academic year. The test history for each student listed the student scale scores for two test occasions in mathematics (Spring,

2006 and Spring 2007), one of which was used as the outcome variable and the other of which was used to control for prior achievement. The scale scores for these test occasions were converted to standard scores for use in analysis, which allowed interpretation of results on similar scales. In addition, data for student attendance, student participation in additional instructional time in mathematics and enrollment in eighth grade Algebra I were provided. When considering the student-level descriptive statistics, a few findings emerge across grade levels. First, the mean number of days for student attendance (between 156 to 160 days) was about three weeks below the 174 days for an academic year.<sup>12</sup> When considering that a semester in the school year is about 18 weeks, CMSD students were found to be absent from school an average of about one-sixth of an academic semester. A second finding that emerges in the student descriptive data is that the prior achievement scores (OAT-M 2006) are from two-thirds to three-fourths of a standard deviation below the state mean. This pattern seems to hold for the OAT-M 2007 scores used as the outcome in this study. Again, the mean CMSD student achievement was about two-thirds to four-fifths of a standard deviation below the mean.

Teacher-level variables for this study included demographic information and descriptive statistics, teacher participation in the MSP program, data regarding the consistency of teaching assignment and the mean prior achievement for the group of students assigned to each teacher. This last variable was an aggregate of the prior achievement for each student and was used to control for disparities in the prior achievement for students of MSP teachers compared to students of nonMSP teachers. When considering the teacher descriptive information, a few findings emerge. First, the majority of teachers (over 60%) were not MSP participants. This unequal grouping for

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<sup>12</sup> This is considering a week to be 5 school days.

the MSP participation variable led to the decision to weight the MSP participation variable in order to simulate equal representation in the sample. Second, the mean stability of teaching assignment across grade levels was about two years. This means that on average, teachers were in their second year of teaching middle grades mathematics, indicating that their prior assignments had been either in another content area or at another grade level altogether over the four-year period. Third, the mean prior achievement on average across grade levels was around three-fourths of a standard deviation below the state mean.

#### *Summary of Two-Level HLM*

A two-level HLM was used to determine the extent to which individual student-level and teacher-level variables could predict student achievement on the 2007 Ohio Achievement for middle grades students, including main effects for student-level and teacher-level variables, as well as cross-level interactions. The findings show that student prior achievement and attendance were significant predictors of student achievement on the 2007 OAT-M for grades six, seven and eight. However, neither additional instructional time nor Algebra I course-taking were significant predictors of student achievement. These represent the intercept and slopes for student main effects.

The main effect for MSP participation was a significant negative predictor of student achievement for OAT-M for 2007 for sixth grade but not for seventh or eighth grades. Stability of teaching assignment was a significant positive predictor of student achievement on the OAT-M for 2007 for sixth grade but not for seventh or eighth grades. In addition, classroom mean prior achievement was a significant positive predictor for eighth grade. The cross-level interactions for teacher MSP participation and student prior

achievement were not significant predictors at any of the three grade levels. However, the cross-level interaction for classroom mean prior achievement and student prior achievement was a significant positive predictor for seventh grade and is associated with widening the gap between student prior and current achievement. The cross-level interaction between teacher MSP participation, stability of teaching assignment and student Algebra I course-taking were not significant predictors of student achievement on the 2007 OAT-M for eighth grade. Neither were these same predictors for the cross-level interaction between the teacher variables and student absenteeism. Teacher MSP participation and additional instructional time were significant positive predictors for sixth and eighth grades and are associated with widening the gap in achievement between students who had increased time and those who did not. Finally, the cross-level interaction for teacher assignment stability and student additional instructional time was a significant negative predictor of student achievement and is associated with narrowing the gap in achievement between students who had increased time and those who did not.

## Discussion

The following discussion addresses the study findings, including unexpected results that deserve attention. Interpretation of the results are offered through a contextual lens that places the results within the study's setting, including those factors which are believed to have contributed to triumphs in learning or created barriers to success.

### *Student Main Effects*

The student level variables of prior achievement and student attendance were expected to be significant predictors of student mathematics achievement as suggested by extant literature (Gottfried, 2009; Nye, Konstantopoulos, & Hedges, 2004; Wayne &

Youngs, 2003) and these were found to be consistent with past research. In addition, based on prior literature, it was expected that student enrollment in an accelerated mathematics course (Algebra I in eighth grade) would be a statistically significant and positive predictor of student mathematics achievement.

*Prior achievement and attendance.* It is no surprise that a student's prior knowledge and achievement has a strong impact on a student's current achievement. Likewise, a student's attendance also is linked to the level of student achievement. These two factors at least partially comprise a student's pedagogical capital and carry with them the weight of the student's prior educational experiences – or lack of experiences (Livingston, 2009). Wayne and Youngs (2003) state that a student's prior test score captures the effects of all previous educational experiences. This view is also held by Nye, Konstantopoulos and Hedges (2004). In other words, students who struggle in school usually continue to struggle in school, and students whose attendance is erratic usually perform poorly on achievement tests. Results from this study support findings related to these two predictors.

*Algebra I.* Both the National Research Council (2001) and the National Mathematics Advisory Panel (2008) called attention to U.S. student achievement in mathematics, and both strongly suggest that all students learn algebra by the end of eighth grade (Garet et al., 2010). Research that examined student participation in an Algebra I course as eighth graders has suggested that participation in an Algebra I course proved beneficial to students (Riegle-Crumb, 2006; Spielhagen, 2006a, 2006b). However, results from this study demonstrate otherwise. This might have occurred for a few reasons.

First, at the time of this study, no consistent criteria existed across the schools in the district for assigning students to Algebra I instead of a general mathematics course. Therefore, many students were scheduled inappropriately in Algebra I classes for which they had not obtained the prerequisite knowledge. Examination of the data set for Algebra I students showed prior achievement scores ranging from a 331 scale score, a score in the limited category on the OAT-M and -3.27 standard deviations below the mean, to a 488 scale score, a score in the advanced level on the OAT-M and 2.46 standard deviations above the mean. This wide range of students' performance scores for those enrolled in the Algebra I course indicates that there was a the lack of consistent criteria being used for scheduling students into this course and also indicates the degree to which some students were underprepared for this course. The converse also was true in the general mathematics course where students who had scored in the accelerated range on the OAT-M in seventh grade were not provided the opportunity to engage in an Algebra I curriculum in eighth grade. Student prior achievement data revealed that 4% of eighth grade students who had scored accelerated or above on the OAT-M for 2006 (.86 to 2.29 standard deviations above the state mean) were not scheduled for the Algebra I course and instead were enrolled in a general mathematics course.

Second, students enrolled in the Algebra I course were lacking in background knowledge and experience necessary to be successful in an Algebra I curriculum because preparatory courses were not available in the sixth and seventh grades. The state of Ohio suggests that districts providing accelerated coursework options for middle school students that allow them to take Algebra I in the eighth grade ensure that the three-year middle grades mathematics curriculum be condensed into the years prior to enrollment in

an accelerated option. ODE policy language regarding the eighth grade Algebra I option states

Some students may have the ability to study the Year 1 course in 8<sup>th</sup> grade if the curriculum has been modified to assure they have studied all topics of the middle school curriculum before grade 8. Because the Ohio Academic Content Standards in Mathematics identify new topics to be introduced in each of the middle grades, no mathematics course can simply be skipped. Students with the potential to be accelerated will need to be identified by the teaching staff and by readiness tests, and have their curriculum appropriately modified in the grades prior to grade 8 (Ohio Department of Education, 2007, p. 8).

However, the 2006-2007 academic year was the first year of eighth grade Algebra I courses in almost all schools across the district. In the years leading up to this point, the curriculum had not been modified and so students did not have access to the entire middle school curriculum before their Algebra I enrollment.

Third, placement and course preparation could have impacted the resulting OAT scores for Algebra I students because the curriculum taught was not the curriculum assessed. Therefore, those who participated in the Algebra I course were tested on content other than what they had learned in the curriculum. The eighth grade state achievement test measures topics required in the eighth grade general mathematics curriculum standards. These standards span a wider variety of general mathematics content than those required in the Algebra I curriculum. According to state testing blueprints, less than one fourth of the OAT-M for eighth grade assesses Algebra topics. Therefore, students in the Algebra I course would not have had full preparation for the eighth grade OAT-M unless provided additional instructional periods. Since there was no Algebra I course examination specifically for eighth grade students, the results would not have accurately measured the content that Algebra I students would have learned.



*Additional instructional time.* Additional instructional time in mathematics also was expected to be a significant predictor of student achievement. As cited in the literature review, consistent positive links have been found between student achievement and increased instructional time (Hossler, Stage, & Gallagher, 1988; Winn, Menlove, & Zsiray, 1997). However, results from this study contradict existing literature related to additional instructional time. Examination of the original data set offered some possible insights to this seeming contradiction.

First, a consistent criteria for determining student placement in an additional mathematics course was not in place across schools. Students assigned to additional instructional time in mathematics had a large and varied range of prior achievement test scores. This variety occurred at all three grade levels. Furthermore, the data suggests that student assignment to additional instructional time was random because the discontinuity of assignment occurred “within the teacher”; that is, when looking at the data for a particular teacher, for example, some of the teachers’ students were assigned additional instructional time and some were not. From examination of the data, it does not appear that the additional time was based on prior achievement scores, which would have given those who scored lowest additional time to learn or those who scored highest extended opportunities to learn.

Second, there were differences in which teachers taught the additional instructional time in mathematics for students. In some cases, the students’ regular course mathematics teacher also taught the additional mathematics course and so had his or her own students. In other cases, the additional mathematics course teacher was a teacher different from the regular mathematics course teacher. The additional instructional time

would be more seamless if both courses were taught by the same teacher. Therefore, this begs the question of how additional mathematics instructional time was structured for students in the middle grades.

Third, the additional mathematics courses did not have a prescribed curriculum across the district or even within a school. For example, some Algebra I students were also assigned to an eighth grade general mathematics course in addition to their Algebra I course. Their additional instructional time consisted of two distinct courses with a set curriculum. This structure also ensured that the students whose courses were assigned in this way had the opportunity to learn the general mathematics curriculum for eighth grade (which is the tested curriculum) while engaging in accelerated study at the same time. However, in the majority of cases where Algebra I students were assigned additional instructional time, the students were assigned to a course called “Math Proficiency.” Unlike the aforementioned situation where both courses had defined curricula, the Math Proficiency course had no defined curriculum and was not standardized across the district. This description was the same at all three grade levels for the Math Proficiency course. Therefore, teachers were left to create their own learning targets and gather resources for the course. While Clark & Linn (2003) have found that “decreasing instructional time is strongly and significantly related to diminishing student knowledge integration around complex concepts” (p. 451), Walberg (1988) stated that simply increasing allocated instructional time will not automatically lead to increased student achievement (Berliner, 1990; Nelson, 1990).

### *Teacher Main Effects*

It also was expected that teacher participation in the MSP would be associated with increased student achievement. This expectation was based on prior research and policy emphases that stress content knowledge background as the most important teacher indicator of increased student achievement. Based on the results of this study, the HLM analysis did not support this expectation as no statistical significance was found to link student mathematics achievement solely to graduate mathematics course-taking for middle grades teachers.

*MSP participation.* MSP participation was significantly associated with student achievement for sixth grade teachers, but not for seventh and eighth grade teachers, and at all three grade levels, the association was negative. However, it is possible that the positive effects of the MSP initiative might be realized in the future. Previously cited research on lagged effects of teacher learning and professional development suggests that the effects of teacher learning might be curvilinear and therefore become increasingly apparent about three years after participating in coursework and professional development (Harris & Sass, 2007; Monk, 1994; Monk & King, 1994; Wayne & Youngs, 2003). Since the first cohort of MSP teachers finished in 2004 with other cohorts following yearly, the influence of the MSP initiative might still have not come to full impact at the time of this study.

*Assignment stability.* A second factor expected to produce statistically significant results was the stability of teaching assignment. Results from this study indicate that teaching assignment stability was significantly and positively associated with improved student achievement for sixth grade teachers, but not for seventh or eighth grade.

Significance for sixth grade teachers might be explained by the previous teaching assignments and demands of the curriculum and standards compared to lower grade levels where some of them had previously been assigned. Examining the data set revealed first that nearly three-fourths of all sixth grade teachers (71%) were new to their assignment or had one years experience at the sixth grade level. Furthermore, the teachers with the least stable teaching assignments previously had been assigned to teach lower grade levels, some of them at a primary grade level much lower than their current assignment. Conversely, students of the 29% of teachers whose assignment had not changed for at least three of the four years in the data, most of whom were MSP teachers, found the greatest increases in achievement scores. In light of the curricular demands placed on middle school teachers, which require increased application of mathematical ideas and more abstract thinking, it is no wonder that a teacher new to the assignment would have difficulty, particularly if the teacher did not have a firm grasp of the content and its many connections and applications.

Teacher mobility provides another possible explanation for sixth grade teachers' significant results but not for seventh or eighth grade teachers. In about half the cases (56%), although the seventh and eighth grade teachers had been assigned to teach middle school mathematics in prior years, it was not in the same building. Thus, teachers were transferred due to low student enrollment or the need to satisfy content area demands due to HQT regulations. As a result, teacher mobility was a particular problem during the 2006-2007 academic year as teachers were reassigned to schools in order to offer the Algebra I course. In addition, a number of teachers who were re-assigned were MSP

teachers since they met the need for licensed teachers.<sup>13</sup> Thus, teacher mobility seems to be an explanatory factor.

*Mean prior achievement.* Finally, the mean prior achievement for students grouped by teacher was positively and significantly associated with student achievement for eighth grade teachers but not for sixth or seventh grade teachers. Grouping into different mathematics courses (general mathematics or Algebra I) provides a possible explanation for this occurrence in eighth grade results but not for the findings at other grade levels since the mean of student scores per teacher for Algebra I were, in general, higher than they were for general mathematics.

#### *Interactions between Student and Teacher Variables*

*Prior achievement and teacher factors.* Findings for the interaction between teacher participation in the MSP and the relationship between student prior and current achievement showed that the associations were negative and not significant at any of the three grade levels. As stated previously, in general MSP teachers were not assigned students who were well prepared with strong background knowledge in mathematics as evidenced by the data. This would suggest that MSP participation does not explain the relationship between student prior and current achievement and that the relationship between past and current achievement was constant as students who did poorly continued to do poorly, and students who did well continue to do well.

Likewise, teacher assignment stability was not found to moderate the strength of relationship significantly for prior and current student achievement at any grade level.

This would suggest that the stability of teaching assignment does not influence the

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<sup>13</sup> As a result of the MSP program, teachers were licensed in middle school mathematics or science as a result of program participation after passing the Praxis II examination.

strength or direction of relationship between the educational experiences that students bring with them into a classroom and their current achievement.

However, the mean prior achievement for seventh grade showed a significant and positive association between student prior and current achievement. This would indicate that increases in mean prior achievement were able to enhance the relationship between student prior and current achievement for seventh grade. This interaction is difficult to interpret in light of the available data. One interpretation of these findings could be that students who were members of classes where the mathematics learning was more rigorous benefited from this association. Although the results were not significant for sixth or eighth grades, the associations for those grade levels were also positive.

*Algebra I and teacher factors.* Findings for the interaction between teacher level characteristics and course-taking in eighth grade (either Algebra I or general mathematics) resulted in no significant associations for any of the teacher-level variables. The interaction between teacher MSP participation and student Algebra I course-taking indicated a negative but not a significant association.<sup>14</sup> Examining the teacher data showed that teachers who were not MSP teachers (i.e., high school licensed teachers), in general, had more beneficial assignments than MSP teachers as indicated by the mean prior achievement per teacher data. In fact, for Algebra I, 42% of MSP teachers had students whose prior achievement was below the proficient level on the OAT-M compared to 23% of high school teachers and the high school teachers were assigned students who qualified as gifted or talented. Similarly, for MSP teachers whose students took general mathematics, student mean prior achievement was below that of nonMSP

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<sup>14</sup> It should be noted that teachers who taught Algebra I were either licensed in mathematics for middle school or high school. The majority of middle grades licensed mathematics teachers (94%) were MSP teachers as a direct result of their participation in the initiative.

teachers. This finding was contrary to popular policy practices and beliefs which assume that a high school license, and therefore the ability of the teacher to teach mathematics, is superior to a middle school license. Initial model building did, in fact, return results that indicated a significant and negative association between MSP participation and student achievement. However, this was before controlling for mean prior achievement. When this factor was added to the model as a control for prior student achievement variability, the results were no longer statistically significant. Thus the results show that students who have a high school licensed mathematics teacher perform no better than those who have a middle school licensed mathematics teacher.

The interaction between eighth grade course-taking options (Algebra I or general mathematics) and teaching assignment stability also was positive but not significant in association. This would suggest that the achievement gap between students who take general mathematics and those who take Algebra I is relatively constant and therefore not influenced by the stability of the teaching assignment.

*Student attendance and teacher factors.* The results for interaction between teacher characteristics and student attendance showed results that were not unexpected. For all teacher characteristics at all three grade levels, there were no significant results. This makes sense since a teacher cannot have great impact on students who are not attending school.

*Additional instructional time and teacher factors.* Findings for the interaction of teacher characteristics and additional instructional time in mathematics provided interesting results.

For MSP participation, the findings were significant and positive for sixth and eighth grades indicating that MSP teachers were able to enhance the impact of additional instructional time for their students. As had been stated previously, the sixth grade teachers with the most consistent teaching assignment were MSP teachers. This could have contributed to the significant results for sixth grade teachers and students. In addition, a number of students of MSP teachers were assigned to a mathematics proficiency class, which the MSP teacher taught. Therefore, many students had additional instructional time with their core mathematics teacher. The results for seventh grade, though not significant, were also positive. This indicates a consistent relationship between the interaction of MSP teacher participation and additional instructional time for students. Research shows that increased instructional time has been identified as one of the factors that leads to increased student achievement. However, it is what is done with this time that makes the difference (Walberg, 1988). The positive effect of additional instructional time in the presence of an MSP teacher might be explained by the instructional focus of the MSP programs. The coursework developed content that was of particular importance for middle school students. Within the courses, attention was devoted to connections within and beyond the mathematics topics of study. As a result, MSP teachers might have been better prepared to uncover the prior knowledge of their students, provide strategic interventions to help close gaps in learning and extend topics where necessary.

The performance gap narrowed for students who had additional instructional time and whose teachers had more stable teaching assignments. This was especially true for eighth grade students. The interaction between teacher assignment stability and additional



instructional time yielded negative results, and although the eighth grade results were not statistically significant, this was marginally the case. This closing of the performance gap between those students who have additional instructional time and those who do not as their teacher's assignment becomes more consistent suggests that teachers are much better prepared to extend or enhance the learning of their students when they are not subject to chaotic staffing decisions. This allows them to focus on the needs of their students.

### Limitations of the Study

Killion (2002) observed that "Because schools and districts are complex social systems, and student learning results from innumerable factors, black box evaluations are not sensitive to unanticipated contextual or organizational factors that may influence results" (p. 26). The interpretation and discussion of results from this study considered the following limitations:

1. The student population included in this study was a convenience sample drawn from sixth, seventh and eighth-grade students in a Midwestern urban district during the 2006 – 2007 school year. The original data set included records for all district students. However, some cases were not included in the study analysis due to missing or incomplete data.
2. The teacher population considered also was a convenience sample drawn from middle school teachers of mathematics during the 2006 – 2007 school year. Teachers were not randomly selected for this study. Some teacher cases were not included in the analysis due to missing or incomplete data. This also meant that data for students linked to that teacher could not be included in the analysis.

3. Teachers self-selected participation in the MSP. Because their participation was voluntary, the teachers may not be representative of the general teaching population. Voluntary participation should be considered a confounding variable. The motivation to participate in the MSP may be one of a desire for professional growth, or it may reflect the teacher's desire to protect his or her job since mathematics and science teachers were excluded from layoff during this time period.
4. Information on teacher experience only reflected the number of years in the district although some teachers may have had additional teaching experience outside the district. This variable was not included in the analysis because it could reflect only the number of years of district experience.
5. Limiting the study to the populations mentioned decreased the possibility of generalization. Therefore, results were not generalized to other grades, contexts or content areas.
6. Social factors that influence learning and achievement of middle school students, such as motivation, classroom and school climate, peer relations, etc., were outside the scope of this research, as were content areas other than mathematics and grade levels other than those commonly regarded as middle grades (grades six through eight).
7. The study did not incorporate some mediating and moderating student level variables that may be associated with student achievement in mathematics, such as gender, ethnicity, identification in special learning situations (i.e., gifted and talented, specific learning disabled, English language learner, etc.), student

participation in extra help session in mathematics, etc., which might have had an effect on the student achievement results.

8. Relevant teacher-level variables were included in the study as the data permitted. However, accessible data are always subject to the reporting mechanisms in place. For example, data for this study on teacher experience could only include the years of experience in the school district since information about prior teaching experience was not recorded in the teacher data files. In addition, teacher mobility information was not available which might have contributed to the study results. Therefore, some teacher characteristics that might relate to student results were not available for analysis.
9. Since this study collected and analyzed historical data, it was not possible to collect data on instruction. Clearly, many other factors besides teacher knowledge affect student learning.
10. Likewise, information regarding other professional development experiences in which teachers might have engaged was not available. Therefore, this might have influenced the study results.

#### Implications for Practice

This study supports prior research that contends teacher content knowledge by itself is not enough to increase student achievement. Student success pivots on whether a teacher has both content knowledge and an understanding of content-specific pedagogy. NCLB (107th U.S. Congress, 2002) requires that all classrooms must be staffed with highly qualified teachers, defined as a teacher who has full certification or licensure, a college degree, and demonstrated content mastery of the subject he or she teaches. This

definition emphasizes content knowledge, but does not require evidence of other components of teaching effectiveness, such as good pedagogy. Therefore, in light of this study's findings, the following recommendations for practice are offered.

1. As policy makers nationwide continue to focus on the implication of NCLB, educational accountability, and how to assist teachers in learning increasingly sophisticated research-based methods of teaching, it is imperative that they understand which teacher and student variables will foster student mathematic success.
2. To assure students receive a high-quality teaching environment, states must be required to implement a comprehensive teacher professional development system based on the balance between teacher content knowledge and content-specific pedagogy.
3. Middle grades teachers who have content preparation in mathematics should be assigned to teach middle grades mathematics courses in order to ensure that all students have opportunities to access a more rigorous course of study.
4. Teaching assignment should remain as consistent as possible from year to year. Administrators should make every effort to provide stability for teachers rather than randomly changing their assignments from year to year, and sometimes even within an academic year.
5. Recognizing that union policies and negotiated contracts also contribute to staffing decisions, more flexibility between both administration and union personnel would be helpful in working out union-management agreements that

would ensure greater teacher assignment stability during times of layoff so that all teachers are placed in positions that best suit their skills and experience.

6. When teacher are re-assigned to a new grade level or content area, every effort should be made to provide the teacher with additional support so that the impact of change is buffered for the students.
7. District practices and policies should design frameworks that identify students who might benefit from taking an Algebra I course in eighth grade earlier in their middle grades schooling so that they have access to the full middle grades curriculum prior to participation in advanced courses.
8. The aforementioned practices should also make certain that the placement of students into advanced courses guarantees that students have the prior preparation to access fully more rigorous and abstract content demands.
9. District practices and policies also should provide for intensive and appropriate support for students who are struggling to meet curricular demands.
10. Additional instructional time should be structured in ways that provide students more time to learn content or opportunities to extend the content, and courses that offer additional instructional time should have a coherent curriculum across the district that is aligned to state standards.
11. Colleges and universities offering mathematics coursework for educators should provide instruction modeling the mathematics pedagogy that is consistent with best practices in mathematics instruction. Too often, these courses are delivered using a transmission mode of instruction. This only ensures that, instructionally speaking, we will continue to get what we have always gotten.

12. According to Johnson (2002), “changing content and performance standards without fundamentally transforming educators’ practices, processes, and relationships cannot lead to success” (p. 11). Therefore, emphasis also should be given to providing more time for teachers to learn appropriate and research-based pedagogical practices in mathematics.
13. Professional development for teachers should be job-embedded and sustained over time. Furthermore, opportunities for teacher learning should be collaborative in nature, focusing on formative assessment to inform instructional practices that produce the intended learning. Therefore, teachers should be afforded time for collaboration to study student learning in light of their instructional practices.
14. Finally, results from this study provide evidence to local, state and federal school administrators that piecemeal teacher professional development policies and mandates not connected to research can be unproductive in raising student achievement and provide roadblocks to successful teaching and learning. A better approach may be a more comprehensive program that aligns research, policies, and incentives for recruitment, certification, preparation, and professional development.

#### Recommendations for Further Research

The following suggestions offer recommendations for further research based on this study that might provide greater insights into the findings.

1. Further research should use student subscale scores from the pre- and post-test occasions. This would allow an examination of specific content strands (e.g., Geometry, Data Analysis, etc.) to see if there were improvements in some strands

over others (e.g., did Algebra I students perform significantly better in the Algebra strand than general mathematics students).

2. Based on the literature that suggests lagged effects for teacher learning and professional development, research should investigate teacher MSP participation by cohort and the relationship to student achievement. This would allow a determination if lagged effect occurred.
3. Further research could also incorporate responses to teacher survey information that might provide additional insights around instructional, curricular and contextual challenges that impede high quality instruction.
4. Additional explanation around findings of this study could be illuminated by including school level factors that impact teachers and students, especially factors of administration and leadership qualities.
5. Recruitment of teachers from rural or suburban school environments could help to determine if the same results as occurred in this study hold true. This would allow results to be more generalizable to other contexts.
6. Application of this study to other grade levels (e.g., primary, elementary, high school, college) could offer comparative information and expand the ability to generalize findings.
7. This study could be enhanced by including information for certain subgroups (e.g., Specific Learning Disabled, English Language Learners and Gifted and Talented) to determine if the results from this study could be further enlightened in the presence or absence of these characteristics.

8. Determination of increases in teacher content knowledge should use other ways to determine if changes had occurred rather than relying on proxies.
9. Further study should incorporate a mixed methods approach that would include qualitative and quantitative data. Measures that include observational data from the classroom, teacher survey, student survey, administration survey, etc. would lend more information and provide a more balanced view related to the study goals.
10. Longitudinal studies that follow students through their educational years and link teachers across years would provide growth information. In particular, linking students to their teachers for each year would allow examination of cumulative effects of teaching. This would allow us to see if students who had MSP teachers over years did better than those who did not.
11. Another avenue for further research could examine the synchronicity between teacher and student ethnicity and/or gender and its relationship to student achievement.
12. Finally, examining school level variables (e.g., school climate, policies, leadership, etc.) and how they impact teacher effects and student achievement, which would require a three-level model, would provide information related to the interaction between these three groups and the contributions to student achievement attributable to teachers and schools.

### Conclusion

Although NCLB has at its heart noble aspirations for America's children, there is no magic formula that has produced the desired results – all students achieving at high



levels; and mathematics remains a particular challenge. Determining ways to measure student achievement is difficult as the measures used do not always measure the instruction and learning that students have received and the growth they have made. In addition, quantifying student learning using singular measures can only assess status at one point in time in one particular context. The student level test measures should be viewed in this light, especially when interpreting the association between student achievement and teacher learning. Therefore, research should continue to seek ways to determine best measures that inform the interaction between teacher and student learning more reliably.

A large body of research provides strong evidence that quality teaching is thought to be the single most important factor impacting student learning over time. However, determining the characteristics of an effective high quality teacher has proven challenging as researchers continue to find ways to determine the link between teacher characteristics and student achievement. Most recently, research has focused on the ways that teachers learn mathematics for teaching. This focus requires a shift in the commonly held notions of the mathematics that teachers must know for quality instruction. On-going teacher learning is imperative if students are to have access to the best instruction. However, this means that the professional learning opportunities designed for teachers need to be high quality experiences that allow them to raise the educational bar for all students and provide them with strong pedagogical capital that will sustain them throughout their lives. Helping teachers change their thinking and practices is a difficult task. Improving teacher quality is critical to low-income, urban schools. Developing a

community of learners holds great promise for urban schools to improve professional practice and ultimately increase student achievement.

While the results of this study do not show conclusively that the MSP benefited students according to the measures used (OAT-M), there was a practical benefit for students that will be apparent in the future – the benefit of pedagogical capital, those experiences that students will bring with them to future courses that will enhance their readiness to learn new content or enhance what already has been learned (Livingston, 2009). As an indirect result of the teachers' MSP experience students were afforded greater opportunities to learn as a door was opened for students to participate in more challenging mathematics courses in their future high school work thereby creating prospects to study for careers that otherwise would not have been an option. Prior to the MSP, a handful of fortunate students were identified for advanced course-taking, placing all other students on a lower footing in relation to their peers. Access was not there for these latter-mentioned students even to attempt Algebra I since it was not offered at their schools. Since the MSP, almost every district school offers an Algebra I course option, allowing students to take the course for high school credit and thus allowing them the opportunity to take advanced level math classes in high school. Hopefully, this ripple effect will be seen at the university level with students enrolled and succeeding in more challenging mathematics courses.

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