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A Two-Level Hierarchical Linear Model Analysis of the Relationship Between Sustained, Targeted Professional Development for Teachers and Student Achievement in Mathematics

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A TWO-LEVEL HIERARCHICAL LINEAR MODEL ANALYSIS OF THE RELATIONSHIP BETWEEN SUSTAINED, TARGETED PROFESSIONAL DEVELOPMENT FOR TEACHERS AND STUDENT ACHIEVEMENT IN MATHEMATICS

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Signature page

DEDICATION

This dissertation is dedicated to my children, Holly and Nicholas. They have made me so proud to be their mother, for they are truly the best part of me.

Holly is my "save the world" child. Her social conscience and determination to help those most in need is inspiring. She has a love for learning that encouraged me to complete this journey, and I know it will take her far in life as a psychologist dedicated to supporting others as they navigate the pathways of their lives.

Nick is my "protect the world" child. His desire to uphold the law, serve the public trust, and secure the safety of others has inspired me to live a better, safer life. His easy going nature and love of life has helped me understand that there is a whole world out there to explore and the time to get started on that is now!

I am blessed in that my children are intelligent, ethical, strong, caring adults that I know will always be there to support me in more ways than I will ever realize. I am only too happy to do the same for them in return.

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My journey would have been much more difficult, frustrating and lonely without the support and encouragement of my co-workers and friends. I am grateful to Nancy Burce and Jamie Milne for all their help with retrieving teacher data, securing teacher consent forms and surveys, working with Excel spreadsheets and Microsoft Word

documents, and essentially for offering me support and empathy when roadblocks were placed in my way. They helped me stay focused and work through my stress.

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A special debt of gratitude must be extended to the data contact personnel in the school districts involved in my study. Through their perseverance and diligence I was able to retrieve student test history data and maintain the linkage of students to their mathematics teacher of record. This was no easy feat and I deeply appreciate their efforts above and beyond what would normally be expected of them in their jobs.

Finally, my sincere thanks go to Kathy Manning, my friend and colleague, for words of encouragement during my times of stress. Her guidance during this process helped me keep the finish line in sight.

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ABSTRACT

ANNA MARIA TABERNIK

The *No Child Left Behind Ac*t (NCLB) of 2001 put in place sweeping educational reforms targeted to raise school accountability for student achievement. Research has confirmed there is a distinct relationship between quality instruction and student learning, so one by-product of this reform movement is to provide every student with a high quality teacher, every year, in every classroom. This presents a challenge to school districts where teachers may not have the training and content knowledge necessary to raise the bar for students.

Professional development has long been a routine service provided by school districts. In Ohio, however, with school funding dependent on property taxes determined by voter approval of school levies, budgets have gotten tighter. Therefore, districts are often forced to choose between funding professional development to improve student achievement and funding other basic programs.

An analysis of variance and Level-2 hierarchical linear models were used to explore the relationship between teacher participation in targeted, sustained professional development in mathematics and student performance on the Ohio Achievement Test for Mathematics (OATM). Sixty-nine teachers were selected for this study from those who

had participated in professional development through the SMART Consortium between June, 2004 and April, 2007. Over 4,100 OATM test histories were retrieved for students of the selected teachers.

Results indicated there was a positive relationship between teacher participation in sustained, targeted professional development and student achievement on the OATM. Teacher participation in a minimum of 90 hours of professional development, years of experience, and certification in mathematics were all significant predictors of student performance on the 2007 OATM. Teacher participation in professional development and teacher certification in mathematics were associated with a narrowing of the gap between male and female students with regard to level of improvement in student performance on the OATM from 2006 to 2007. Finally, teacher background in mathematics was associated with a narrowing of the minority achievement gap with regard to level of improvement in scores over the two year period. Professional development, as shown in this study, can serve to enhance teacher characteristics, adding value to student learning and supporting increased student achievement.

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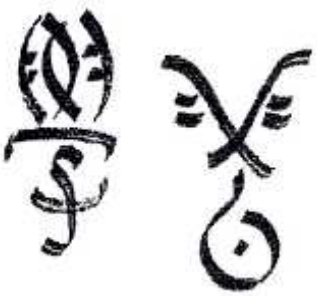
LEARNING

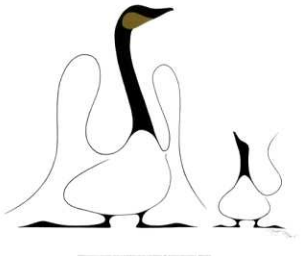
These Chinese characters represent the word “learning”.



The first character means *to study*. It is composed of two parts: a symbol that means *to accumulate knowledge*, above the symbol for a child in a doorway. The second character means *to practice constantly*, and it shows a bird developing the ability to leave the nest. The upper symbol represents flying; the lower symbol, youth. For the Asian mind, learning is ongoing. *Study* and *practice constantly*, together suggest that learning should mean: “mastery of the way of self-improvement”. The roots of the English word for learning suggest that it once held a similar meaning. It originated with the Indo-European word *leis*, a noun meaning *track* or *furrow*. To *learn* came to mean gaining experience by following a track – presumably for a lifetime.

- Senge, P., Kleiner, A., Roberts, C., Ross, R., & Smith, B. (1994)

The Fifth Discipline Fieldbook (p. 49)



"**Learning**"- Benjamin Chee Chee

CHAPTER I

INTRODUCTION AND PURPOSE

Introduction

Teaching has long been viewed as a very noble profession. Individuals invest years in learning subject area content, studying instructional pedagogy, understanding the teaching/learning cycle, and preparing to enter the profession with confidence. New teachers learn more on the job than they ever picked up in college, and begin to realize that there is so much more to learn. They learn from their students, from their colleagues, from the parents, from society, and from themselves. This continuous learning might take place in the classroom, in a graduate course, through an on-line course, in a chat room, through a blog, via distance learning, or through lesson study. Since the primary outcome of teaching is student learning it is essential that teachers continue to learn themselves, stay current in their subject area(s) and grow as professionals. The hope is that the more a teacher learns about his/her subject matter, about learning, about teaching, and about student thinking, the greater his/her effect will be on student achievement. Roland Barth (2000) supports this train of thought saying: "A teacher who has stopped learning cannot create a classroom climate rich in learning for students." School districts and state departments of education have long believed it was in the best interest of

students to provide teachers with these opportunities to learn, so they were willing to invest heavily in promoting life-long learning for teachers. Most would agree with researchers that teachers are the critical element in promoting student achievement (Garet, Porter, Desimone, Birman, & Kwang, 2001; Shaha, Lewis, O'Donnell, & Brown, 2004; Wenglinsky, 2000).

Teachers are often invited and sometimes required to participate in an endless array of professional development opportunities during the span of their career (National Center for Education Statistics [NCES], 2006; Parsad, Lewis, & Farris, 2001). Professional development is defined by Smylie, Allensworth, Greenberg, Harris, & Luppescu (2001), as formal learning opportunities provided to teachers to improve their knowledge, skills, and classroom practices. The term is often used interchangeably with the terms staff development, in-service, and training. Some school districts refer to these opportunities as in-service, some call them staff development sessions, while others call them workshops or training seminars. Regardless of what the opportunities are called, helping teachers refine their skills to increase their effectiveness in the classroom, to grow intellectually as well as professionally, and to continue to be lifelong learners is often seen as a district responsibility.

The world changes so quickly that there is always something new to discover and assimilate every day. The Campaign for Learning, an initiative sponsored by an advocacy group that believes that every person understands and values learning, that lifelong learning is every person's right, and that every person should have the chance to learn throughout their lifetime, supports the concept of lifelong learning. The thought is that everyone can take advantage of learning opportunities at any age and in any context.

Their website, (http://www.campaign-for-learning.org.uk), lists the following statistics in support of continual learning:

> 93% of us believe that it's never too late to learn.
> 83% of us believe that learning will become more important in the next millennium.
> 72% of us think we should devote more time to personal development.
> 95% of people think that learning about new things boosts your confidence. (National Adult Learning Survey, DfEE, 1998)
> 92% of people think that learning about new things is enjoyable. (National Adult Learning Survey, DfEE, 1998)
> Seven in ten adults (71%) think that learning can lead to a better quality of life. (Attitudes to Learning, Campaign for Learning/MORI, 1996)

Teachers have always been ready to take in new ideas to see where the ideas might fit into their personal scheme of things, but most honestly can't say they always welcome professional development opportunities. Many teachers dread going to in-service sessions in their school districts because they believe the content of these sessions is going to be repetitive, boring, or even irrelevant to their teaching life. It is difficult for teachers to see how some topics might lead to improved instruction and make a difference for their students. If teachers aren't engaged in a professional development session it's easy to find a myriad of other things to do while in attendance such as grading papers, writing lesson plans, daydreaming or even talking to colleagues. When a workshop focuses on subject area content and provides teachers with opportunities for active learning, however, they generally perk up and realize how participation can be a real benefit to them and their students.

Many teachers shared this same skepticism about the value of participating in professional development activities back in the seventies and eighties. Now, over twenty-five years later, the same holds true. Sparks (2002) found "…for far too many teachers, staff development is demeaning and mind-numbing as they passively 'sit and

get' the wisdom of 'experts'. It is often mandatory, as driven by seat-time requirements such as continuing education units, and evaluated by *happiness scales*" (p. 2). In 2005 the NCLB Task Force of the National Staff Development Council conducted an online survey of over 2,100 teachers which revealed similar sentiments. A collection of teacher generated comments include:

> Much of the staff development offered is 'make and take' types of activities …cute and fun, cookie cutter types of activities not coupled with interesting and challenging experiences and as a tenured teacher, I find much of this staff development training to be repetitious and a waste of time (Mizell, p. 4).

Thinking back over all the things that compete for a teacher's time and attention, it's amazing how they can manage to find time for what needs to be done everyday in life. Teachers are pulled every which way every day by demands from a spouse, children, family, health and career. If a teacher has the choice between attending an after school workshop, helping students, or being with their family; it's safe to say that attending a workshop would generally be a last choice. After all teachers went to college, know their subject matter, received a degree, possess a license to teach, and have their own classroom. What else do they need to be an effective teacher?

Elmore (2002) has spent long hours researching education, schools and teaching and would answer the above question with this comment:

> The prevailing assumption is that teachers learn most of what they need to know about how to teach before they enter the classroom – despite massive evidence to the contrary - and that most of what they learn after they begin teaching falls into the amorphous category of 'experience,' which usually means lowering their expectations for what they can accomplish with students and learning… (p. 4).

This belief, that teachers come to the classroom with the knowledge necessary to promote student achievement, is widely held by teachers themselves, by parents, school boards,

and community members (Parsad et al., 2001) despite the findings by the National Center for Education Statistics (1999) that most teachers do not feel well prepared to implement national and state standards or to adequately meet the needs of their students.

Statement of the Problem

The *No Child Left Behind Act (NCLB),* signed by President Bush on January 8, 2002, set in motion a program of historic educational reform that increased the level of accountability for student achievement results. The U.S. Department of Education (2002) devoted an entire website to the pros and cons of this legislation, noting that "*No Child Left Behind* puts special emphasis on determining what educational programs and practices have been proven effective through rigorous scientific research". Federal funding is now targeted to support these programs and the teaching methods that work to improve student learning and achievement (http://www.ed.gov/policy). This legislation reiterates what some researchers believe, that our best shot to increase student achievement in schools is by improving teaching, and the important role professional development plays in school reform by bridging the gap between standards-based reform and teacher training (Elmore, 2002; Garet et al., 2001; Guskey, 2002; Shaha et al., 2004). Section 2213.C7 of NCLB provides funding for states to carry out activities that are focused on "developing systems to measure the effectiveness of specific professional development programs and strategies to document gains in student academic achievement". Through NCLB legislators are taking a hard look at quality professional development and asking a question many have investigated, whether or not the investment of federal funds for professional development really yields any tangible

payoffs for students (Guskey, 1995). Professional development can no longer be viewed as an entitlement by teachers or a service routinely provided by school districts.

NCLB's adequate yearly progress (AYP) provision shines a huge spotlight on student achievement in reading and mathematics, stresses the need for teachers to be "highly qualified" and to possess the skills necessary to provide students with high quality learning experiences. Dollars targeted to improve student achievement through improving teacher knowledge and skills are embedded in the NCLB legislation. It is a new age in education. It is a new day all across the land!

In Ohio, this new age of heightened accountability is coupled with rising costs and a persistent struggle by school districts to maintain local funding. In essence, schools are being asked to do more with less and to meet the challenge of having every student succeed without increasing the financial burden on local taxpayers. Public discontent with low graduation rates, student skill levels below what is necessary to successfully enter the job market and increasing levels of impatience for schools to "fix the problem", routinely translates into levy failures and cries for increased fiscal responsibility. As a result, districts face a two-edged sword: the need to earmark funds for continuous professional development to impact student outcomes competing against budgeting dollars for basic district functions and instructional programs. Which side of the sword should a district ignore? Can funding for professional development be eliminated or greatly reduced? Will this have an impact on student achievement and eventually on schools and districts meeting AYP?

Purpose of the Present Study

The purpose of the study was to investigate the relationship between teacher participation in sustained, targeted mathematics professional development and student achievement as demonstrated by performance on the Ohio Achievement Test for Mathematics (OATM). The widespread belief is that high quality, targeted, sustained professional development supports increased student achievement and is worth the expenditure at a federal, state and local level. Guskey (2002) suggests that school districts carefully examine their resources and target funds to support critical comprehensive improvement efforts. A sound, high quality professional development plan needs to be part of this comprehensive effort. Guskey (2002) would argue: "But in the absence of proof, you can collect good 'evidence' about whether a professional development program has contributed to specific gains in student learning" (p. 47). This study attempts to collect such evidence.

Research Questions

This study will compare the achievement levels of two groups of students. The first group will be students assigned to teachers who have participated in over 90 hours of targeted professional development through the SMART Consortium[1] during the last three school years. This group will be compared to students whose teachers participated in less

[1] The SMART Consortium (Science and Mathematics Achievement Required for Tomorrow) is a collaborative of 58 school districts and five Educational Service Centers in Northeast Ohio. The Consortium was formed in 1998 in response to concerns raised by the findings and implications of the Third International Mathematics and Science Study (TIMSS). The Consortium's mission is to bring school districts together to capitalize on each other's diversity and to share resources, innovative practices, instructional strategies and curriculum materials. SMART is a regional provider of targeted mathematics and science professional development.

than 90 hours of professional development. The study will examine whether or not there is a relationship between teacher participation in professional development and the following student outcomes: increased student proficiency rates, individual student scores on the 2007 OATM, and the level of improvement in student scores on the OATM from 2006 to 2007. Research questions for this study are:

(1) To what extent does teacher participation in sustained, targeted professional development in mathematics predict student passage rates on the 2007 OATM?

(2) To what extent does teacher participation in sustained, targeted professional development in mathematics predict:

   a. individual student outcomes in terms of student performance at the proficient level or above on the 2007 OATM?

   b. a change in the gender gap with regard to student performance at the proficient level or above on the 2007 OATM?

   c. a change in the minority achievement gap with regard to student performance at the proficient level or above on the 2007 OATM?

(3) To what extent does teacher participation in sustained, targeted professional development in mathematics predict:

   a. the level of improvement in student performance on the OATM from 2006 to 2007 for students assigned to the teacher's classes in 2007?

   b. a change in the gender gap with regard to level of improvement in student performance on the OATM from 2006 to 2007 for students assigned to the teacher's classes in 2007?

   c. a change in the minority achievement gap with regard to level of

improvement in student performance on the OATM from 2006 to 2007 for students assigned to the teacher's classes in 2007?

(4) What views do teachers and administrators hold with regard to the value and benefits of professional development related to student achievement and personal growth?

Significance of the Study

A major challenge today for many districts in Ohio in light of the rigors of NCLB, is how to meet the need to support teacher growth with limited funding. District budgets continue to increase while state financial support for schools continues to shrink, and taxpayers demand relief from increased property taxes. The newspapers routinely run stories about rising property taxes, failed school levy campaigns, and community efforts to monitor school spending. The funding crunch escalates the urgency of determining priorities at a time when, under NCLB, it is imperative for teachers to increase their content knowledge, stay abreast of research on teaching and learning, and implement best practices in standards-based instruction while meeting the needs of an increasingly diverse student population. So if a district is to set aside funds for professional development, the expectation must be that student learning will be directly and positively affected by the expenditure. What proof is there that a link between student achievement and professional development exists? Why should precious dollars be set aside for teacher learning? Do students really benefit from their teacher's participation in learning activities? In the end, if such a relationship does exist, school districts can feel confident

that investing dollars for professional development is as important as funding any other instructional or support program with respect to increasing student achievement.

The prevailing thought is that there is a complex relationship between teacher participation in professional development and increased student achievement, one that distinctly contributes to student outcomes (Darling-Hammond, 1997; Guskey, 2000; National Staff Development Council [NSDC], 2001; Sparks, 2002; Wenglinsky, 2002). Guskey and Sparks (1996) note that, "although the relationship between staff development and improvement of student learning is complex, it is not random or chaotic" (p. 5). Killion (2002a) supports this view and stresses that finding the link between professional development and student achievement is both challenging and essential to pursue if we are to improve our schools.

This study has the potential to provide school districts with evidence to support the investment of funds to promote teacher participation in sustained, targeted professional development as a means to positively affect student outcomes. The study also has the potential to reinforce the value of professional development targeted to increasing mathematics content knowledge and to understanding instructional strategies that support standards-based education.

Organization of the Thesis

Chapter I delineates the statement of the problem and the purpose of this study. Included in the chapter is an explanation of the relative importance of this study. The research questions explored through the study are set forth, followed by a description of the limitations of the study, and definitions of terms used in the thesis.

Chapter II provides for a review of literature about the topic of this study. Included in the review are studies, research, essays and other writings dealing with the past and present role of professional development in education, the relationship between professional development and student learning, the perceived value of life-long learning for educators in improving their knowledge base and skills, the need for increased understanding of content knowledge in mathematics, and the payoff for investing in teacher quality.

Chapter III describes the methodology, data collection procedures, and a description of the variables considered in the study. Presentation of the data, analysis of the collected data using level-2 Hierarchical Linear Models and the rationale for using this type of model follow.

Chapter IV provides descriptive information found through the study and the research findings.

Chapter V summarizes the study and its findings. A discussion of the analysis of the data, implications for practice, limitations of the study, and recommendations for future study are included.

Delimitations of the Study

Any interpretation and discussion of the results of this study should be based on consideration of the following:

(1) The population considered for inclusion in this study is a sample drawn from those teachers instructing students in grades four through eight during the 2006-2007 school year whose school district is a member of the SMART Consortium.

Only these grade level teachers are being considered since the (OATM) is given in grades three through eight and longitudinal data is limited in certain test years for specific grade levels. By focusing on teachers working with students in grades four through eight, a minimum of two years of data relative to student performance on the OATM can be retrieved. The selected teacher sample will not include high school teachers since the Ohio Graduation Test (OGT) is the only achievement test given at the high school level, and high school students have the option to enroll in a variety of mathematics courses, making the task of linking student scores to specific teachers problematic.

(2) The following information is important for understanding the parameters of data included in this study. The Ohio Department of Education phased in the OATM over time. Prior to October of 2003 Ohio students in grades 4, 6 and 9 participated in Proficiency Testing. Ohio's Achievement Test program began in October of 2003 with the administration of only a reading test administered to third graders. The OATM for specific grade levels was put in place according to this timeline:

- October, 2004 - Grade 3 OATM (Proficiency tests were administered for grades 4, 6, 9)
- October, 2005 - Grades 3, 7, 8 OATM (OGT was administered for grade 10)
- October, 2006 - Grades 3, 4, 5, 6, 7 and 8 OATM (OGT was put in place for grade 10)

Based on Ohio's assessment program the implications for retrieving data are:

- Students enrolled in 8th grade during the 2006-2007 school year will have OATM results for 2007 and OATM results from 2006 as 7th graders (in 2005 these students took the Ohio Proficiency Test in 6th grade).
- Students enrolled in 7th grade during the 2006-2007 school year will have OATM results for 2007 and OATM results from 2006 as 6th graders (in 2005 these students were not required to participate in state testing as 5th graders).
- Students enrolled in 6th grade during the 2006-2007 school year will have OATM results for 2007 and OATM results for 2006 as 5th graders (in 2005 these students took the Ohio Proficiency Test in 4th grade).
- Students enrolled in 5th grade during the 2006-2007 school year will have OATM results for 2007, OATM results for 2006 as 4th graders, and OATM results for 2005 as 3rd graders.
- Students enrolled in 4th grade during the 2006-2007 school year will have OATM results for 2007 and OATM results for 2006 as 3rd graders (Note: only diagnostic tests are administered in kindergarten through 2nd grade and not reported statewide.).

(3) This study will be limited to the consideration of professional development activities provided through the SMART Consortium for the selected teacher sample. The professional development activities included for consideration in the study were offered over the last three school years, 2004–2007 and focused on one of two topics: (a) increasing teacher content knowledge in mathematics, and/or (b) deepening teacher understanding of scientifically research-based instructional strategies for mathematics. Including only professional development

centered on these two topics creates a very narrow focus and provides for the identification of "targeted" professional development for use in the study.

(4) This study does not consider the impact of professional development activities the sample population of teachers might have participated in over the last three years that were not offered through the SMART Consortium. This would present a difficult dynamic to control for given teacher entry year program requirements for professional development, Ohio licensure requirements, district level professional development programs, district contractual obligations and/or restrictions, and the discrepancy surrounding the lack of required continued professional development for teachers who possess "permanent" certificates available under previous Ohio statutes.

(5) This study does not consider the participation in professional development activities for mathematics teachers of the student population for the 2005–2006 school year, only those teachers of record for the 2006-2007 school year.

(6) There is no control for student mobility in this study. This dynamic will have to be kept in mind when retrieving test histories as it may result in missing test scores, making it difficult to track student achievement year to year.

(7) There is no control for student socioeconomic status in this study.

(8) The conclusions drawn from this study are intended to show relationships among identified variables, not cause and effect.

Definitions of Terms

Term	Definition
Accountability	Under the *No Child Left Behind Act*, this includes holding students, schools and districts responsible for academic performance to meet standards for achievement, set at a national and state level (Elmore, 2002).
Adequate Yearly Progress (AYP)	Under the *No Child Left Behind Act*, each state must set minimum levels of improvement - measurable in terms of student performance - that school districts and schools must achieve within time frames specified in the law (U. S. Department of Education).
A-Site	Information technology centers that provide school districts with computer software and support for fiscal software, student and EMIS data, library services and internet services (Lakeshore Northeast Ohio Computer Agency).
Content Knowledge	A set of knowledge, skills or abilities in specific subject areas for instruction (Ohio Department of Education).
Gender Gap	The difference in the Ohio Achievement Test scores in Mathematics between male and female students.
Individual Student Scaled Score	Scaled scores offer a distinct advantage for comparing different students taking different forms of a test within a subject area. Raw scores are converted to scaled scores through a numerical transformation process. This is done

	since raw scores are not comparable from one form of a test to another and provide limited information for interpretation (Ohio Department of Education).
In-service	Training for teachers targeted to provide them with the information and skills needed to remain current with changes in the practice of teaching (Guskey, 2000). Often used interchangeably with the terms professional development and staff development.
Instructional Practices	Interactions between teachers and students, materials and resources used in the classroom, the nature of the learning tasks student perform in school and at home, and methods for assessing student progress (Wenglinsky, 2000).
Knowledge	Familiarity, awareness or understanding gained through experience or study; the sum or range of what has been perceived, discovered or learned (American Heritage Dictionary).
Minority Achievement Gap	The difference in the Ohio Achievement Test scores in Mathematics between minority and non-minority students.
Ohio Achievement Tests	Summative assessments that measure achievement of the academic content standards and generally cover a broad range of content knowledge, skills and processes (Ohio Department of Education).

Pedagogy	The art, science, or profession of teaching; the study of teaching methods, including the aims of education and the ways in which such goals may be achieved; relies heavily on educational psychology, or theories about the way in which learning takes place (Encyclopedia Britannica Online).
Professional Development	Formal learning opportunities provided to teachers targeted to improve knowledge, skills, and classroom practices (Smylie, Allensworth, Greenberg, Harris, & Luppescu, 2001). The term is often used interchangeably with the terms staff development and in-service.
Proficient	Indicates the student has met a specific minimum level benchmark or showing knowledge, ability or skill as in a profession or field of study (www.Ask.com). With regard to Ohio Achievement Tests, a scaled score of 400 or above meets the established standard for every grade level and subject area test (Ohio Department of Education).
Skill(s)	The ability to demonstrate knowledge and understanding of concepts, procedures, facts, etc. (Ohio Department of Education).
Staff Development	Training intended to assist workers in keeping up with changing technology and current practices in a profession in the context of lifelong learning (Wikipedia). The term is

	often used interchangeably with the terms professional development and in-service.
Standards-Based Reform	High standards and expectations for all students coupled with rigorous and challenging tests to measure student success in meeting the clearly defined standards, and a specific system of accountability to track student success (NCLB, 2002).
Student Achievement	Measures of student success in meeting academic standards for performance, using specific evaluative measures that indicate what a student has learned, knows and can do at a specific point in time (Anderson, 2004). This study will focus on the Ohio Achievement Tests designed to correlate with the Ohio Academic Content Standards.
Student Learning	Changes in student achievement over time; the process by which students increase their knowledge and skills base (Anderson, 2004).
Sustained Professional Development	Professional development delivered over an extended period of time that provides for job embedded opportunities to practice new learnings and skills.
Targeted Professional Development	Professional development that is rich in content, delves deeply into the understandings behind concepts and subject area knowledge, and is intellectually challenging (Killion, 2002b).

CHAPTER II

REVIEW OF THE LITERATURE

Teacher Quality

Although teachers do not directly cause student learning, they definitely set the stage for learning to take place by providing students with the time, classroom climate, structures and worthwhile activities that promote learning (Lasley, Siedentop, & Yinger, 2006). The future of society depends on students entering the work force prepared to face the challenges of the day. Fullan (1999), in talking about why teaching is so very important to our society, discusses that pursuing a moral purpose is the foundation of our educational system. Parents, school board members, and community groups all routinely speak of how teachers play a fundamental role in determining the quality of our educational system. In fact, it is not uncommon for parents to request their children be assigned to specific teachers they perceive are more effective in the hopes of getting the best education possible for their children in a flawed educational system. Highly qualified teachers are thought to give districts a "bigger bang for their buck" with regard to promoting student achievement (Hanushek, 2006; Rockoff, 2004). In a perfect world schools would have a highly qualified and highly effective teacher in every classroom (National Alliance of Business [NAB], 2001; NCLB, 2002).

In a report prepared for the Carnegie Corporation, McCaffrey, Lockwood, Koretz, and Hamilton (2000) note that: "Teaching and learning are aspects of a synergistic phenomenon whereby dynamic forces continuously interact to produce accumulating changes in student knowledge" (p. 290). Twenty years ago Brophy (1986) summarized two decades of research that studied the effects teachers had on their students' achievement. He focused on research that used the "process-product" paradigm to shift away from examining teachers' personal traits to zeroing in on teachers' effects on student achievement. This work served as a cornerstone for establishing a base of information on which educators could build. Brophy was careful to point out that, at the time of his review, one had to distinguish between research on teachers' effects versus research on teacher effectiveness since teacher effectiveness research was in the infancy stage and educators were struggling to determine what characteristics could be used to identify an "effective teacher". Research during the last decade has analyzed the effects of teachers on student achievement and provides support for the belief that quality teaching makes a difference in student learning since teaching expertise is considered to be a critical variable in the student achievement equation (Ball, Lubienski, & Mewborn, 2001; Laczko-Kerr & Berliner, 2002; Lasley et al., 2006; Lewis, 2002). The question still remains, what determines "teacher quality?" What characteristics determine an "effective teacher?"

Darling-Hammond (2000) compiled an extensive review of the research on teacher qualifications and the resulting effect on student achievement. This discussion centers on investigations of teacher quality in terms of specific qualifications that include teacher preparation, pre-service coursework, test scores, degree and certification. Her

synthesis provides support for the belief that student achievement in mathematics is influenced by whether or not the teacher is certified in mathematics. She goes one step further to note that a teacher who is certified in mathematics and has training in educational philosophy (pedagogy and student learning theory) has an even greater effect on student outcomes. Goldhaber and Brewer (2000, 2001) analyzed the National Education Longitudinal Study of 1988 (NELS:88) data and found strong evidence that students assigned to teachers with certification in mathematics outperform their counterparts assigned to teachers without this qualification. The data in several other studies revealed that teacher certification and degree has a stronger effect on student achievement than socioeconomic status, race or language (Darling-Hammond, 2001). A synthesis of the available research on the topic done by Wilson, Froden, and Ferrini-Mundy (2001), provides a detailed summary of various studies concluding that subject area certification really does make a difference in student outcomes. On the other side of the coin, however, Rivkin, Hanushek, and Kain, (2005) found that there is minimal variation in teacher quality, as evidenced by student achievement gains, due to teacher characteristics such as certification, pre-service education and even experience. So it appears the controversy continues.

Subject area certification aside, what about the effect of years of teaching experience on student outcomes? It's not uncommon for people to believe that the longer a person is in their job the more adept they become at completing the work effectively. With teachers the assumption might be that the more years of experience a teacher has, the better they are at designing effective instruction and raising student achievement each year for every student. There is evidence that teaching experience does have a somewhat

positive, though not statistically significant effect on student achievement (Fetler, 2001; Hanushek et al., 2003; Laczko-Kerr & Berliner, 2002; Rowen, 2002; Wayne & Youngs, 2003). In 2001, Rivkin et al. conducted a study in Texas and found that student achievement gains for a sample of fourth and fifth graders assigned to a first year teacher were about twenty percent of a standard deviation below that of students assigned to teachers with more than three years of experience. In a later study, Rivkin et al. (2005) reinforced their initial findings with more data and concluded that beginning teachers generally have a neutral or even a slightly negative effect on student achievement when compared to teachers with more than three years of experience. This finding was also true for Hanushek et al. (2005) after they examined data from Texas schools using value-added methodology.

In the end when all is said and done, Goldhaber and Brewer (2000) conclude that measurable teacher characteristics such as certification, experience and education, account for only three percent of the difference in student achievement. Thus, a review of over a decade of studies highlights the controversy that is generated when researchers try to accurately determine teacher quality solely through an examination of the observable teacher characteristics, since the evidence is not consistent from study to study (Ferguson & Brown, 2000; Rowen, 2002; Wayne & Youngs, 2003).

In an effort to search for a cause and effect relationship between teachers and students Wenglinsky (2002) explored the effects of classroom practices on student outcomes. He focused his study on examining the effect of distinct aspects of teacher quality on student outcomes, such as teacher classroom practices versus teacher inputs, and characteristics such as certification and pre-service training. Using 1996

mathematics test data from the National Assessment of Educational Progress (NAEP), Wenglinsky concluded that teachers' classroom practices had the greatest effect on student outcomes, far surpassing the effect of teacher characteristics and inputs. Rockoff (2003), in a review of available research, summarizes the findings to conclude that many of the observable characteristics of teachers do not have a direct relationship to teacher quality; thus making it difficult to identify, recruit and hire effective, highly qualified teachers. So, where does this leave us in today's age of accountability? It becomes clear that any discussion or examination of teacher quality must move beyond the basic consideration of general teacher characteristics (pre-service education, certification and teaching experience) to include a focus on teacher effectiveness and outcome-based measures (Hanushek, 2006; Rockoff, 2003; Sanders & Horn, 1998).

Any discussion about teacher quality today should include a discussion as to whether or not National Board Certification can be viewed as an indicator of teacher quality. The National Board of Professional Teaching Standards (NBPTS) was created in 1987 in the hopes of providing high standards by which to assess teacher quality. Teachers who apply for National Board Certification (NBC) participate in a year long adventure creating a portfolio, videotaping classroom lessons, gathering evidence of their teaching, and taking a rigorous exam. Several studies have attempted to show that NBC teachers are more effective in raising student achievement scores than non-NBC teachers, and that the entire process increases teacher effectiveness (Cavalluzzo, 2004; Goldhaber & Anthony, 2005; Stone, 2002; Vandervoort, Amrein-Beardsley, & Berliner, 2004). Stone (2002) found that students assigned to a sample of NBC teachers in Tennessee schools posted no greater achievement gains than students assigned to non-NBC teachers.

Vandervoort et al. (2004) and Cavalluzzo (2004) however, disagreed with this finding and instead claim NBC can serve as an indicator of teacher effectiveness in that they found the students of NBC teachers did post greater achievement gains than students of non-NBC teachers. Goldhaber and Anthony (2005) found fault with the above studies in that although the researchers attempted to tie National Board certification to student outcomes, limited sample sizes were used and no adjustments were made for student demographics. Instead Goldhaber and Anthony argue that NBC may be seen as an indicator of teacher quality only since the more effective teachers are generally the ones who tend to complete the NBC program. Unfortunately they found no evidence that going through this certification process increases a teacher's effectiveness. It's clear that more research needs to be done on this topic before concrete conclusions can be drawn.

Defining the characteristics of an effective, high quality teacher is only one piece of the achievement puzzle. It is important to examine the data to determine the actual effect of teacher quality on student achievement. This can be done using value-added analysis, a trend that is gaining momentum across the United States in light of NCLB. Value-added analysis provides a snapshot of student growth at a single point in time, how much growth a student makes year-to-year, and how well the student performs when measured against set standards. The design is based on the value-added model commonly used in the business sector. One of the premises behind a value-added analysis in the educational realm is that gains in student achievement in a given year can be attributed to the behaviors and instruction of the individual classroom teacher. This model is designed to measure the amount of *change* that occurs in a student's achievement during the year when the student is in a particular teacher's classroom and in

a particular school (Rowen, 2002; Sanders & Horn, 1998). The focus here is on student growth year to year not on a single test score as a benchmark of total achievement.

Research from the 1960's supported the assumption that the effects of teachers and schools on student achievement were limited, and that a student's background and socioeconomic status had a greater effect on achievement. Now, through value-added analysis, researchers can control for student background factors and truly assess the effects linked to the teacher and to school factors (McCaffrey, Lockwood, Koretz, Louis, & Hamilton, 2004). Sanders explains:

> Because the value-added method measures gain from a student's own starting point, it implicitly controls for socioeconomic status and other background factors to the extent that their influence on the post-test is already reflected in the pre-tests score (Ballou, Sanders, & Wright, 2004).

Essentially this is an opportunity to estimate the short and long term effects of the educational system and its personnel on student outcomes (McCaffrey et al., 2003).

The first extensive use of the value-added model was put in place by the state of Tennessee in 1990 in response to a lawsuit over inequalities in school funding, and in response to pressure from the business community. The Tennessee Value-Added Assessment System (TVAAS) is built around a model designed by William Sanders and is sometimes referred to as the Sanders Model. This statistical model uses scaled scores from the state tests to indicate a student's level of academic achievement in an effort to chart past and future academic growth for each student.

> The primary purpose TVAAS serves in the EIA (Education Improvement Act) is to provide information for summative evaluation regarding how effective a school, system, or teacher has been in leading students to achieve normal academic gain over a three-year period…the standards to which school districts and schools are held accountable are expressed in terms of academic gains instead of an expectation set in terms of absolute scores (Sanders & Horn, 1998, p. 250).

Sanders and Rivers (1996) reviewed TVAAS data and found that having a highly effective teacher generally resulted in an average of two additional months of academic progress for a student each year. [TVAAS defines a highly effective teacher as one whose average student score gain is in the top twenty-five percent (The Center for Public Education, 2005)]. TVAAS data show that students assigned to a highly effective teacher for one year demonstrate an average gain of 52 percentile points versus an average gain of 14 percentile points per year for students assigned to the least effective teachers. Sanders' work also showed that 65% of the effect on student achievement is based on teacher effect, 30% on school effect and 5% on district effect highlighting greater differences in the effect on student achievement within a school than across schools in the same district. Additional research on the use of value-added assessment provides evidence to support the belief that individual teachers have a measurable effect on student learning (Babu & Mendro, 2003; McCaffrey et al., 2000; Bembry & Schumacker, 2003). There is also evidence to show that teacher effect has a greater impact on student learning than class size, ethnicity, family socioeconomic status, or other school factors (The Center for Public Education, 2005; Pipho, 1998; Sanders & Rivers, 1996).

Further review of TVAAS data provides evidence that if a student has a highly effective teacher several years in a row they post higher test scores than a student assigned to ineffective teachers (Nye, Konstantopoulos, & Hedges, 2004; Resnick, 2004). The data support the belief that when a student has an ineffective teacher for two or more years in a row, their gains in achievement and learning are lower than for a student who has several highly effective teachers. Consider this example from TVAAS data: a group of fifth-grade math students who were assigned to highly effective teachers for three

years in a row, scored 52 to 54 percentile points higher than their peers who did not have this same experience. The findings also showed that there are negative residual effects when a student is assigned to a series of ineffective teachers. In general then

> …the teacher effects are both additive and cumulative with little evidence of compensatory effect of more effective teachers in later grades. The residual effects of both very effective and ineffective teachers were measurable two years later, regardless of the effectiveness of teachers in later grades (Sanders & Rivers, 1996, p. 6).

A study using value-added methodology done by Jordan, Mendro, and Weerasinghe (1997) analyzed longitudinal achievement data for student cohorts in the elementary grades in Dallas, Texas and used test data from a battery of tests different from those used in Tennessee. The Dallas data show that there was an average loss in achievement gains of 23.00 percentile points for students who were assigned to ineffective teachers for one, two or three years in a row. For example, consider a group of third grade students achieving at about the 55^{th} to 57^{th} percentile. Students in this sample who were assigned to highly effective teachers for three years in a row demonstrated an average increase of 21 percentile points in mathematics by the end of the fifth grade. Conversely, students in this sample who were assigned to ineffective teachers for three years in a row posted average scores in the 27^{th} percentile – leading to a gap in mathematics achievement of almost 50 percentile points over three years when compared to their peers. Babu and Mendro (2003) summarized their findings of the Dallas data by noting: 1) The percentage of students who passed the seventh grade mathematics achievement test after being assigned to an effective teacher (a teacher in the top two quintiles) for three consecutive years was almost 100% for middle- and high-achieving students, and 90% for low-achieving students; 2) The percentage of students

who passed the seventh grade mathematics achievement test after being assigned to ineffective teachers for three years in a row was 90% for high-achieving students, 89% for middle-achieving students, but only 42% for low-achieving students. Similar results have been documented through a study in Boston where students assigned to highly effective teachers demonstrated gains exceeding the national average, while students assigned to ineffective teachers showed virtually no gains in achievement (Haycock, 1998).

A number of states have implemented value-added assessment systems: Texas, Tennessee, Michigan, North Carolina, South Carolina, and Minnesota. There are also a growing number of states including Ohio, that are ready to follow the lead of Tennessee and Texas in instituting a value-added assessment system to determine the effects of the teacher on student achievement as a way to measure teacher effectiveness related to direct student outcomes. One caveat, however, is that the value-added models are not free from criticism. McCaffrey, et al. (2004) have taken issue with using a value-added assessment model noting that there are no statistical adjustments made to compensate for teacher assignment issues, variances in test composition from year to year, and variance in teacher/school curriculum, and that much depends on the way the researcher "manages" missing student test data to avoid using incomplete data that might skew or bias the results. Further research is needed to resolve differing opinions surrounding the model's assumptions and methodology.

Anderson (2004) cautions that value-added models may examine teacher effects on student achievement but do not provide insights into why the individual teacher has a

positive effect on their students' learning. McCaffrey et al. (2003) defined teacher effect as:

> …the average causal effect on student achievement across all students of interest. This outcomes-based definition describes teachers only in terms of student achievement. It is not necessarily a meaningful characterization of other attributes of teacher effectiveness…It provides no description of the practices, traits, or characteristics of teachers with large effects (p.14).

With this said, can it be assumed that effective teachers (as measured by a value-added assessment system) are also quality teachers? Research has shown that teacher effectiveness is believed to be one of the strongest determinants of student learning, even more so than reduced class size (Darling-Hammond, 2000). Anderson (2004) states: "An effective teacher is one who quite consistently achieves goals – be they self-selected or imposed – that are related either directly or indirectly to student learning" (p. 25). Should our educational system then support increasing teacher effectiveness and improving teacher quality as a pathway toward improving student achievement?

The Need for Professional Development

Every decade the cries for systemic educational reform rise up again throughout the United States. Fullan (1993) thoroughly reviewed a century of educational reform. He found that the 1960s generated large scale national curriculum efforts focused on implementing new ideas, not changing the culture of the educational system. The 1970s focused on the structure of schools and regrouping educational reform through the effective schools movement, while the 1980s saw large scale state level government regulation take over and promote restructuring toward school-based management. During the 1990s, the focus was on driving large scale educational reform and now in the

2000s, the focus has been sharpened to include the need for sustainability in reform. To put things in perspective, a century of innovations has taught us that the focus must be on teaching and learning – the core culture of education, not on the institution itself (Hargreaves, 2005).

Fullan's work centered on an exploration of the change process for institutions and found that the process is complex, with order springing forth from chaos, balanced by an understanding that there will always be uncertainty (1993, 1999). The research makes it clear that educational change takes time and is riddled with challenges, failures, and complexities. Fullan (1993) set forth eight lessons to help society best understand complex educational change situations and to know how to act to maximize change. He subsequently reformatted/reworded the lessons in 1999, but the original wording is clear and will serve best here:

Lesson 1: You can't mandate what matters.
Lesson 2: Change is a journey, not a blueprint.
Lesson 3: Problems are our friends.
Lesson 4: Vision and strategic planning come later.
Lesson 5: Individualism and collectivism must have equal power.
Lesson 6: Neither centralization nor decentralization works.
Lesson 7: Connection with the wider environment is critical for success.
Lesson 8: Every person is a change agent. (p. 21-2)

The message is that educators must deal with change as a routine part of the educational system, a way of life to be embraced and worked through as a journey along winding paths. Change begins with the teacher. Lesson 8 has proven to be critical in educational reform – the teacher is a change agent, and must self-renew and embrace lifelong inquiry as a generative characteristic for change. Top down change is often problematic while purposeful change that arises from within individuals can lead to systemic reform (Senge et al., 1994).

If change must begin with each individual teacher, they must possess the skills necessary to understand and effect change. Some people believe that teaching is an innate skill that select individuals are blessed with from birth. On the opposite end of the spectrum there are those who believe that teaching is a skill that can be learned in college. Which belief is correct? Stigler (1999) believes that teaching is a "cultural activity" that is, an activity guided by generalized knowledge embedded in the minds of the participants, widely shared, and learned implicitly through participation or observation. He found:

> Teaching is … more like participating in family dinners than like learning to use the computer… (it) is learned through informal participation over long periods of time. This is something one learns to do more so by growing up in a culture than by studying it formally (p. 86).

We all share some idea of what effective teaching should be and what to expect in a classroom – a *script* as Stigler would call it – that we began to form as children when we played school. Anecdotal information obtained from teachers shows that they often teach in ways similar to how they learned in school, and most believe they are effective based on their own learning and memories of how learning takes place (Ball & Cohen, 1999; U. S. Department of Education, 2000). In fact, researchers have found that most teachers already have preset ideas about teaching and the qualities of an effective teacher long before they ever take their first class in college. By age 18 they have experienced thousands of hours in classrooms with teachers through high school and have internalized their experiences (Pajares, 1992; Walls, Nardi, vonMinden, & Hoffman, 2002). These experiences then become the framework around which pre-service teachers work to create their own teaching practices. The result is that new teachers unknowingly work to become part of the culture they know as teaching. This whole cultural framework is the

cornerstone of Fullan's belief that: "The hardest core to crack is the learning core – changes in instructional practices and in the culture of teaching…to restructure is not to reculture" (Fullan 1993, p.49).

Now some may contend that teachers are in the business of learning, and as professionals they have a responsibility to keep abreast of research and initiatives in education to best meet the needs of their students (Killion, 2002a; NSDC, 2001; Wenglinsky, 2000). This is the same expectation society holds of doctors, lawyers, accountants, nurses, engineers, and other professionals. Every profession is in a constant state of flux in today's world so professionals must accept the responsibility to keep current of new findings and research in their fields. Doctors must learn the newest methods to treat diseases; lawyers must keep up with new laws; engineers must stay current about the newest technology; and for teachers, it is imperative that they continuously learn, grow, and improve their skills in response to the demands of the current standards-based reform movement. Teachers know this, superintendents know this, colleges know this, and the public knows this to be true. The Teaching Commission points out that: "Surveys have shown that the public agrees that improving the quality of teaching is the most important thing our nation can do to strengthen public education" (p. 14).

Teachers new to the profession need support as they begin to navigate the profession and learn to work with students. However, focusing only on new teachers is a myopic view. Practicing teachers need to continually increase their knowledge base and improve their skill levels to be able to meet the changing needs of the students (NAB, 2001). Therefore, we need to focus on all teachers since students today cannot simply

wait around for new, highly qualified teachers to teach them. We have to make sure that current teachers are as skillful, knowledgeable and effective as possible (Wenglinsky, 2000). Ball & Cohen (1999) point out that:

> A great deal of learning would be required for most teachers to be able to do the kind of teaching and produce the kind of student learning that reformers envision, for none of it is simple. This kind of teaching and learning would require that teachers become serious learners in and around their practice (p. 4).

It's not easy for a teacher to rewrite the script they have embedded in their minds, the script they grew up knowing, the script that is deeply ingrained in their culture (Stigler, 1999).

Hargreaves (2005) found that teachers typically either embrace or resist the various waves of educational reform based on the content of the reform and the perceived effects of the change on their professional lives. They are skeptical of the "repetitive change syndrome", the flavor of the month per se, and assertively ask "What exactly is changing and why?" Teachers may be reluctant to rewrite their scripts and change how they teach for several reasons: (a) They may believe they are effective and doing a good job so are not really aware that there is a need to change; (b) They may lack conceptual and procedural knowledge in their subject area but not be aware of it; and (c) They may not think that changing their practices or increasing their knowledge will have any effect on student learning due to the influence of external, uncontrollable factors (Anderson, 2004). Teachers can tear up the script by objectively exploring the process of teaching and learning, as well as delving deeper into their subject area content (Ball & Cohen, 1999). They can, and should, examine their beliefs with a critical eye toward student outcomes and a curiosity to find out what the data show is happening in the classroom

(Killion, 2002b). Teachers need to reflect on their instructional practices and investigate new practices, learn more about working with students, and delve deeper into their subject matter (Ball et al., 2001).

One way to provide time for teachers to learn, grow and improve is through professional development opportunities. Re-culturing the teaching profession requires that teachers focus on their own learning in an effort to better understand the various learning styles and multiple intelligences students bring to school (Fullan, 1993). Quality professional development can be a powerful tool for promoting teacher learning which, in turn, can lead to rewriting the scripts of what effective teaching is, and ultimately lead to increased student learning (Stigler, 1999). Professional development focused on examining specific teaching strategies can increase teacher use of effective instructional practices, and ultimately have a positive effect on student achievement (Desimone, Porter, Garet, Yoon, & Birman, 2002; Huffman & Thomas, 2003). The National Research Council (1999) conducted a study of over 1,000 school districts and found that spending additional funds on developing teachers led to greater gains in student achievement, more so than expenditures on any other school resource.

Professional development is a widespread practice in public and private schools across the United States. The NCES (1999) found that 99% of U. S. teachers participate in professional development activities each year. Of these, 73% of the teachers reported having participated in professional development opportunities in their content area during the previous 12 months, and a similar percentage of the teachers were trained in how to use new teaching methods. Since so many teachers participate in a myriad of professional development sessions each year, should we assume teachers use what they

learn to enhance their teaching skills? Should we assume then that there is a direct positive effect on student learning when teachers attend in-service opportunities? Is there a correlation between teacher participation in professional development and increased student achievement?

The National Staff Development Council (2001) compiled a comprehensive report on results-based staff development and summed up the need for professional development in this way:

> Educational literature in the last decade has built a convincing argument about the role of professional development in promoting teaching quality and increasing student achievement. Simply put, the argument is this: What teachers know and do impacts what their students know and do. Deeper content knowledge, more content-specific instructional strategies, and greater understanding about how students learn will better enable teachers to craft instruction to meet the varying needs of students and help them achieve rigorous content standards…For practicing teachers, staff development is an essential vehicle for continuous improvement of teaching (p. 9).

Effective Professional Development

Is the implication that all professional development improves teaching and learning? What are the components or characteristics of effective professional development? Feedback from teachers routinely shows that they consider many professional development opportunities to be random one-day events designed to share new ideas, rehash old problems, push district agendas, and basically serve to increase their frustration level. Ball (1999) found that most professional development is fragmented, superficial, not reflective, and not targeted to issues of student learning, but rather is centered on providing teachers with quick tips, advice, or binders of activities they can leaf through. Basically, teachers do not value and in fact do not want to attend

professional development sessions that lack relevance to the subject they teach or are not aligned to the curriculum they are responsible to teach in light of mandated assessments (Killion, 2002b). They don't have the time to figure out how to incorporate generic teaching strategies and visionary ideas into their lessons (Thompson & Zeuli, 1999). Sessions that provide discrete activities designed by central office personnel and are intended to provide teachers with a menu of activities on selected topics may generate resentment and frustration in teachers. Sparks (2002) determined:

> It is clear that large-group 'batch processing' of teachers who are talked at in the name of exposing them to new ideas are ineffective…more often than not, staff development is fragmented and incoherent, lacks intellectual rigor, fails to build on existing knowledge and skills, and does little to assist (teachers) with the day-to-day challenges of improving student learning (p. 9-10).

Others readily concur with this thought that staff development which is of short duration, not focused on systemic improvement, and not intellectually stimulating has little effect on teaching practice and is not well received by teachers (Kent, 2004; Elmore, 2002; Fishman, Marx, Best, & Tal, 2003; Ohio Mathematics and Science Coalition, 2001).

Jacob and Lefgren (2004) cautioned that educators must examine the nature, quality, content and frequency of teacher professional development to ensure that there are payoffs in terms of student achievement. Elmore (2002) stressed that in order for professional development to be effective and have an effect on student learning, it must focus on increasing teacher knowledge and skills in areas they don't really know well enough. Teachers prefer professional development that is applicable to their classroom and curriculum, that incorporates activities where they learn concepts and skills in a manner similar to how their students would learn them, and that actively engages them as learners in an effort to mirror the dynamics of student learning (Rogers et al., 2007).

Professional development must create 'cognitive dissonance' and disturb the balance between a teacher's current beliefs and practices and new experiences with content, teaching and student learning (Ball & Cohen, 1999; Killion, 2002b; Thompson & Zeuli, 1999). Anxiety and creativity may work together to promote change. The experiences must have a personalized focus for teachers so that they see a need to transfer what they learn in the sessions to classroom practice (Wiggins & McTighe, 2006). Since knowledge can't be borrowed from others, professional development must help teachers internalize new knowledge, personally develop it, and embed it in their own beliefs in order to ultimately guide their actions (Fullan, 1993). Would these components then assure that this investment of time and money will have a positive effect on student learning?

Guskey (2002) outlined five critical levels that should be used to evaluate the quality of professional development. The first four levels examine: a) reactions teachers have to professional development opportunities; b) the knowledge or skills teachers gain from attending sessions; c) the degree to which the teachers' development is supported in the organization, and d) the teachers' use of the new knowledge and skills they have acquired. It is the fifth level he points out that is most important and should be the primary focus of all professional development - student learning outcomes. Fishman et al. (2003) conducted a study and concluded that "…the most important measure of whether professional development is 'working' is whether teacher enactment yields evidence of improved student learning and performance" (p. 655). NCLB legislation also supports this caveat by stressing professional development must lead to increased student achievement in order to be considered high quality.

This is the bottom line when it comes to determining the value of professional development. Educators must seek answers to these tough questions: How did the professional development activity affect students? Did it benefit them in any way? Did it impact student learning and achievement? These questions point to the importance of examining professional development using a "glass box process" (Killion, 2002a) whereby evidence is gathered to show the actual results of professional development on student achievement, and to determine what specific components of the professional development had the greatest effect on student outcomes. Wenglinsky (2000) supports this level of inquiry and cautions that any evaluation of the effectiveness of professional development must make specific use of data on both student and teacher learning. Tracking teacher involvement in high quality professional development opportunities and then tracking their students' learning provides great insight into the effectiveness of the activities with regard to positively effecting student achievement. Evaluation of professional development programs using the "black box process" (Killion, 2002a) which *assumes* that professional development produces increased student achievement is no longer acceptable under the reform focus on accountability for student outcomes.

A three year study by the U. S. Department of Education (2000) sought to evaluate the Eisenhower Professional Development Program. The program impacted thousands of teachers each year with a huge infusion of federal funds. Overall 93% of the school districts in the United States received Eisenhower funding. This longitudinal study used national data to identify six features of high quality professional development that lead to increases in teacher knowledge and skills, and changes in their reported teaching practices. These components are: a) the type of professional development, i.e.,

reform or traditional; b) the duration, i.e., number of contact hours provided over time; c) the degree of collective participation to foster a community of learners; d) the degree of active learning that takes place; e) the level of coherence of sessions with curriculum and goals, and f) the content, i.e., the degree to which the focus is on deepening teachers' content knowledge in the subject (Porter et al., 2003). The professional development cycle in Appendix A illustrates the interconnectivity and impact of these six components.

A number of research studies support the consideration of these six components and provide evidence that professional development designed with these ideas in mind can lead to changes in teacher practice, which in turn, will effect student achievement (Birman et al., 2000; Garet et al., 1999; Garet et al., 2001; Hill, 2004; Ohio Mathematics and Science Coalition, 2001; Rogers et al., 2007). The National Staff Development Council (2001) included these elements in their list of characteristics of effective professional development (Appendix B). Guskey (2003) concurred with the importance of these components and, using his research, extended the list to twenty-one characteristics. Loucks-Horsley, Love, Stiles, Mundrey, & Hewson (2003) reviewed the research and literature then used Guskey's criteria to narrow the list to only seven components focused on effective professional development in mathematics and science in particular. With all this in mind researchers (Elmore, 2002; Guskey, 2003a; Sparks, 2002; Wenglinsky, 2002) often refer to a "consensus view" of the characteristics of effective professional development (Appendix B).

Guskey and Sparks (1996) believe that the relationship between staff development and increased student achievement is complex but not random. Professional development must be designed around three interdependent concepts: learning, engagement and

improved practice in order to positively effect student achievement (Bredeson, 2002). Studies confirm that effective professional development promotes teacher growth and student learning which then leads to increased student achievement (Lowden, 2005; Wenglinsky, 2000). Findings show that teachers who engage in high quality, targeted, sustained professional development are more likely to employ effective classroom practices which, in turn, positively effect student achievement in mathematics and science (Birman et al., 2000; Frank, Carpenter, Levi, & Fennema, 2001; Garet et al., 1999; Sparks, 2002). In the end, the belief is that targeted, sustained, high quality professional development for teachers is essential if schools are to meet the national goal to leave no child behind by 2014.

Targeted Professional Development

Elmore (2002) states:

> The knowledge necessary for successful teaching lies in three domains: (1) deep knowledge of the subject matter and skills that are to be taught; (2) expertise in instructional practices that cut across specific subject areas, or 'general pedagogical knowledge'; and (3) expertise in instructional practices that address the problem of teaching and learning associated with specific subjects and bodies of knowledge, referred to as 'pedagogical content knowledge' (p. 17).

What teachers teach, that is, the content of instruction, plays a critical role in promoting student achievement (Fishman et al., 2003; Porter, 2002). It cannot be assumed that teachers know their content knowledge well enough to provide students with learning at the deepest levels of concepts (Ma, 1999; Ball et al., 2001; Darling-Hammond, 2000) or that they clearly understand how best to frame instruction around the concepts and skills. Teachers need solid mathematical knowledge and a firm understanding of the nature and

role of mathematical knowledge in order to teach students (Ma, 1999). For the first time in the history of education in the United States there is a federally imposed standard for determining teacher quality, and it focuses on teacher knowledge of the subject matter above every other characteristic. "It goes without saying that you cannot teach what you do not know. The notion that teachers should have strong knowledge in the subjects they teach is intuitively logical and prompts little argument" (Walsh & Snyder, 2004, p.5).

Shulman (1986) focused on the importance of teachers having deep knowledge of the subjects they teach and coined the phrase "pedagogical content knowledge." He stressed that teachers must understand their content well enough to be able to anticipate common misconceptions by students and have the ability to provide students with assistance in clearing up these misconceptions to best understand the material. Pedagogical content knowledge weaves together mathematical content knowledge with knowledge about pedagogy, knowledge about students as learners, and knowledge about the learning process itself (Ball & Bass, 2000). Others echo Shulman's views (Ball et al., 2001; Ball & Bass, 2000), and suggest that the type of knowledge teachers hold - conceptual or procedural, connected to big ideas or partitioned into isolated facts – is more important than how much knowledge they have. Researchers at the National Center for Improving Learning and Achievement in Mathematics and Science (NCISLA) found that teachers must reorient their beliefs and learn more pedagogical content knowledge in order to teach for understanding (Carpenter, Blanton, Cobb, Franke, Kaput, & McClain, 2004).

A teacher must understand his/her subject matter in ways different from how he/she might have learned it so that the teacher can understand student thinking and

misconceptions, as well as to be able to explain how and why algorithms or procedures work to help students make sense of the mathematics (Ball, 1999; Hill et al., 2004). NSDC (2001) and Loucks-Horsley et al. (2003) support this belief that it is not enough for teachers to know their content at a peripheral level but rather to know content in a deep sense and understand its conceptual complexities.

Birman et al. (2000) found that teachers prefer professional development that directly addresses content knowledge with an emphasis on appropriate teaching techniques that can effectively impact their instructional strategies. A study of 1,027 mathematics and science teachers revealed that teachers who attend professional development opportunities in which they can increase their knowledge and skill levels are more likely to change their teaching practices and thus positively impact student learning (Garet et al., 2001). Teachers in a study done by Rogers et al. (2007) echoed the same sentiment that effective professional development needs to engage participants as learners of the same content they are teaching their students. When teachers participate in professional development centered on understanding content and using higher order thinking skills, their students perform 40% of a grade level ahead of students with teachers who did not participate in the sessions (Wenglinsky, 2000).

The National Council of Teachers of Mathematics [NCTM] (1991) delineates six standards for professional development programs to follow if there is to be a link between teachers' professional learning activities and increasing student learning. These standards emphasize the need to focus on teachers' development of mathematical content knowledge as well as their pedagogical understanding of how to teach mathematics (See Appendix B). NSDC (2001) also includes focusing on deepening teacher content

knowledge as a necessary component of quality professional development programs. Both of these organizations align with the consensus view discussed by Wenglinsky (2002) and Sparks (2002) in specifying that professional development must be connected to specific issues in student learning, model research-based instructional strategies, and utilize student assessment data to inform instruction. Teachers are technical learners of new content and pedagogy, but they are also social learners which means they must "want" to re-examine current instructional practices with an eye toward improvement (Hargreaves, 1995).

Professional development must take teachers deep into understanding their subject matter. It should be rich in content, intellectually challenging, and create dissonance within the teacher to increase their interest to succeed and help them structure student learning experiences that will lead to improved achievement (Hill et al., 2005; Joyce & Showers, 2002; Killion, 2002b; NSDC, 2000; NSDC, 2001). Guskey (2003) reviewed research on the characteristics of effective professional development, analyzing thirteen lists created by national organizations such as the American Federation of Teachers, NSDC, the U. S. Department of Education, the Educational Testing Service, and The Association for Supervision and Curriculum Development. He found that the most commonly referred to characteristic was that the professional development lead to increased knowledge of content and pedagogy. This growth in teacher knowledge should then translate into better instruction built on the teacher's experiences as a learner. The next step would be for the teacher to utilize this new knowledge to inform instruction and promote student learning. Results of several longitudinal studies provide evidence of the relationship between content focused professional development and teacher use of new

practices with their students to improve instruction, noting that teachers are more likely to change their teaching practices if they participate in content focused professional development (Desimone et al., 2002; Carpenter et al., 2004).

This cycle ties together teacher learning, teacher implementation of what they learn, and student learning as a means to generate continuous improvement in schools. Therefore, one critical component of any professional development program must be to concentrate on helping teachers better understand their subject area content as well as to increase their personal understanding of how students learn the content.

Sustained Professional Development

Professional development focused on increasing teacher content knowledge is one part of the equation for improving teaching. Wenglinsky (2000) discusses a link between certain types of professional development and increased student learning in mathematics and science. He believes teachers who engage in sustained professional development in their content area are more likely to utilize effective instructional practices that support increased student achievement (Wenglinsky, 2002). Sustained is used here to indicate the professional development opportunities are offered over time and teacher learning is supported during this period.

Research compiled through NCES (2006) using the Schools and Staffing Survey (SASS) information from 2000, provides evidence that professional development which is ongoing and includes follow-up and support for teachers promotes further learning and translates into improved instruction. The study found, however, that teachers reported participating in professional development activities less than a week in length for an

average of 25 contact hours in a school year, with about half of the teachers reporting involvement in 15 hours or less of professional development each school year. Ninety-five percent of the teachers reported participating in workshops, random trainings, or short conferences with no follow-up activities to support long term change. In general, less than one in five professional development programs offered by school districts actually take place over a period of six to twelve months, while only 2% of the activities cover a period of more than one year (Porter et al., 2003). Teachers reported the most common form of support they received for professional improvement was scheduled in-service time dictated by negotiated agreements (71%), or release time with substitute coverage (53%). Both were provided intermittently and usually permitted teachers an opportunity to attend one-shot, one-topic sessions.

Lowden (2005) found that 91% of the teachers in her study participated in one-day workshop sessions and 66% participated in demonstrations or lectures. A small percentage of teachers (22%) were involved in a professional development program that unfolded over time. The teachers in Killion's study (2002b) who reported participating in more than eight hours of professional development said that it improved their teaching, but only 11% of the teachers reported participating in over 32 hours of professional development during the course of the school year. Killion found that the percentage of teachers who said participation in professional development activities improved their teaching increased substantially when they had the opportunity to participate in a program that was in-depth and extended to include over 32 hours of activities. Yet NCES data (2006) show that only about 20% to 50% of the teachers reported participating in "in-depth" professional development.

The NCLB Act defines high quality professional development programs as programs that are sustained, intensive, and classroom-focused. The legislation points out that NCLB funded professional development should not include one day, short term workshops, conferences, activities or events. Instead initiatives must involve teachers in learning that extends over a period of time and is job-embedded. High quality, effective professional development includes opportunities for practice, research, and reflection and is embedded in the teachers' work (Desimone, Smith, & Ueno, 2006; Lowden, 2004; Sparks, 2002). A national study of teachers done by Garet et al. (2001) examined the effects of types of professional development on teachers' learning. The researchers reported:

> Our results indicate that sustained and intensive professional development is more likely to have an impact…Our results also indicate that professional development that focuses on academic subject matter (content), gives the teacher opportunities for 'hands-on work' (active learning), and is integrated into the daily life of schools (coherence), is more likely to produce enhanced knowledge and skills…(pp. 935-936).

Smylie et al. (2001) investigated the effectiveness of professional development opportunities with an eye toward measuring the eventual impact on student achievement, and concluded that professional development should be "…sustained, intensive, and supported by follow-up activities" in order to be most effective (p. 14).

Project Discovery, an Ohio initiative funded by the National Science Foundation, provides evaluative evidence that sustained, high quality professional development effects student achievement. The program, designed to support educational reform within the context of systemic change, started with middle school level teachers in 1991. During the first five years of *Project Discovery* over 4,000 mathematics and science teachers participated in professional development focused on increasing teacher content

knowledge and pedagogy. Teachers were invited to participate in summer institutes, day-long seminars during the school year, biweekly seminars, electronic blackboard discussions, and annual conferences. Extensive evaluation of the first phase of the program showed that between 1995 and 1999 students in *Discovery* classes increased their passage rate on state mathematics assessments from 67% to 73%, while students in non-*Discovery* classes posted a smaller rate of improvement from 60% to 63%. Similar results were found to be true on the science assessments given by the state: *Discovery* classes increased their passage rate from 66% to 70%, while non-*Discovery* classes showed smaller gains going from 60% to 63% (Kahle & Meece, 2000). The extensive evaluation and research behind *Project Discovery* led to its expansion in 1996 to support pre-service education in mathematics and science at colleges and universities, and in 1999 expanded to include a "Model Schools" component which supported whole school reform through effective leadership. Finally, in 2000 the *Discovery* program expanded to include high school mathematics and science teachers as well. Between 1991 and 2001 the program provided professional development to 13,000 mathematics and science teachers and 350 administrators across the state of Ohio.

Project Discovery focused on the process of educational reform and on removing barriers to reform. This initiative contributed to the body of research supporting sustained professional development as a means toward systemic educational reform. *Bridging the Gap: Equity in Systemic Reform* was released in 2001 and served as an evaluative report of all the mathematics and science reform efforts in Ohio, including *Project Discovery*. The authors, Tobin, Rogg, Scantlebury and Meece noted that:

> *Bridging the Gap* resulted in several important contributions to the knowledge base on systemic reform in mathematics and science education.

> The results indicated that sustained professional development can increase the teachers' use of teaching methods aligned with the standards of the National Council of Teachers of Mathematics (NCTM) or the National Research Council (NRC)…Thus, the results support the efficacy of sustained professional development activities for increasing the use of standards-based teaching practices in mathematics and science education (p.2).

Providing professional development and follow-up support for teachers over time is critical in this age of accountability (Elmore, 2002). Teachers involved in professional development to an extended degree have time to be reflective, initiate change, evaluate change in practices, and feel a sense of growth. It takes time for individuals to develop their own capabilities, question the status quo, and internalize then develop new knowledge (Fullan, 1999). Sustained professional development coupled with ongoing support for teachers through a network of communication and opportunities to collaborate and reflect, has a very definite effect on teacher beliefs (Desimone et al., 2002; Loucks-Horsley, et al., 2003; Rogers et al., 2007). Engaging in this type of learning helps teachers appreciate the value of professional development programs and increases their desire to continue to learn (Wiggins & McTighe, 2006). This desire then translates into a willingness to utilize new learnings and practices in the classroom.

Elmore, Sparks, Wenglinsky and others support the "consensus view" of effective professional development (Appendix A). They all agree that providing targeted, sustained opportunities for adult learning over time is one key for improving instructional practices which, in turn, will effect student achievement. The road to improving student learning is long, challenging and complicated, and so is the process of high quality professional development.

The Effect of Teacher Gender and Race Interaction

Statistics documenting the existence of an achievement gap between different racial/ethnic/gender groups often lead to cries for more minority teachers, more male teachers at the elementary and middle school level, and more female teachers in advanced mathematics and science. NAEP results highlight the gender gap in both mathematics and reading. NAEP data (Dee, 2007) show that although students of both genders perform at similar levels in kindergarten, by fourth grade boys generally perform better than girls in mathematics. By eighth grade this gap increases by about 66%. The gap continues to be evident through high school and SAT data show a persistent gap in performance between boys and girls across every racial/ethnic group (Coley, 2001). Coley also points out that boys continue to outscore the girls across all racial/ethnic groups on the Graduate Record Examination (GRE) by 43 to 70 points, and on the Graduate Management Admission Test (GMAT) by 34 to 49 points. An important question to investigate then might be: "To what degree do gender, racial and ethnic dynamics in the classroom effect student outcomes"?

A very prominent, widely reviewed study has become somewhat of a cornerstone of discussions around the effects of gender on classroom interaction and student achievement. The National Education Longitudinal Study of 1988 (NELS:88) gathered data from a national cross-section of over 24,500 eighth graders and their teachers to examine the relationship between teachers' subjective evaluation and behaviors and student performance. This study is interesting since it collected data from two different teachers of each student in the sample population to study the gender dynamics in classrooms. Dee (2005, 2007) studied the data extensively and concluded that the effect

of teacher gender on student achievement, though evident, is limited and full of contradictions. His review of the data led to a conclusion that the race, gender and ethnicity of the teacher do in fact influence teacher perceptions of how well their students will perform. In addition he found that having a female teacher led to increased test performance for girls but decreased performance for boys in reading, science and social studies. In mathematics, however, both boys and girls in classes with female teachers posted significantly lower scores (7% to 8% of a standard deviation) when compared to the scores of students in classes taught by male teachers.

Dee (2007) notes that:

> The prior results suggest that assignment to an opposite-gender teacher influences the achievement of both boys and girls, and that the educational relevance of these gender interactions cannot be easily explained by the unobserved characteristics of students, teachers, or classrooms (p. 24).

He raises several issues that he cautions may be affecting the data and must be kept in mind when interpreting the results of this study with regard to mathematics: a) the impact of "passive" teacher effects on classroom interactions (i.e., actions resulting from a teacher's racial, ethnic, and gender identity such as role-model effects or stereotype threat effects); b) the impact of "active" teacher effects on classroom interactions (i.e., unintended biases on the part of the teacher with regard to behaviors toward students); c) the possibility that female teachers are more often given the "less promising" students in mathematics especially in middle school where courses are tracked based on student performance, and d) that most elementary and middle school teachers are female. Ehrenberg, Goldhaber, and Brewer (1995) interpreted the NELS:88 data somewhat differently concluding that teacher race, gender and ethnicity did not have a significant

effect on student learning, but rather created increased subjectivity on the part of teachers with regard to grading and tracking.

With regard to the effect of race within teacher/student classroom interactions and student achievement, Ferguson (1998) found that student achievement is influenced by the race of the teacher. In other words, a student who has a teacher of the same race performs better than one with a teacher of a race different from their own. Further, he found that student achievement continues to increase for students when assigned to same-race teachers for consecutive years, suggesting an additive effect of race. He coupled the explanation of his findings with a caveat that the benefits of same-race teacher/student interactions are suggestive, not definitive, noting that: "…other student, teacher, classroom or school traits may have important consequences for the racial interactions between students and teachers" (p. 208). Dee (2004) and Duffy (2001) reviewed Ferguson's data and agreed with his findings and with the caution that the results could be influenced by other unobserved teacher qualities. A review of the results of the STAR program in Tennessee led Dee to conclude that for both African-American and white students, having a teacher of their same race and gender resulted in increased gains in achievement in mathematics of between two and three percentile points per year. Data gathered in Texas schools provided further support for the theory that student outcomes increase when students are assigned to classrooms of same-race teachers (Hanushek, Kain, O'Brien, & Rivkin, 2005).

These studies utilized the black box process and though they yielded evidence to support a link between teacher and student gender and race on student achievement, they

were unable to identify exactly how the passive and active effects of teacher race might affect results for students.

Chapter Summary

> *Learning is a process of active engagement with experience. It is what people do when they want to make sense of the world. It may involve increase in skills, knowledge, understanding, values and the capacity to reflect. Effective learning leads to change, development and a desire to learn more (Unknown).*

Research provides strong evidence that a relationship exists between quality teaching and student achievement. In fact, quality teaching is thought to be the single most important factor impacting student learning over time. Quality teaching translates into student learning. Determining the characteristics of an effective high quality teacher however, has proven to be a challenge for researchers and is underscored by the new value-added models for assessing student achievement. Focusing on teacher certification, education credentials or years of experience does not yield statistically sound evidence that these observable, easily measurable characteristics have an effect on student achievement. It is essential to pursue a deeper understanding of teachers through an examination of how they learn, how they experience their work, how they grow and develop, and how they experience change in their profession (Hargreaves, 1995).

The majority of the studies cited in this review of the literature utilized linear regression, analysis of variance, or other statistical methodologies. Few studies cited in this review utilized a hierarchical linear model (HLM). Since student achievement data linked to teacher characteristics presents as "nested" data, research which does not utilize a hierarchical linear model may be limited by the constraints of the methodology. Nested data raises the question: "Should we analyze the individual or the group?" The

hierarchical nature of the data here is clear in that students are assigned to classes, the classes are part of a school, and the school is part of a school district. Raudenbush & Bryk (2002) found that it is very important not only to examine student performance over time, but also to examine the effect of variables at the different levels in order to satisfactorily determine the effect of variables at every level. HLM methodology provides an opportunity to examine the variability at each level in the hierarchy examining within-group and between-group variation. Linear modeling assumes the same effects across groups, but provides no insight into explaining the differences that occur across the groups. This is why HLM is the best choice of methodology for working with student and teacher data. The study by Decker, Mayer, and Glazerman (2004) assessing the effect of *Teach For America* teachers on student achievement, and the three-year longitudinal study by Desimone et al. (2002) are research studies that did recognize the hierarchical nature of the data and utilized HLM methodology. The use of HLM in the present study removes the constraints found in other research studies in an effort to provide a more comprehensive, statistically sound examination of the data.

The current standards-based reform movement demands change in the educational system. The focus is on continuous improvement in student learning which then points to the need for continuous improvement in teaching. This is where effective professional development can become the link between improving teacher quality and increasing student achievement (Kent, 2004). Professional development must support a re-culturing of teaching (Fullan, 1993; Hargreaves, 1995). Unfortunately, all professional development is not created equal or appreciated equally by all teachers. Some professional development opportunities ignite sparks of interest in teachers while others

turn them off. Some programs take teachers deeper into understanding content, developing pedagogical content knowledge, and transforming instructional practices (Shulman, 1986), while other programs are generic and have no lasting effect on teacher practices. The investment of district funds in some professional development programs will translate into increased student performance, while others will be regarded as a waste of time and money.

Jacob and Lefgren (2004) studied teachers in the context of participation in professional development and found that they can be divided into four categories with regard to their attitudes about professional development: a) Gourmet Omnivores – teachers who reach for opportunities to grow or initiate these opportunities and are high-activity people who desire to continue to improve their knowledge and skills; b) Active Consumers – teachers who want to grow, but do less in the way of initiating, creating or seeking out opportunities to improve; c) Passive Consumers – teachers who are amiable, conforming and generally do what they are asked to do, but seldom follow through to do anything with what they learn, and d) Reticents - teachers who push away opportunities to grow. This is something districts should keep in mind when designing professional development programs. As school districts respond to NCLB and draft continuous improvement plans, educators now realize that random acts of professional development do not generally lead to measurable improvement in student learning. The focus must be on providing teachers with opportunities for targeted, sustained, high quality professional development. The goal should be to immerse teachers in interesting activities and research-based practices centered on content knowledge to create a level of cognitive dissonance. This type of professional development when supported over time, will help

teachers get to where they need to be to support student learning and increased performance as demanded by the provision of NCLB.

CHAPTER III

METHODOLOGY

Killion (2002a) noted: "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). To definitively determine the level of effect teacher participation in professional development has on student achievement may not be possible. At best, research could gather evidence to support a link between teacher participation in professional development and student achievement.

This study examined the relationship between teacher participation in targeted, sustained professional development in mathematics (macro level) and individual student variables (micro level) on the Ohio Achievement Test for Mathematics for students in select SMART Consortium member schools. Simple descriptive statistics were utilized to review demographic data.

Data Sources

Four data sources were utilized in this study. The first data source was an electronic database secured from the SMART Consortium. This database included the names of educators from over 58 school districts who have participated in activities sponsored by the Consortium over the last seven years. The database included the names of educators (teachers and administrators) as well as their address, phone number, email address, school district, building assignment, grade level assignment, subject area assignment, and hours of participation in professional development activities sponsored by the Consortium over each of the past five years. The researcher had first hand knowledge of the quality of the professional development opportunities sponsored by the SMART Consortium during the time period under consideration, having attended most of the sessions. Sixty-nine teachers consented to be participants in the study.

The second data source was student test history and demographic data provided to school districts by the Ohio Department of Education. Some local school districts store their own data, while smaller districts contract with an A-site to manage and store data. Fourteen school districts were asked to provide student demographic information and OATM individual scaled scores for the 2006 and 2007 test administrations (also for the 2005 test administration when available) for students assigned to the mathematics classes of the teacher participants during the 2006-2007 school year.

A survey instrument (Appendix D) served as the third data source. This survey was needed in order to supplement and update the SMART Consortium database information about the teachers included in the sample. The survey was initially sent to 159 teachers. Students were not asked to complete any surveys or fill in any forms.

The fourth data source was a combination of six teacher participants and their supervising administrators and superintendents who were invited to participate in individual interviews in an effort to provide further insight into the role of professional development in our schools. Seidman (2006) points out that interviewing is grounded in:

> …an interest in understanding the lived experience of other people and the meaning they make of that experience…Interviewing provides access to the context of people's behavior and thereby provides a way for researchers to understand the meaning of that behavior (p. 9-10).

Interviewing, as a form of qualitative research, offers one the ability to uncover unexpected information that can serve to enhance quantitative findings and validate or clarify them (Hargreaves, 1995). The interview questions can be found in Appendix E.

Data Collection Procedures

Teacher Participants

Permission to collect data was obtained from the Cleveland State University Human Subjects Review Board. Permission was granted to the researcher by the SMART Consortium to access teacher records in the database. Level-2 data consisted of the mathematics teachers selected from the SMART Consortium database for inclusion in the study. One hundred fifty-nine teachers were invited to participate in the study based on their level of participation in mathematics professional development activities sponsored by the SMART Consortium during the period of time from July 1, 2004 through April 30, 2007. All the teachers were listed in the database as the teacher of record for students in grades 4, 5, 6, 7, or 8. Of this population, 50 teachers (31.5%) were identified as having participated in a minimum of 90 hours of mathematics professional development through the SMART Consortium, and were solicited for inclusion in group

A. The remaining 109 teachers (68.5%) were identified as having participated in less than 90 hours of mathematics professional development through the SMART Consortium so were solicited for inclusion in group B. The initial goal was to pair each teacher in group A with a colleague from the same district, grade level, and/or school building to be placed in group B so that clearer comparisons might be drawn using student test history data from similar student populations.

The 159 teachers identified as eligible to participate in the study received an email (Appendix C) explaining the purpose of the study, informing them of their right not to participate, and asking them to complete a short survey (Appendix D). The survey was used to verify the information stored in the SMART Consortium database and to provide additional information needed for the study. The additional information included: 1) years of teaching experience; 2) type of license/teaching certificate; 3) whether or not the teacher was certified specifically to teach mathematics; 4) the extent of the teacher's college studies in mathematics (major or minor in mathematics); 5) whether or not the teacher had earned National Board Certification, and 6) the number of hours of participation in mathematics professional development outside of those provided through the SMART Consortium, from July 1, 2004 through April 30, 2007. Participants were given the option to return the survey via email or hard copy through the United States mail. The target population was to include a minimum of 30 teachers in each group A and group B, for a total of at least 60 teacher participants.

This initial email did not yield an adequate response: only 12 teachers in group A agreed to participate and 11 in group B. Consequently a second email was sent one week later. Since the timing of the second email coincided with the week before winter break,

hard copies of the consent form and survey were also mailed to each teacher's home during the vacation break, asking that forms be returned in an enclosed, self-addressed, stamped envelope. Two follow-up emails were sent to teachers two days after they returned from winter break in an effort to increase the sample population to the minimum of 30 participants in each group. Additional follow-up requests were made through two more personally directed emails and a phone message left for each teacher at their school and/or home. The deadline for securing teacher consent was extended to allow for inclusion of a minimum of 30 teachers in group A and a minimum of 30 teachers in group B.

Of the original 159 teachers solicited for inclusion in the study, 51 (32.1%) were eliminated for a variety of reasons. Sixteen teachers (7 targeted for inclusion in group A, and 9 for group B) were eliminated when permission to access student data could not be obtained from their school districts. One teacher from group B retired at the end of the 2006-2007 school year and could not be located. Four teachers in group B could not be located after having separated from their school districts. Ten teachers declined to participate in the study (3 in group A, 7 in group B). Fifteen of the teachers who did respond to the survey (2 in group A, 13 in group B) were ineligible for inclusion in the study since they were not the identified mathematics teacher of record for students during the 2006-2007 school year, so student achievement test data could not be retrieved as linked to the teachers. These teachers were inclusion co-teachers, ESL teachers, or mathematics coaches. Perhaps this could have been avoided if the survey instrument had been more specific to include a question relative to possible participants belonging to any of the above listed groups. An additional five teachers who consented to participate in

the study had to be eliminated when their respective school districts could not retrieve the required student test history data. The remaining 39 teachers (24.5%) did not respond to the numerous invitations to participate in the study.

The population of teacher participants for the study was finalized to include 33 teachers in group A and 36 teachers in group B. Some of the originally intended pairings did not occur since this was dependent upon which teachers agreed to participate in the study. Demographic information for the study participants as well as records of participation in professional development sessions from July 1, 2004 through April 30, 2007 were retrieved from the SMART Consortium database. This sample of teachers represented 46 different school buildings in 11 school districts (1 rural school district, 4 urban/first ring school districts, and 6 suburban school districts).

One issue arose during the review of teacher information provided by the survey instrument. The question: "Are you certified to teach mathematics?" appeared to be unclear to many participants in the upper elementary grades. Technically a teacher with Ohio certification for grades 1-8, or K-8 is "certified" to teach mathematics at those grade levels, as are special education teachers. However, the question was intended to determine which teachers in the sample were state approved to specifically teach mathematics – especially at grades 7 and 8. Due to the confusion generated by this question a follow-up email was sent to each participant to obtain clarification.

Student Data

Concurrent with efforts to solicit teacher participation, the process of securing school district approval to retrieve student test history data was initiated. Personal contact was made with a central office administrator in each of the original 17 school

districts to ascertain what documents had to be submitted to request access to student data in compliance with school board policy. Only one school district required a specific request form be completed in accordance with the board policy. The other 16 districts required a letter outlining the study parameters and details of student records to be retrieved, as well as a copy of IRB approval. As a next step a letter was sent to each superintendent in the identified school districts to request permission to retrieve student test history data for selected teachers. A copy of this initial contact letter is found in Appendix F. Requests to access student data conformed to the board policies of each district, and all guidelines delineated by the school districts for use of student data were strictly adhered to throughout the study. Two superintendents did not respond to the request to access student data and one superintendent declined to have the district participate. Fourteen superintendents granted approval to access student test history data.

Once the teacher participant group was finalized, a follow-up letter was sent to the data contacts in the 11 districts to formally request student test history data for the teachers in the sample. A copy of this communication is found in Appendix G. The request was to obtain student test history data specifically linked to the teacher of record for mathematics in May of 2007. The request was for the data to be sent as a spreadsheet via email and as a CD so that data could be retrieved if the email file was corrupted. A personal phone call to the data contact person identified by each superintendent provided clarification of the request. Several follow-up or explanatory emails were also sent to keep the study moving forward in a timely manner.

Several challenges presented during the retrieval of student test history data. Follow-up conversations were necessary with select personnel in most of the school

districts to further explain the details of the request for data. This proved to be adequate to retrieve data from eight of the school districts. A first look at the retrieved data, however, revealed that two of the eight school districts returned data which appeared to be "incomplete" or problematic. A follow-up conversation with the data contacts revealed that the data provided could not be used since it linked the students to their mathematics teacher of record for the 2007-2008 school year, instead of the 2006-2007 school year. After additional explanation a new set of data was provided by these two districts that met the study requirements.

The data contacts in the six remaining school districts were unsure how to retrieve the needed student test history data since they were not responsible for managing or storing the data. In these districts the data contact serves as a liaison to an A-site. Three of these six districts granted the researcher permission to discuss the request directly with personnel from the A-site. A follow-up visit to the A-site representing these three districts proved to be successful and resulted in the retrieval of requested student test history data.

The three remaining districts presented an increased level of challenge. These districts contracted with a different A-site for data storage, and personnel at that A-site stated they were not able to retrieve the student test history data as requested. A number of phone calls to the personnel at the A-site proved to be fruitless. One last call was made to the data contacts in these three school districts in an attempt to discuss the issue and brainstorm possible alternate solutions. The suggestion was made for each district contact person to provide the researcher with student test history data for 2007 and 2006 and the researcher would merge the databases and select students for the teachers in the

study. This still proved to be a problematic for the data contacts and resulted in the elimination of the teachers from these three districts from the study.

Variables and Measures

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

Teacher-Level Variables:

Data on the following teacher-level variables were retrieved for this study:

- *TGENDER* - Gender of the teacher (Coded as: 0 = Male, 1 = Female)
- *TRACE* - Race of the teacher (Coded as: 0 = Non-minority, 1 = Minority)
- *TAGE* - Grade level the teacher taught in May of 2007 (Coded as: 1 = 4^{th} Grade, 2 = 5^{th} Grade, 3 = 6^{th} Grade, 4 = 7^{th} Grade, 5 = 8^{th} Grade)
- *TEXPER* - Years of teaching experience for the teacher
- *TLICENSE* - Type of license/certificate held by the teacher (Coded as: 1 = 2 year provisional license, 2 = 5 year professional license, 3 = Permanent teaching certificate)
- *TCERT* – Teacher was certified to teach mathematics (Coded as: 0 = No, 1 = Yes)
- *TMATH* – Level of college studies in mathematics as indicated on the teacher's transcript (Coded as: 0 = No major or minor in mathematics, 1 = Major or minor in mathematics)
- *TNBCT* – Teacher earned National Board Certification (Coded as: 0 = No, 1 = Yes)

- *PPD* - Hours of participation in targeted professional development in mathematics offered through the SMART Consortium from July 1, 2004 through June 30, 2006 for the teacher
- *CPD* - Hours of participation in targeted professional development in mathematics offered through the SMART Consortium from July 1, 2006 through April 30, 2007 for the teacher
- *PDC* - Total hours of participation in targeted professional development in mathematics offered through the SMART Consortium from July 1, 2004 through April 30, 2007 for the teacher (Coded as: 0 = less than 90 hours, 1 = 90 or more hours)
- *OPD* - Hours of participation in mathematics professional development not offered through the SMART Consortium from July 1, 2004 through April 30, 2007 for the teacher

Student-Level Variables:

Data on the following student-level variables were collected for this study:

- *SGENDER* - Gender of the student (Coded as: 0 = Male, 1= Female)
- *SRACE* - Race of the student (Coded as: 0 = Non-minority, 1 = Minority)
- *SAGE* - Grade level of the student in May of 2007 (Coded as: 1 = 4^{th} Grade, 2 = 5^{th} Grade, 3 = 6^{th} Grade, 4 = 7^{th} Grade, 5 = 8^{th} Grade)
- *SLEP* – Student is identified as limited English proficient (Coded as: 0 = No, 1 = Yes)

- *SIEP* – Student has an active IEP (Individualized Education Plan) specifying the need for accommodations and/or modifications in mathematics (Coded as: 0 = No, 1 = Yes)
- *SS07* - The scaled score for the student on the 2007 OATM
- *SS06* – The scaled score for the student on the 2006 OATM
- *SS05* – The scaled score for the student on the 2005 OATM (only available for 5th grade students during the 2006-2007 school year)
- *NORM07* – The standard score for the student as converted from their individual scaled score for the 2007 OATM (expressed in units of standard deviation)
- *NORM06* – The standard score for the student as converted from their individual scaled score for the 2006 OATM (expressed in units of standard deviation)
- *CHANGE* – The student's change in level of performance on the OATM from 2006 to 2007, found by subtracting NORM06 from NORM07
- *PASSAGE7* – Designation indicating the student scored at the proficient level or above on the 2007 OATM (Coded as: 0 = Below proficient with a scaled score less than 400, 1 = Proficient, accelerated or advanced with a scaled score of 400 or above)

Individual student test data were assigned to the student's 2006-2007 mathematics teacher of record by using blind student and teacher identification numbers.

Data Analysis

Simple descriptive statistics were used to summarize demographic data. Two statistical procedures were used to analyze the data for this study. An analysis of variance (ANOVA) was used to examine the differences between and among teacher characteristics, teacher participation in professional development, and student outcomes expressed in terms of the percentage of students who scored at the proficient level or above on the OATM for 2007. Two different level-2 hierarchical linear models were used to test the relationship between professional development and student outcomes as posed in the second and third research questions. Qualitative data were analyzed to identify thematic connections and patterns for research question four.

Rationale for Using the Hierarchical Linear Model (HLM)

Studies investigating student achievement seek to examine relationships or correlations between combinations of student characteristics, classroom characteristics, school characteristics, and school district characteristics. Researchers have found that it is difficult to separate the effects of a school or individual teacher from the effects of individual student characteristics (Raudenbush & Bryk, 2002). Student test data, for example, is referred to as being "nested" in that students are assigned to classes, the classes are part of a school, and the school is part of a school district. It is important to determine not only how student performance varies over a period of time, but also how much of this variation is due to individual student differences and how much is based on differences from class to class. Raudenbush and Bryk (2002) found that with student data nested in this way, or structured in what is considered to be a hierarchical manner,

there is a need to use a multilevel analysis in order to incorporate variables from the different levels.

These authors point out that simply aggregating or disaggregating the student data does not provide satisfactory insight into the effect of variables at every level, so it is more appropriate to use the Hierarchical Linear Model (HLM) for research in this type of educational context. This form of statistical modeling allows for the study of relationships at any level in a singular analysis while not ignoring the variability associated with each distinct level of the hierarchy. HLM provides information about within-group and between-group variation, and is still based on the assumptions of linearity and normality.

The level-2 HLM used in the context of this study sought to relate both students' scores on the OATM and the increase in students' scores over two years on the OATM, to the characteristics of the teachers to whom they are assigned. A number of independent predictor variables were included for consideration in this study, pointing to the need to use a multiple regression analysis. Since the data for this study presented in a nested structure (student data from the Ohio Achievement Test for Mathematics in each of two years for students assigned to an individual teacher's classroom), the HLM was a clear choice to best support an honest statistical analysis. The model effectively accounted for interdependence among variables since it is routinely used to support the study of how one variable might depend on a number of other variables. Raudenbush and Bryk (2002) found,

> With hierarchical linear models, each of the levels in this structure is formally represented by its own submodel. These submodels determine relationships among variables within selected levels, and how variables at one level influence relations occurring at another (p. 7).

A second level-2 HLM was then used in this study to determine the existence of a link between the growth trajectory in student achievement test scores over a two-year period and teacher participation in targeted, sustained professional development over a three-year period of time. "A fundamental phenomenon of interest in educational research is the growth of the individual learner within the organizational context of classrooms and schools" (Raudenbush & Bryk, 2002). HLM provided insight into the relationships among teacher variables such as participation in professional development, years of experience, certification, and background in mathematics, and student outcomes while also accounting for student-level and class-level variance. The model estimated the regression within each teacher's class and then looked for individual teacher characteristics that might explain the variation among classes in an effort to explain the variation in student outcomes. The level-2 HLM effectively permitted for an examination of relationships at both levels in the analysis while also examining the variability found within each level. The model was used to provide insight into the relationships identified, regardless of the statistical outcome.

Model Specifications

The first research question was addressed through the use of an analysis of variance to determine the significance of the differences in student passage rates associated with specified teacher characteristics. The variables of teacher certification in mathematics, years of teaching experience, teacher background in mathematics, and participation in professional development through the SMART Consortium from July 1, 2004 through June 30, 2006 were considered. The overwhelming majority of teacher participants were female and non-minority, so the variables of gender and race were not

included in the analysis since they would provide limited statistical power. The ANOVA effectively analyzed the relationship between the teacher variables and the percent of students scoring at the proficient level or above on the 2007 OATM.

The second and third research questions were addressed through the use of level-2 hierarchical linear models (HLM). The second research question examined the extent to which teacher characteristics could predict student performance on the 2007 OATM. This question did not take into account the level of student performance on the OATM for the previous year. On the other hand, research question three examined the extent to which teacher characteristics could predict the level of improvement in student performance on the OATM from 2006 to 2007. In both models, student data were linked to the mathematics teacher of record for 2007. Both research questions also examined the association of the teacher-level variables with the widening or narrowing of the gender gap and the minority achievement gap.

The level-2 hierarchical linear models utilized the known values of identified independent variables to predict the dependent variable of students' standard scores for 2007, along with the dependent variable of level of improvement in students' standard scores from 2006-2007. This type of analysis provided a means to assess the magnitude and direction of each independent variable's relationship to the outcome variables. The independent variables were weighted to ensure maximum predictive power in the model. The weights of each independent variable served as an indicator of that variable's relative contribution to the overall prediction in the model, and assisted in the interpretation of the influence the variable had over the prediction. Descriptive analysis was done to elaborate on the quantitative findings.

Student-Level Model (Level-1)

The student-level (level-1) model is expressed as:

$Y_{ij} = \beta_{0j} + \beta_{1j}$ (SGENDER $_{ij}$) + β_{2j} (SRACE $_{ij}$) + β_{3j} (SAGE $_{ij}$) + R_{ij} where,

Y_{ij} = individual student's standard score or level of improvement on the OATM for student *i* in a class of teacher *j*,

β_{0j} = adjusted mean OATM standard score or level of improvement for student *i* in a class of teacher *j*,

β_{1j} = gender gap in standard scores or level of improvement for students in a class of teacher *j*. This is the gap in the standard scores or level of improvement between males and females,

B_{2j} = minority achievement gap in standard scores or level of improvement for students in a class of teacher *j*. This is the gap in the average standard scores or level of improvement between minority and non-minority students,

B_{3j} = effect of student grade level on standard scores or level of improvement for students in a class of teacher *j*,

R_{ij} = residual error for student *i* in a class of teacher *j*.

It is assumed that R_{ij} is distributed normally with a mean of zero and some variance which is the same across teachers. This model is specified for each of the two outcome variables, students' standard scores on the 2007 OATM and the level of improvement in students' standard scores on the OATM from 2006 to 2007.

Teacher/Classroom-Level Model (Level-2)

The teacher-level model is expressed as:

$\beta_{0j} = \gamma_{01}(TEXPER_j) + \gamma_{01}(TCERT_j) + \gamma_{02}(TMATH_j) + \gamma_{03}(PDC_j) + \mu_{0j,}$ where,

β_{0j} = predicted mean OATM standard score or level of improvement for students in classes with teacher *j,*

$\gamma_{0n} = (\gamma_{01}, \gamma_{02}, \gamma_{03})$ are the regression coefficients associated with the teacher/classroom-level predictors (TEXPER and TCERT, TMATH, and PDC) respectively,

μ_{0j} = unique random effects associated with teacher/classroom *j*.

This model is repeated for the student-level parameters β_{1j} and $\beta_{2j.}$

Qualitative Methodology

Gathering qualitative data through an interview process is an art form. The venture of conducting in-depth interviews is a research philosophy not just a method of data collection. This philosophy is built on the premise that it takes skill built through experience to gain true insight into the lived experiences of the participants. An initial set of interview questions and participant consent forms were designed and submitted for IRB approval. The questions were used to conduct three pilot interviews (one teacher who participated in over 90 hours of professional development through the SMART Consortium, one with less than 90 hours of participation, and their central office administrator) to provide the researcher with an initial experience in conducting interviews and to determine if the questions would be sufficient to gather the information needed to enhance the study. These pilot interviews were scheduled to occur before the initial visit with targeted participants in order to provide an opportunity for question

revision. As a result of these interviews, tentative follow-up questions were designed to encourage more interaction with participants and to provide for enhanced retrieval of information.

Two teachers from group A were selected from the study sample and invited to participate in face-to-face interviews to discuss their views and experiences with professional development. Once these teachers consented to the interview process, their counterpart in group B and their respective administrators were also contacted in an effort to provide for a wider perspective. Finally the superintendents of these teachers were invited to be interviewed. It was anticipated that each set of four individuals from a school district would provide for a vertical view with anecdotal data obtained at three different levels. All subjects were interviewed individually in order to provide for a more involved experience and to guarantee confidentiality.

In line with best practices the interviews were designed using a semi-structured format. That is, there were pre-planned questions but the flow of each interview conversation determined the actual questions asked and the order in which they were discussed. This allowed respondents to include comments on other questions raised during the course of the interviews (Seidman, 2006). Each question was designed to be open-ended so that respondents could not just answer "yes" or "no", but rather would be required to provide more in-depth responses. The interviews provided insight into how the respondents made sense of their experiences with professional development.

An initial email was sent to the eight interview participants selected for this part of the study. The email served as an opportunity for the researcher to review the parameters and goals of the study, specify the format of the interviews, dates, times and

locations for the sessions, audio-taping procedures, and how confidentiality would be guaranteed. Participants were given the option to be interviewed at their job site or off-site at a location of their choice. Only one participant chose to meet off-site. The others agreed to the interview if it could be done during their work day. Teacher interviews were limited to 45 minute sessions out of respect for their wishes to have the interviews scheduled during their planning time. These interviews were conducted about one week apart. The administrators agreed to one interview each, ranging from 45 minutes to 1 hour and 50 minutes in length.

Teacher participants were reminded that they had already provided consent through their original email survey, but were presented with a copy of the consent form for their records. The administrators were asked to sign a copy of the consent form and given one for their records. All interviews were tape-recorded to provide the interviewer with the opportunity to afford each subject with a maximum level of personal attention. Non-verbal behaviors were observed and the interviewer recorded final thoughts immediately after each interview on a post-interview comment sheet. Tapes were transcribed by the interviewer and both tapes and transcriptions were secured. Participants received a thank-you note and a gift card as an expression of appreciation for their time and participation.

The role of the researcher in the interview process must be understood as affecting the process. The interaction between the participant and the researcher should be recognized and appreciated. The use of open-ended questions provided participants with an opportunity to tell their own stories, making each interview unique.

Summary

This chapter served to outline how the study was conducted. Discussion included how the participants in the study were selected, what data were targeted for collection, how the data were collected, the teacher and student variables considered for analysis, and the procedures utilized for analyzing the data. Chapter IV will examine the results of the empirical investigation.

CHAPTER IV

RESULTS

This research was primarily designed to study the relationship between teacher participation in targeted professional development in mathematics provided over a three year period of time and student performance on the Ohio Achievement Test for Mathematics. This chapter will provide the descriptive statistics about the teacher sample and their students, as well as the findings related to the research questions.

Descriptive Information

Teacher Demographics

Table I outlines the basic demographic information for the teacher population selected for inclusion in the study.

Table I

Demographic Data for Teacher Participants (n = 69)

Demographic Information	Category	Frequency (f)	Percent (P)
Gender	Male	20	29.0
	Female	49	71.0
Race	Non-Minority	63	91.4
	Minority	6	8.7
Grade Level in 2007	Four	27	39.1
	Five	9	13.0
	Six	11	15.9
	Seven	10	14.5
	Eight	12	17.4
License	Provisional	20	29.0
	Professional	29	42.0
	Permanent	20	29.0
Certification in Mathematics	No	47	68.1
	Yes	22	31.9
Level of Mathematics	No major/minor	46	66.7
	Major/minor	23	33.3
National Board Certification	No	64	92.8
	Yes	5	7.2

One hundred fifty-nine teachers were invited to participate in the study. Sixty-nine teachers (43.3%) were selected for inclusion in the study. The majority of the

teachers were female (71%) and non-minority (91.3%), which is fairly representative of teachers in grades four through eight in the region. In the group of teachers who participated in less than 90 hours of professional development, 14 were male and 22 were female. In the group who participated in 90 or more hours of professional development, only 6 teachers were male and the remaining 27 were female. The years of experience reported by teachers in the sample ranged from 1 year to 35 years, with an average of 14.8 years of experience. The mean years of experience for teachers who participated in 90 or more hours of professional development was 15.5 years, and the median was 13 years of experience. For the teachers who participated in less than 90 hours of professional development, the mean years of experience was 14.1 and the median was 10 years of experience.

The majority of the teachers in the sample (68.1%) were not certified specifically to teach mathematics. Two-thirds of the participants (66.7%) did not take enough courses during their pre-service training in college to earn a major or minor in mathematics. With regard to licensure, 20 teachers (29%) reported holding a provisional teaching license, 29 (42%) had a professional teaching license, and the remaining 20 teachers (29%) had permanent teaching certificates. Only 5 teacher participants (7.2%) reported having earned National Board Certification. The number of minority teachers and those having earned National Board Certification was not sufficient to factor into the analysis for the study. Twenty-seven participants (39.1%) taught 4^{th} grade mathematics during the 2006-2007 school year, 9 teachers (13.0%) taught 5^{th} grade, 11 teachers (15.9%) taught 6^{th} grade, 10 (14.5%) taught 7^{th} grade and 12 (17.4%) taught 8^{th} grade mathematics. Forty percent of the teachers in the sample worked in districts where less

than 15% of the students were identified as economically disadvantaged. Forty-four percent of the teachers worked in districts with 30% to 40% economically disadvantaged students, and 16% worked in districts with 50% to 75% of the students identified as economically disadvantaged.

Teacher participation in SMART Consortium professional development in mathematics ranged from 0 hours to 198 hours, with a total of 4,455 hours of participation for all the participants over the three year period under consideration. Teachers in Group A participated in an average of 123 hours of professional development through the SMART Consortium, while teachers in group B averaged 17 hours of professional development through the SMART Consortium. Participation in mathematics professional development outside of the SMART Consortium ranged from 0 hours to 283 hours, for an aggregate total of 1,499 hours for all teachers in the sample. Teachers in group A participated in an average of 30 hours of outside professional development and the teachers in group B participated in an average of 13 hours.

Student Demographics

Table II provides information outlining the demographic characteristics of the students whose test histories were retrieved for the study.

Table II

Demographic Data for Students (n = 3,817)

Demographic Information	Category	Frequency (f)	Percent (P)
Gender	Male	1,902	49.8
	Female	1,915	50.2
Race	Non-Minority	3,069	80.4
	Minority	748	19.6
Grade Level in 2007	Four	696	18.2
	Five	315	8.3
	Six	731	19.2
	Seven	921	24.1
	Eight	1,154	30.2
Limited English Proficient	No	3,783	99.1
	Yes	34	0.9
IEP for Mathematics	No	3,507	91.9
	Yes	310	8.1
2007 Scaled Score of 400+	No	627	16.4
	Yes	3,190	83.6

A total of 4,125 student test histories were retrieved for students assigned to the classes of the 69 teachers in the study, but 308 cases did not show scaled scores for both test administration dates so these cases were deleted. Table II shows the demographics for the 3,817 valid student test histories used in the study. Of these test histories, only 221 (5%) were for 5th grade students and included test scores spanning three years. The

scores for the 2005 test administration were not included in the study since the number of cases was too small to present with statistical power in the analysis. The final set of test histories presented a total of 7,634 student scaled scores.

The student population was determined by the grade level of the teacher participants in the study population, and was almost evenly divided between males (49.8%) and females (50.2%). The overwhelming majority of the students (80.4%) were non-minority students. Very few students were identified as being limited English proficient (.9%) or as having a valid IEP for mathematics (8.1%). These three variables were eliminated from the analyses of the data due to their limited statistical power. The grade level distribution of students was: 30.2% in 8th grade during the 2006-2007 school year; 24.1% in 7th grade; 19.2% in 6th grade; 8.3% in 5th grade, and 18.2% in 4th grade. Forty-one percent of the students in the study were from districts where less than 15% of the students were identified as economically disadvantaged. Forty-nine percent of the students were from districts with 30% to 40% of the student population identified as economically disadvantaged, and the remaining 10% of the students were from districts where 50% to 75% of the students were identified as economically disadvantaged.

Table III provides summary information about the student performance scores retrieved for this study. The unit of analysis here is the student as assigned to classes of the teacher participants during the 2006-2007 school year. The minimum and maximum scaled scores on the 2006 and 2007 OATM for the students assigned to the teachers in the study, and the corresponding means and standard deviations are also shown in the table.

Table III

Summary Information of Scaled Scores for Students Assigned to Teachers in the Study for the 2006-2007 School Year (n = 3,817)

Score	Maximum	Minimum	Mean	Standard Deviation
Scaled Score 2007				
Grade 4	557	354	429.22	32.19
Grade 5	509	333	428.23	33.95
Grade 6	561	316	429.80	36.39
Grade 7	501	351	420.75	22.55
Grade 8	550	333	420.95	24.53
Scaled Score 2006				
Grade 4	520	249	422.55	29.33
Grade 5	547	354	437.70	28.15
Grade 6	503	233	416.03	31.07
Grade 7	554	327	425.09	32.30
Grade 8	539	308	420.50	31.03

Scoring System for State of Ohio Achievement Tests

It is important here to provide an explanation of the scoring system used by the State of Ohio for the achievement tests being considered in this study. The State of Ohio converts the raw scores for individual students on the achievement tests to "scaled scores" for ease in identifying students with regard to established performance standards. The state performance standards are: advanced, accelerated, proficient, basic and limited.

The statistical summary document dated July 9, 2007 and found on the Ohio Department of Education website (www.ode.state.oh.us) states:

> Ohio uses the Rasch model (a single parameter logistic model) for computing item difficulties and student abilities. The Rasch model is based on the probabilities that examinees answered each item correctly. This model is used because of its widespread acceptance, its ease of use, and commercial availability of software for implementing it. The Rasch model provides estimates of the difficulties of each item on a linear scale in log-odds units, or logits (p.3).

Raw scores are integer values and scaled scores may be decimal number values so the state uses a rounding rule to match the raw score with a scaled score nearest to the performance standard.

The test items are calibrated after each test administration so that the "proficient" performance standard is always set equal to a scaled score of 400, and test forms are equated over levels of difficulty for the test items. The Ohio Department of Education gives this explanation on their testing website (www.ode.state.oh.us):

> Scaled scores are invariant while raw scores reflect minor differences in the difficulty of test items in any test administration. A scaled score of 400 for one test administration is the same as a scaled score of 400 from another administration of the same test in terms of indicating a student's overall performance, but the number of raw score points corresponding to a 400 may shift slightly from administration to administration (p. 4).

The table in Appendix H outlines a summary of test information from the Ohio Department of Education for each grade level used in this study. The maximum raw score on the Ohio Achievement Test in mathematics varies from grade level to grade level, but remains constant within individual grade levels from year to year. For example, the 3rd, 4th and 5th grade OATMs have a maximum raw score of 52 each year, the 6th and 7th grade OATMs have a maximum raw score of 50 each year, and the 8th grade OATM maximum raw score remains at 46 from year to year. The maximum scaled

score changes each year in every grade level, however. At some grade levels the change from year to year is small (i.e., 3 points in 3rd grade, 2 points in 7th grade), and at other grade levels the gap is larger (35 points in 4th grade). Looking at the 4th grade, a scaled score of 400 was equal to 25/52 correct in 2006 but 26/52 correct in 2007. For the 5th grade test, a scaled score of 400 was equal to 24/52 correct in 2006 but 25/52 correct in 2007. The raw score equivalent for a scaled score of 400 in grades 6 through 8 remained constant from 2006 to 2007. Since this study initially sought to compare individual student scaled scores from year to year, longitudinal tracking of the scaled score of 400 and the corresponding cut scores are presented in Table IV.

Table IV

Cut Score Information for the Ohio Achievement Test in Mathematics

Test Year	Grade Level	Cut Score/ Percent	Test Year	Grade Level	Cut Score/ Percent
2007	8	16/46 34.8	2006	7	16/50 32.0
2007	7	16/50 32.0	2006	6	20/50 40.0
2007	6	20/50 40.0	2006	5	24/52 46.2
2007	5	25/52 48.1	2006	4	25/52 48.1
2007	4	26/52 50.0	2006	3	34/52 65.4

The table provides evidence that a student could still be identified as proficient or above, that is having a scaled score of at least 400, yet present with a lower percentage of items correct on the test year to year. Conversely, a student with a scaled score of 400 in

one year might appear to have made no improvement, but in fact, could have responded correctly to a higher percentage of questions the next year. This dynamic creates a challenge for comparing individual student scaled scores from one year to the next with the hope of measuring growth. In essence, students shoot at a moving target in that the cut score to indicate a minimum level of proficiency on a test changes from grade to grade, and sometimes within a grade level from year to year. Consider this:

- 8th grade students in May of 2007 had to answer 32% of the items correctly when tested as 7th graders in 2006 in order to reach the proficient mark, but 34.8% correctly in 2007. If the proficient cut score in 2007 had been set at the 32% correct level as it was in 2006, students would have had to answer 14.7 items correctly to be identified as proficient instead of 16. This would have been converted to a scaled score of 396, or 4 points below the minimum of 400 needed to be proficient. In essence then, a student who answered the same percentage of items correctly each year, would have been identified as proficient in 2006, but dropped to the basic level in 2007.
- 5th grade students in May of 2007 present with three years of achievement test history. These students had to answer 59.6% of the items correctly when tested as 3rd graders in 2005, 48% correctly in 2006 as 4th graders and 48.1% correctly in 200, and 48.1% in 2007. If the proficient cut score in 2007 had been set at the 59.6% correct level as it was in 2005, students would have had to answer 31 items correctly to be identified as proficient. This would have been converted to a scaled score of 419, or 19 points higher than the minimum of 400 needed to be

proficient. This student would have been closer to the accelerated level than the proficient, even though presenting with a lower percentage of correct answers. This issue is a prime impetus behind the use of NCE scores in the Value-Added models that the state of Ohio is in the process of adopting to track student performance. By converting raw scores to NCE scores, the value-added model can efficiently account for the fact that the OATM is not calculated to be a continuous variable.

A statistically valid way to account for this variability in the true meaning of a test scaled score was to convert each student's individual scaled score to a standard score. This conversion was done to support the use of the State of Ohio student achievement data for the analytical purposes of this study. The standard score was used to determine how far away from the mean of a set of values a particular score is in terms of standard deviations. That is, when presented with the distribution of all the observed values of a variable, the standard score indicated how many standard deviation units a particular case was above or below the mean by using the mean as a reference point for comparing values. The standard score made it possible to compare several different variables for a case and put the values in perspective when they had different means and different standard deviations.

Each student's scaled score from 2006 and 2007 was converted to a standard score by taking the individual's 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. The students' standard scores for 2007

served as the outcome variable for the HLM analysis used for question two. The outcome variable for the HLM model used in research question three was the level of improvement for each of the students assigned to the teacher participants. The level of improvement for each student was determined by subtracting their 2006 standard score from their 2007 standard score.

Research Findings

Research question 1: To what extent does teacher participation in sustained, targeted professional development in mathematics predict student passage rates on the 2007 OATM?

An analysis of variance (ANOVA) was used to examine the aggregate total for the percent of students who scored at or above the proficient standard of 400 on the 2007 OATM for each teacher. The teacher characteristics of gender and race were not included in this analysis since the demographics as presented for the participants were overwhelmingly female and non-minority, thus reducing the statistical power of these two variables in the model. Findings for this analysis are found in Table V.

Table V

Analysis of Variance Results for the Relationship Between Teacher-Level Variables and the Percent of Students Performing at or Above the Proficient Level on the 2007 OATM

Factor	Levels	Mean	SD	F-value	p-value
Professional development				4.36	.041*
	< 90 Hours	.78	.18		
	90+ Hours	.86	.14		
Background in Mathematics				.93	.338
	None	.81	.18		
	Major/minor	.84	.13		
Interaction of Professional Development x Major/minor In Mathematics				.37	.547

R^2 = .071 (adjusted R squared = 2.9), *p < 0.05

The findings in Table V show that 2.9% of the variance in the rate of students performing at or above the proficient level on the 2007 OATM can be attributed to teacher participation in a minimum of 90 hours of professional development. The standard error of the estimate was 0.16 and reflects the accuracy of the prediction in this model. Only teacher participation in a minimum of 90 hours of professional development (F = 4.36, p < 0.05) significantly contributed to the model. Here the mean student passage rate was significantly different for teachers who participated in 90 or more hours of professional development (.86) versus those who participated in less than 90 hours (.78).

Teacher possession of a major or minor in mathematics (F = 0.93, p = .338) was not a significant predictor. The graph in Figure 1 shows that students assigned to

teachers who participated in a minimum of 90 hours of professional development performed better than their counterparts. Within the group of teachers who had a major or minor in mathematics, however, the students assigned to those teachers who also participated in at least 90 hours of professional development consistently outperformed their peers who were in classes with the other teachers. Although the interaction of the two factors in the model was not statistically significant, the benefit to students of being assigned to a teacher who had a major or minor in mathematics was enhanced when their teacher participated in 90 or more hours of targeted, sustained professional development.

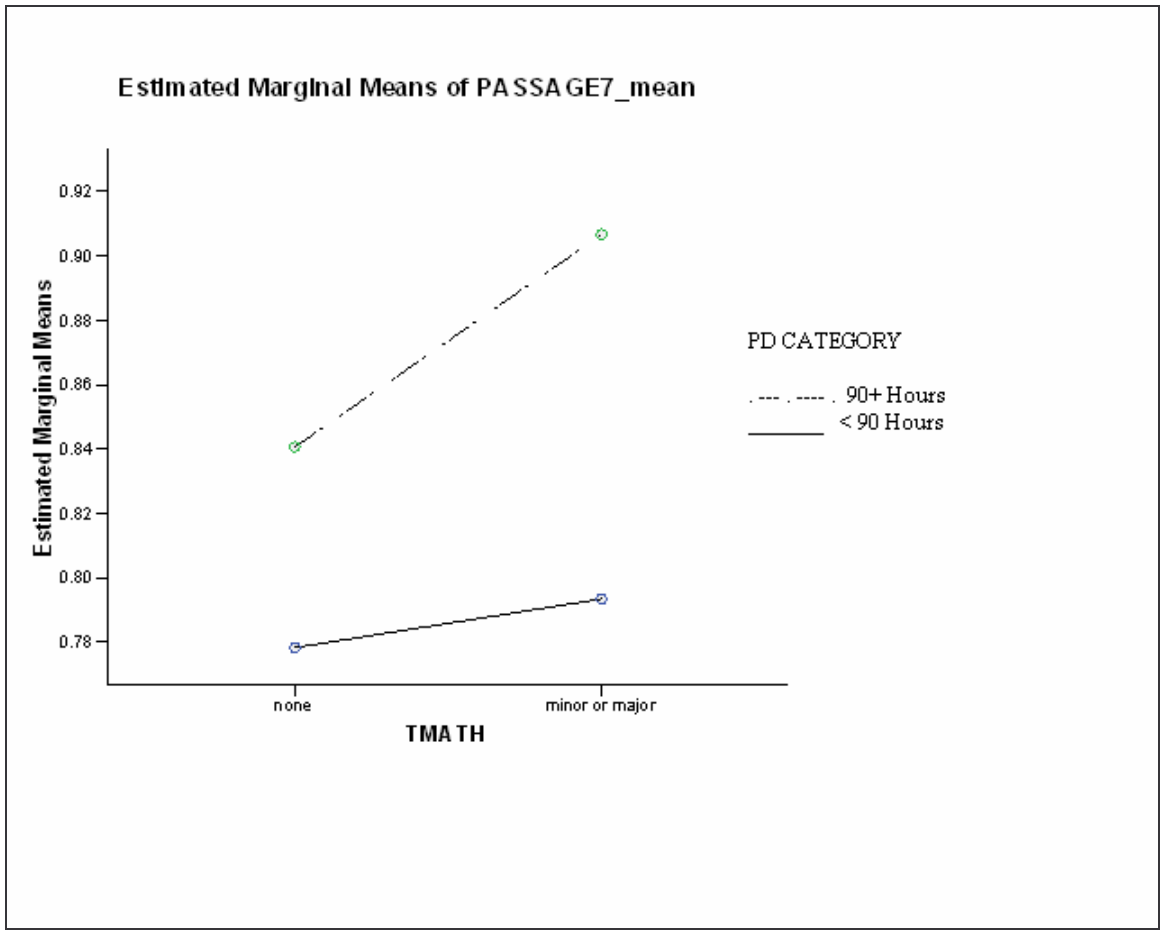


Figure 1. Estimated Marginal Means of Student Performance at the Proficient Level or Above on the 2007 OATM

Research question 2a: To what extent does teacher participation in sustained, targeted professional development in mathematics predict individual student outcomes in terms of student performance at the proficient level or above on the 2007 OATM?

This question was addressed using a level-2 HLM. In this analysis, teacher participation in professional development was recoded as a dichotomous variable with 0 = teacher participated in less than 90 hours of professional development through the SMART Consortium, and 1 = teacher participated in 90 hours or more of professional development. The findings are found in Table VI.

Table VI

HLM Results for the Relationship Between Teacher-Level Variables and Student Performance on the 2007 OATM, Expressed as Standard Scores

Teacher Characteristic	Coefficient	S. E.	p-value
Teacher Professional Development	0.29	0.11	0.014*
Teacher Years of Experience	0.02	0.01	0.037*
Teacher Certification in Mathematics	0.56	0.25	0.027*
Teacher Background in Mathematics	0.10	0.22	0.661

*$p < 0.05$

The results in Table VI indicate that teacher participation in a minimum of 90 hours of professional development ($\gamma = 0.29$, $p < 0.05$) was a significant predictor of student performance. The findings show that students with a teacher who participated in at least 90 hours of targeted professional development were predicted to have an average standard score approximately one-fourth of a standard deviation greater than students assigned to a teacher with less hours of participation in professional development. Teacher experience ($\gamma = 0.02$, $p < 0.05$) was also a significant predictor. These findings

specify that for each year of additional teaching experience the teacher had, their students were predicted to have a standard score .02 of a standard deviation higher than the other students. Teacher certification in mathematics ($\gamma = 0.56$, $p < 0.05$) was significant such that students of a teacher specifically certified to teach mathematics could be predicted to score about one-half of a standard deviation higher than their counterparts. Teacher possession of a major or minor in mathematics ($\gamma = 0.10$, $p = 0.661$) was not significant.

The graph in Figure 2 illustrates that although students in general perform better when their teachers have more years of experience, students assigned to teachers with over 90 hours of professional development consistently outscore their counterparts.

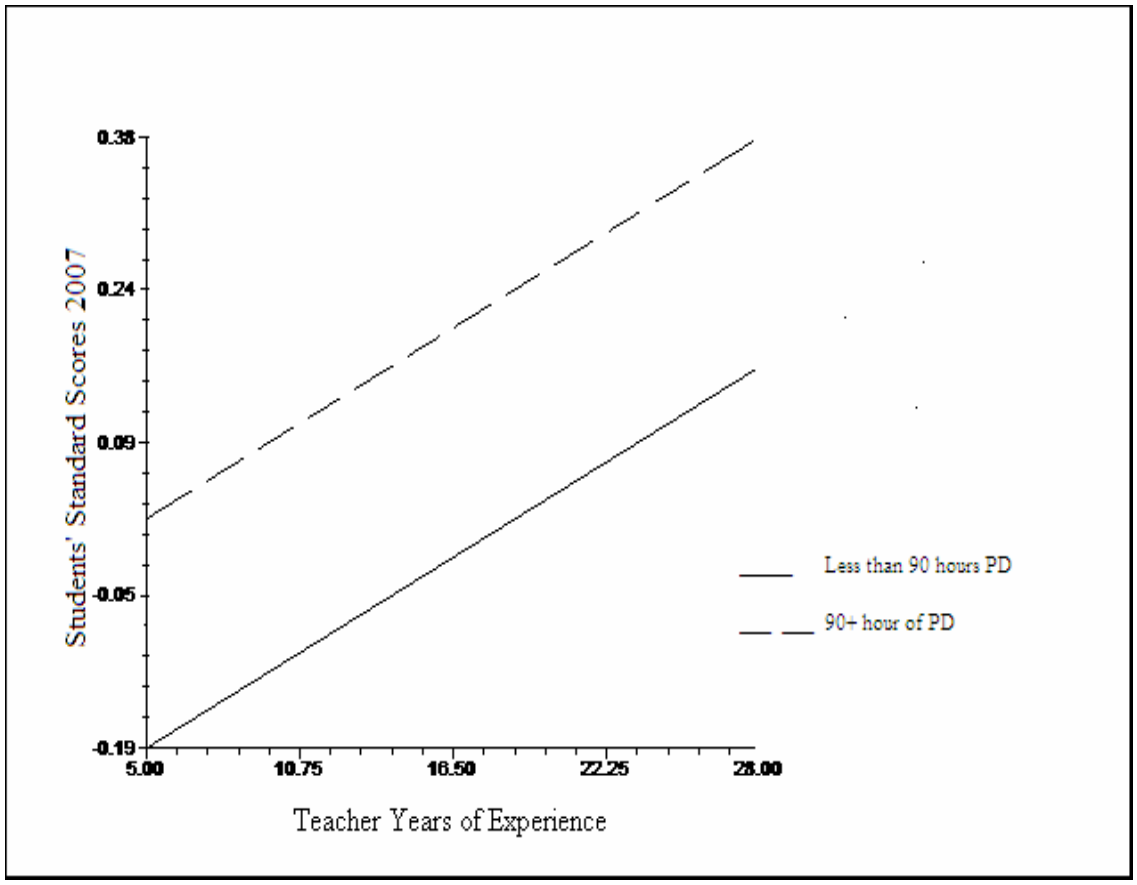


Figure 2. HLM Results Representing the Relationship Between Teacher Years of Experience and Students' Standard Scores on the 2007 OATM

Research question 2b: To what extent does teacher participation in sustained, targeted professional development predict a change in the gender gap with regard to student performance at the proficient level or above on the 2007 OATM?

Table VII presents the teacher-level results associated with the selected characteristics and the gender slope (β_1), which is an indicator of the gender gap.

Table VII

HLM Results for the Relationship Between Teacher-Level Variables and the Change in the Gender Gap (β_1) in Student Performance on the 2007 OATM, Expressed as Standard Scores

Teacher Characteristic	Coefficient	S. E.	p-value
Teacher Professional Development	-0.07	0.05	0.160
Teacher Years of Experience	0.00	0.00	0.924
Teacher Certification in Mathematics	-0.03	0.06	0.636
Teacher Background in Mathematics	-0.03	0.06	0.547

*$p < 0.05$

The findings in Table VII show that teacher experience ($\gamma = 0.00$, $p = 0.924$), teacher certification in mathematics ($\gamma = -0.03$, $p = 0.636$), and teacher background in mathematics ($\gamma = -0.03$, $p = 0.547$) were not significant predictors of a widening or narrowing of the gap in standard scores on the 2007 OATM between male and female students. Though not statistically significant at the 0.05 level, teacher participation in professional development ($\gamma = -0.07$, $p = 0.160$), was associated with a slight narrowing of the gender gap.

Research question 2c: To what extent does teacher participation in sustained, targeted professional development in mathematics predict a change in the minority achievement gap with regard to student performance at the proficient level or above on the 2007 OATM?

None of the teacher characteristics listed in Table VIII proved to be predictors of narrowing or widening the minority achievement gap *(β_2)*.

Table VIII

HLM Results for the Relationship Between Teacher-Level Variables and the Change in the Minority Achievement Gap (β_2) in Student Performance on the 2007 OATM, Expressed as Standard Scores

Teacher Characteristic	Coefficient	S. E.	p-value
Teacher Professional Development	-0.22	0.12	0.079
Teacher Years of Experience	-0.00	0.00	0.387
Teacher Certification in Mathematics	-0.39	0.33	0.238
Teacher Background in Mathematics	0.26	0.40	0.508

*$p < 0.05$

The findings listed in Table VIII indicate there was no relationship among the teacher characteristics of years of teaching experience ($\gamma = -0.00$, $p = 0.387$), certification in mathematics ($\gamma = -0.39$, $p = 0.238$), and mathematics background ($\gamma = 0.26$, $p = 0.508$) and a change in the minority achievement gap in terms of student standard scores in 2007. Participation in professional development ($\gamma = -0.22$, $p = 0.079$) was associated with a narrowing of the achievement gap between minority and non-minority students, but not at a statistically significant level.

Research question 3a: To what extent does teacher participation in sustained, targeted professional development in mathematics predict the level of improvement in student performance on the OATM from 2006 to 2007 for students assigned to the teacher's classes in 2007?

Table IX shows the HLM results for the analysis of teacher variables as predictors of the change in student performance on the OATM from 2006 to 2007.

Table IX

HLM Results for the Relationship Between Teacher-Level Variables and the Level of Improvement in Student Performance on the OATM From 2006 to 2007

Teacher Characteristic	Coefficient	S. E.	p-value
Teacher Professional Development	0.09	0.09	0.322
Teacher Years of Experience	-0.00	0.00	0.351
Teacher Certification in Mathematics	-0.13	0.14	0.345
Teacher Background in Mathematics	0.04	0.14	0.797

*$p < 0.05$

The change intercept in the model represents the average increase in level of improvement for a student from the test administration done in 2006 to the test given in 2007. The findings in Table IX show teacher years of experience ($\gamma = -0.00$, $p = 0.351$), teacher certification ($\gamma = -0.13$, $p = 0.345$), and teacher background in mathematics ($\gamma = 0.04$, $p = 0.797$) were not significant predictors for the level of improvement in student performance. Participation in professional development ($\gamma = 0.09$, $p = 0.322$) was associated with an increased level of improvement for students, though not at a statistically significant level.

Research question 3b: To what extent does teacher participation in sustained, targeted professional development in mathematics predict a change in the gender gap with regard to level of improvement in student performance on the OATM from 2006 to 2007 for students assigned to the teacher's classes in 2007?

Table X presents the teacher-level results indicating the level of association between the listed variables and a change in the gender slope (β_1), which can be seen as an indicator of a change in the gender gap.

Table X

HLM Results for the Relationship Between Teacher-Level Variables and the Change in the Gender Gap (β_1) With Regard to the Level of Improvement in Student Performance on the OATM From 2006 to 2007

Teacher Characteristic	Coefficient	S. E.	p-value
Teacher Professional Development	-0.09	0.04	0.027*
Teacher Years of Experience	0.01	0.00	0.010*
Teacher Certification in Mathematics	-0.09	0.04	0.010*
Teacher Background in Mathematics	0.03	0.03	0.230

*$p < 0.05$

The findings in Table X show that there was a relationship between the characteristics of teacher participation in professional development ($\gamma = -0.09$, $p < 0.05$), teacher experience ($\gamma = 0.01$, $p < 0.05$), and teacher certification in mathematics ($\gamma = -0.09$, $p < 0.05$) and the gap between male and female students with regard to improvement in OATM scores. Teachers' participation in 90 or more hours of targeted professional development, and teachers' certification in mathematics were associated with a narrowing of the gap between male and female students with regard to level of

improvement in student performance on the OATM by about one-tenth of a standard deviation. Teacher experience was associated with a slight widening of the gender gap by increasing the level of improvement for female students more so than male students. There was no relationship between teacher background in mathematics ($\gamma = 0.03$, $p = 0.230$) and the level of improvement in performance between male and female students.

Figure 3 illustrates the relationship between teacher experience and the change in the achievement gap for male and female students with regard to the level of improvement in OATM scores. The graph shows that female students in classes of teachers with more years of experience performed better than their male peers. The female students appeared to benefit from teacher years of experience more so than the male students, widening the achievement gap between the two groups.

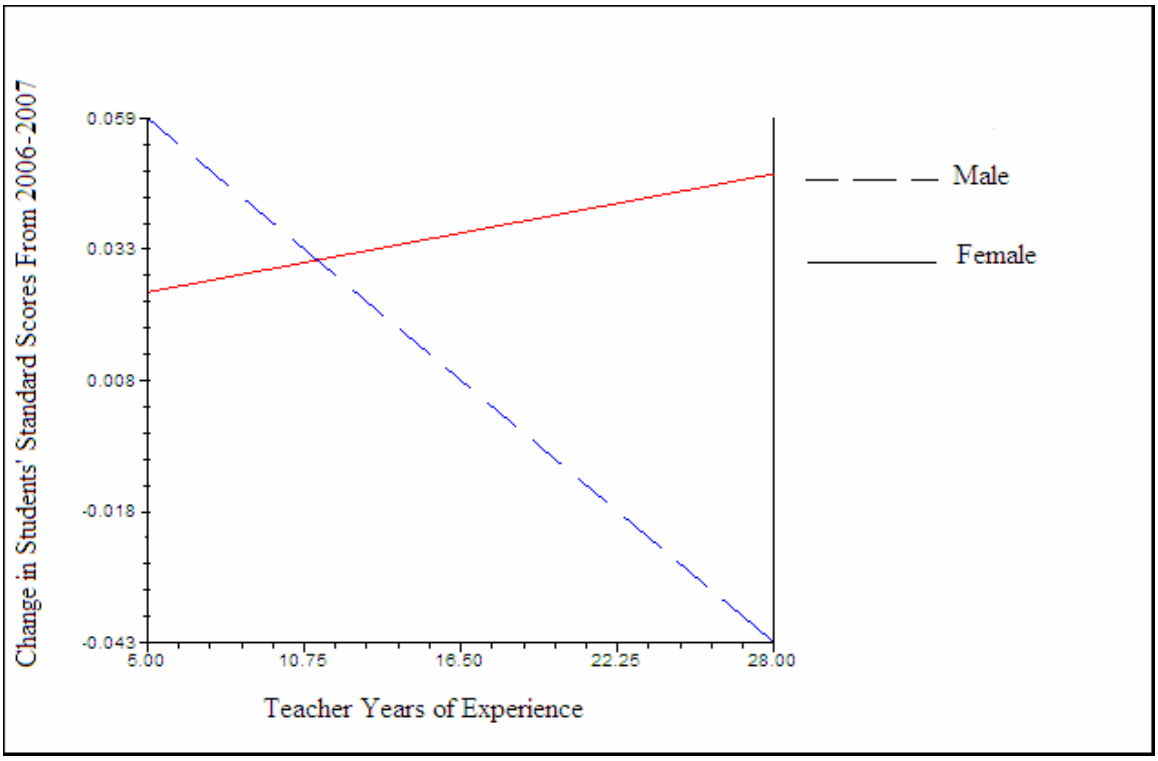


Figure 3. HLM Results Representing the Relationship Between Teacher Years of Experience and the Change in the Gender Gap (β_1) With Regard to the Level of Improvement in Students' Standard Scores From 2006 to 2007

Research question 3c: To what extent does teacher participation in sustained, targeted professional development predict a change in the minority achievement gap with regard to level of improvement in student performance on the OATM from 2006 to 2007 for students assigned to the teacher's classes in 2007?

The findings with regard to the change in the minority achievement gap are presented in Table XI.

Table XI

HLM Results for the Relationship Between Teacher-Level Variables and the Change in the Minority Achievement Gap (β_2) With Regard to the Level of Improvement in Student Performance on the OATM From 2006 to 2007

Teacher Characteristic	Coefficient	S. E.	p-value
Teacher Professional Development	-0.07	0.05	0.133
Teacher Years of Experience	-0.00	0.00	0.962
Teacher Certification in Mathematics	0.31	0.06	0.000*
Teacher Background in Mathematics	-0.29	0.07	0.000*

*$p < 0.05$

The results shown in Table XI indicate that only the two variables of teacher certification in mathematics ($\gamma = 0.31$, $p < 0.05$) and teacher background in mathematics ($\gamma = -0.29$, $p < 0.05$) were significant predictors of a change in the minority achievement gap in terms of level of improvement in student performance on the OATM from 2006 to 2007. Teacher certification in mathematics was associated with a widening of the minority achievement gap, such that there was about one-third of a standard deviation greater increase in the level of improvement in performance for non-minority students whose teachers were certified to teach mathematics. On the other hand, teacher

background in mathematics was associated with a narrowing of the minority achievement gap, such that there was about one-fourth of a standard deviation reduction in the gap in performance between non-minority and minority students. There was no relationship between the factors of years of experience ($\gamma = -0.00$, $p = 0.962$) and teacher participation in professional development ($\gamma = -0.07$, $p = 0.133$) and the level of improvement in student performance on the OATM from 2006 to 2007.

Research question 4: What views do teachers and administrators hold with regard to the value and benefits of professional development related to student achievement and personal growth?

The interviews with select participants and their administrators provided an opportunity to examine the quantitative results of the study in terms of the lived experiences of the participants. Questions focused on the definition of high quality effective professional development, the need for professional development, the role of professional development in district and personal improvement plans, the perceived relationship between participation in professional development and increased student achievement, and personal experiences with professional development opportunities. The interview tapes were transcribed and the content was examined to identify thematic connections, patterns, categories, and/or commonalities. All participants were identified by randomly assigned initials to provide for anonymity and to preserve confidentiality. Administrators' remarks were coded with an asterisk in the transcription and superintendents' remarks were coded with a double asterisk. A review of the interview transcripts provided for the identification of several major themes: (a) the need for professional development; (b) the role of professional development in driving

improvement in the school district; (c) the perceived relationship between teacher professional development and increased student achievement, and (d) professional development and personal growth.

It is essential to point out that there was a sense the administrators and superintendents generally spoke with their "public" voices which reflected their awareness of speaking on tape for a study that could be read by others. The fact that the researcher has worked alongside these administrators professionally over the last few years might have caused them to be more cautious with their remarks. On the other hand, this same level of collegiality might also have contributed to the trustworthiness of the interview data. The teachers seemed to speak freely, share their thoughts openly, and communicate with more of an "inner" voice.

The Need for Professional Development

Participants were identified by randomly assigned initials to provide for anonymity and to preserve confidentiality. All of the interview participants agreed that professional development was critical in today's educational realm. The reasons for their views, however, differed between administrators and teachers. The teachers talked about the need for professional development as a means of sharing experiences with colleagues and learning new skills to better meet the increasingly diverse needs of their students. In essence teachers expressed a desire to attend professional development sessions where they could walk out with something to use the next day in the classroom. This "make it – take it" mentality was reflected in their comments:

> A: It has to be, for me, something that is going to be usable in class…I look for a direct application for me to the class instruction.

B: [I look for] things that I can do in my classroom that help students understand the concepts…obviously it has to be heavy in content to help us as professionals understand the concepts and go back and revisit concepts so we can thoroughly understand them to be able to explain them many different ways because all kids don't get it in the same way.

C: When professional development is just informational there's no application or connection to what you're doing everyday with kids. Or it's all just done in a vacuum or in isolation and you never come back and do any of it in the classroom.

Administrators on the other hand, tended to have a more global view of professional development looking at it through the lens of fostering long-term change and compensating for gaps in teachers' pre-service learning, rather than providing a series of stop-gap activities. Their comments reflected this view:

H*: Teachers can't rely on a methods class they learned at Cleveland State in 1980, which is a whole different world…they're relying on a bag of tricks that's outdated and unless they're willing to change classroom strategies, because our population of kids has changed …that's a case for the same old tricks, never going to work anymore, and really it's a total disservice to students.

D*: I think they [teachers] even come in thinking they know what they need to know to teach. They come in, they have to experience deep levels of collaboration to get past that point…I think teachers believe they have the content, especially mathematics and science [certified teachers]. I think they all honestly believe they know what they need to teach. I also believe we have a lot of evidence that they don't.

S**: I think, in general, the greatest place we can put professional development money today is on content. I don't know if I'd have said that 10 years ago. But I'm convinced of it now. Maybe some-day that won't have to happen because maybe someday the colleges will produce teachers who have a depth of content, especially in the elementary grades, but even in the high school grades. With deeper content maybe we would need to be only providing teachers with professional development on new content…but right now we have, and we continue to get teachers, especially in the elementary and middle grades who don't have deep content knowledge…It's not the teacher's fault and it's not

> the kids' fault. I can't teach what I don't know and the kid can't learn what I can't teach. So this has to be corrected through professional development.

These comments provided a level of insight into the factors that account for why so many teachers in general, choose to participate in one-day workshops instead of professional development sustained over time.

The Role of Professional Development in Driving Improvement in the District

The teachers expressed frustration over district professional development activities they perceived as "the flavor of the month", the latest initiatives in education, or just listening to the most popular speakers on the circuit. It was difficult for teachers to articulate how their district professional development offerings come together to drive improvement in the district. They saw most of the offerings as disjointed or targeted to address issues far removed from their day-to-day experiences with students in the classroom. Teachers expressed a view of how professional development should be designed to drive improvement that differed from that given by the administrators:

> W: It seems like it's something different every time. There are some areas that I know are our main focus but I'd like to see us take one thing or two things and try it…you have to pick and choose and try one thing instead of trying everything new because it becomes overwhelming…I was at a football clinic a couple of weeks ago and the guy said something that made a lot of sense. He said, "When I was first coaching I'd spend hours and hours and hours and spend all this time trying to come up with a game plan. Then we'd go into the game and lose by 50 points! But then I had kids of my own so I couldn't spend all that time on planning for each game. So the less time I spent doing a million different things the better the team got." He had all these statistics and records to show it. He said all he did was pick a couple of things, get real good at them, and that's all he did. And when he did that, that's when his team started improving. So I thought about that related to the district. If we pick a couple of really good ideas and hit them hard, and get really good at them, maybe that's a good way to go.

A: Usually it was whatever the latest fad is that we jumped on. So we went through three years of different professional development that none of us can recall whatsoever of what they were and tsohat they were of no use to anyone.

C: It [professional development] needs to be funneled from below and shared by us…it's tough instituting so many new things at once.

Administrators pointed out that district professional development initiatives must be focused on promoting improvement at multiple levels in the district. In their view professional development should be aligned to the overarching goals of the district, not necessarily aligned with the desires of the teachers.

S**: It's thinking about professional development in different ways. This means to me…what should change as a result of professional development or the involvement in professional development, is how you think about teaching and learning. That's really vital…If you focus professional development on the goals of the school district, you have a better chance of everyone moving in the same direction and you also have a better chance of some interplay between staff that makes it even more effective. A lot of professional development needs to be broad based and focused.

H*: All of our [high quality professional development] has the same common theme – to assist teachers in developing strategies that help students achieve success in the classroom. It has to fit into our district goals.

F**: Data driven professional development [is important]…activities that yield significant student achievement gains and/or changes in instruction that you can observe. We should try to find a way to thread professional development around one topic through the entire year so that teachers aren't trying to correct everything about their instruction, rather focusing in on one thing. You're looking at what is our highest need at the moment and then moving it from there and spending the entire year on this.

These comments provided some level of insight into how teachers and administrators differed in their views with regard to the role of district driven professional development. These differences are often reflected in district level plans for professional development.

The Perceived Relationship Between Professional Development and Increased Student Achievement

The teachers and administrators readily reported a belief that teacher participation in sustained, targeted professional development in mathematics would lead to increased student achievement. The teachers held faith that participation in professional development opportunities would improve teaching and increase student achievement. The administrators agreed with the teachers, but added the caveat of requiring a level of accountability for improved student performance on the part of the teachers:

> B: Yes a sustained professional development program would affect my students because it would impact me and how I teach everything. I could learn a lot of different things in a lot of different ways that could change my teaching style from the way I grew up learning about teaching.
>
> W: For somebody who has had [high quality professional development] I think their kids would do better on the tests. If a person wouldn't have professional development they would be hit or miss with what they're teaching.
>
> H*: Absolutely! When we immerse our teachers in high quality professional development with regard to mathematics, those teachers are learning from the masters the strategies to help students succeed and excel in the classroom.
>
> S**: You should see some improvement and if you don't then I'd seriously question whether you should continue doing the professional development or maybe look into whether or not the professional development is being implemented in the classroom.

The interviewees tended to respond to the questions with their public voices, generally careful to make statements that would be perceived as politically correct. Since these comments reflected the beliefs of the participants it would be necessary to track how these thoughts translate into improved instruction and increased student achievement.

Professional Development and Personal Growth

All the teachers and administrators appeared to honestly believe that participation in professional development was important for personal growth and would continue to be a vital part of their professional lives. Their comments supported the findings of the *Campaign for Learning* and reinforced their desire to be lifelong learners:

A: I think I'll always be interested in professional development now that I've begun this route. I don't see it ending for me. I had a very wise teacher share this story – One of his favorite teachers amazed him because at the beginning of the year he'd have this beautiful clean desk and then he'd start this pile. And then a second pile would start to grow and he'd just let these piles grow until they were tipping. By the end of the year his desk had stacks all the way across, as high as it could hold. He pulled in – he wheeled in at the end of the year - a giant garbage can and swept off the desk and dumped it all in the garbage can. And he said he finally asked the guy when he saw him, "How could you possibly do that?" And he [the teacher] said "It isn't worth teaching if I don't have to think about what I'm going to teach tomorrow – it's just not worth it…I have to be able to think about how I want to teach tomorrow in order for it to be worth my while."

B: [Without continued professional development] I would probably continue to do what I do and fall into a rut like a lot of other people. I mean in that way, professional development really helps me open myself up to what works now, what works with our kids now, and with how society is always changing. I think it's important to keep growing.

C: I have to keep thinking about learning new things. I have to think that if you're not making changes, gaining insights into what you're doing, and reflecting on what you're doing, then you're not a benefit to your students at all.

W: I need to keep things interesting and learn more so I can teach things in a more interesting way…I think that teaching and learning is an ongoing process and people come up with good ideas and so I think professional development will always be a part of what I do for the next 20 to 25 years. I don't think I'll ever say "that's enough" or "I've had enough" or "I can't learn anything new". I just don't think that will ever happen for me.

G*: When you've been working as long as I have in one particular field you need that shot in the arm…to feel good about myself and my work, that's really what good professional development does. It makes you feel excited to go back to work. It makes you excited to make a difference in your life and in somebody else's. And notice what I said, make a difference in YOUR life first and then in somebody else's. Teaching is so much like the saying "If momma ain't happy, ain't nobody happy!"

D*: [High quality professional development] gets me to think deeply about something I'm already familiar with. Something that's going to create that awesome moment to say "This is the piece I've been missing" or "This is how I can get someone to…" or "This is how I fit in to the big picture".

S**: It has to bring me to a new level of awareness, of interest, of learning. It has to engage me in deeper thought and provide me with new skills or allow me to refine my current skills so that I can become better at my job.

The teachers and administrators all expressed a strong belief in the power of professional development as a means for promoting growth in themselves, their students, and the educational system as a whole. These beliefs should provide the support and impetus school districts need for designing, implementing and sustaining systemic reform.

Summary Statements

At the end of each interview session participants were asked to provide a summary statement reflective of their experiences and views on professional development. The teachers reiterated their desire to participate in professional development opportunities that provide them with concrete experiences and activities that could be replicated in their classrooms. The administrators, however, once again commented in more global terms about professional development:

G*: [Professional development] is really the heart and soul of what makes us move forward in a meaningful and cohesive way. If your professional development is cohesive at a district level, you really are going to take the district where you want them to go.

If you want to have an outstanding school district your professional development program has to be comprehensive.

H*: Well professional development is one of those critical components of a school district that's on the move to be excellent. You can't justify enough the dollars that are spent to provide those opportunities for our teachers with the understanding that when we're sending teachers to professional development opportunities, they're also giving back to the district through the implementation of those strategies in the classroom.

S**: I think that if, in fact, we want to continue to grow as a school district toward more excellence, whether you want to define that as passing the tests or other authentic kinds of growth, then we need to continue to do professional development…if I don't do any professional development then I don't think that my teachers are ultimately going to be as effective as they can be.

If personal commitment to quality professional development is necessary to move a school district forward in terms of increasing student achievement and refining teacher skills, these comments show that this level of commitment is present and should be capitalized upon in order to be a factor in promoting change.

CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

This final chapter consists of six sections. The first section provides a summary of the quantitative and qualitative findings for the study. A discussion of the relationship between teacher participation in sustained, targeted professional development, other teacher characteristics, and student achievement as demonstrated on the Ohio Achievement Test for Mathematics is presented in section two. Section three outlines implications and recommendations for practice based on study results. The limitations of the study and recommendations for future research are outlined in sections four and five. Section six provides closure with concluding remarks.

Summary of the Findings

The purpose of this study was to examine the relationship between teacher participation in sustained, targeted professional development and student performance on the Ohio Achievement Test for Mathematics, using a multilevel analysis. Teacher-level data were compiled for 69 teachers who were the mathematics teacher of record for students in grades four through eight during the 2006-2007 school year in 46 schools across 11 Northeast Ohio school districts. The teacher-level variables collected and

categorized for this study included demographic information, hours of participation in professional development provided through the SMART Consortium, and additional information obtained through a survey instrument. Student-level data included 3,817 Ohio Achievement Test in Mathematics test histories listing individual student scaled scores from 2006 and 2007, and the classification of each student as proficient or above (presenting with a scaled score of at least 400) in each of the two test years. Individual scaled scores were converted to standard scores for use in the analyses. This conversion made it possible to calculate the level of improvement in student performance from 2006 to 2007 by finding the difference of the two scores.

An analysis of variance (ANOVA) was used to examine how the aggregate total for the students who scored at the proficient level or above on the Ohio Achievement Test for Mathematics in 2007 varied by teacher participation in professional development and/or was influenced by other teacher-level variables. Teacher participation in 90 or more hours of professional development was associated with a higher student passage rate on the 2007 OATM. In addition, teachers with a major or minor in mathematics were predicted to have a higher student passage rate than their colleagues. When these same teachers with the background in mathematics also participated in 90 or more hours of professional development, passage rates for their students were predicted to be even higher.

A level-2 hierarchical linear model (HLM) was used to determine the extent to which individual student and teacher-level variables could predict student performance on the 2007 Ohio Achievement Test for Mathematics, and predict a change in the gender and minority achievement gaps. The analysis showed that student outcomes, expressed

as standard scores, were predicted to be higher for students assigned to teachers who participated in 90 or more hours of professional development, and for teachers who were certified specifically to teach mathematics. Increased years of teaching experience was associated with higher standard scores for students on the 2007 OATM. If these teachers with more years of experience also participated in a minimum of 90 hours of professional development, their students' scores were predicted to be even higher. None of the teacher-level variables were significant predictors of a change in the gap of student performance when examined by gender or race.

A second level-2 HLM was designed to predict the level of improvement in student scores on the OATM from 2006 to 2007. This model was also used to examine the extent to which the teacher-level variables could predict a change in student scores when grouped by gender and minority characteristics. The findings showed that none of the teacher-level variables proved to be predictors of the level of improvement in student performance. Teacher participation in 90 or more hours of professional development and teacher certification in mathematics were associated with a narrowing of the gap in level of improvement between male and female students. The characteristic of increased years of experience was predicted to have a widening effect on the gender gap with regard to level of improvement in student performance from 2006 to 2007. Teacher certification in mathematics was associated with a widening of the gap in level of improvement between minority and non-minority students, while teacher possession of a major or minor in mathematics was associated with a narrowing of the minority achievement gap for this outcome.

The qualitative data obtained through the interview process provided information about the value teachers and administrators place on professional development as a means to support increased student achievement and promote personal growth. The two groups viewed professional development through different lenses, with teachers focused on what can be of immediate use in their classrooms, while administrators tended to look at the bigger picture for the district as a whole. These beliefs framed their comments relative to the need for professional development. Teachers expressed the view that professional development was needed as a means to help them address the diverse needs of today's students, while administrators were more concerned with providing teachers with content knowledge to compensate for gaps in pre-service education programs. Both groups stated they believed professional development should lead to increased student achievement, but administrators sought to add a caveat that teachers should be held accountable for efforts to increase student achievement. Finally, all respondents expressed the belief that professional development must remain an important part of their professional lives.

Discussion

The teaching and learning cycle is complex, and though researchers continue to study the dynamics of this cycle, there is strong evidence that quality teaching has a positive effect on student achievement (Wenglinsky, 2002). Teaching is one of the cornerstones of the educational system and serves as a catalyst for student learning. Teachers are the heart of teaching and need to be at their best every day for every child. Learning is a result of what happens when the teacher closes the classroom door and

interacts with the students. This is why it is imperative that teachers become what Jacob and Lefgren (2004) call "gourmet omnivores," that is, professionals committed to improving their knowledge and skills through growth opportunities. Quality professional development can provide teachers with opportunities to experience cognitive dissonance, to explore the dynamics of student learning, and to be learners themselves (Ball & Cohen, 1999). "No Child Left Behind" is heralded by some as a noble goal for all educators to embrace, but the reality remains that there is no silver bullet that schools can employ to increase student achievement. To attain this goal teachers will have to continue to grow professionally, develop a deeper understanding of content matter, learn new instructional strategies, stay abreast of technology, and commit to life-long learning.

Determining how to effectively measure student achievement is a difficult and intricate process. Educators continue to struggle with what all the test data really mean in terms of student achievement. Student achievement cannot, and should not be measured using a state test score, a standardized test score, or any other singular measure of student performance which can only serve to provide a snapshot of a child's learning at a singular point in time. The OATM as previously discussed, is in essence a moving target since the cut score for minimum proficiency does not remain constant across tests or within tests at a grade level. Thus, Ohio's test system is built around a changing array of test scores, with the meaning of proficiency shifting slightly year to year and grade level to grade level. With this in mind the OATM cannot be used as the sole benchmark for measuring student achievement. Doing so may cause researchers to under or over estimate the possible changes in student achievement that can be associated with teacher participation in professional development. Therefore, until agreement is reached on what

measures can be used to best determine student achievement levels, the task of determining what factors may serve to promote increased student achievement remains unfinished.

The results of the present study do provide findings to support the existence of a positive relationship between teacher participation in sustained, targeted professional development in mathematics and student achievement as measured by the OATM. One outcome of this study was that 2.9% of the proportional variance in passage rates for students on the achievement tests was accounted for by teacher participation in professional development. This finding is consistent with research done by Goldhaber and Brewer (2000), as well as Rowen (2002), who found that teacher characteristics generally account for as little as 3% of the variance in student achievement. Since the variance is small, consideration must be given to the relationship between other variables and the change in student achievement. Nonetheless, professional development can be seen as a significant, contributing factor in the learning cycle. The study also shows that in general, students assigned to teachers with a background in mathematics had a higher passage rate on the OATM. When these teachers also participated in extensive professional development, the student passage rate for their students was even higher. This suggests that professional development can serve to enhance other teacher characteristics and provide added value to student learning.

During the interviews teachers expressed their anxiety over the pressure they feel to increase OATM passage rates in light of AYP and state generated report cards. Most school districts provide teachers with professional development opportunities to study student test data, align test items to content standards, and explore available resource

materials designed to assist with test preparation. Perhaps this professional development has prompted teachers to be more focused on mathematics content aligned to state standards and has provided them with tools to examine instructional strategies in an effort to help more students achieve the necessary level of proficiency. The relationship between teacher participation in professional development and increased student achievement should reinforce the need for professional development as a support mechanism for teachers in today's schools with today's parameters for accountability.

Though professional development was found to enhance the teacher effects in this study, a plethora of other variables such as student family background, school funding levels, course tracking, class size, and school organization could also be factors associated with changing levels of student achievement. For example, there has been a long-standing debate focused on examining how student socioeconomic status (SES) can be used to predict changes in student achievement. Some studies have shown that this variable has a greater effect on student achievement than teacher characteristics (Darling-Hammond, 1999; U.S. Department of Education, 2001a, 2001b). This is a major factor embedded in the design of the Value-Added model which professes to control for student background variables (Sanders & Horn, 1998). Since this student-level variable was not included for analysis in the current study, its influence on student achievement when coupled with teacher participation in professional development is unclear. However, since over 60% of the teachers in this study work in school districts where 30% to 75% of the student population is identified as economically disadvantaged, professional development should be designed to highlight strategies for effectively instructing this particular group of students.

An important outcome from this study was generated through an analysis of the nested nature of the data where teacher participation in professional development was determined to be associated with increased student achievement. This variable was the strongest predictor in the HLM analysis. Students assigned to teachers who participated in less than 90 hours of professional development were predicted to have lower standard scores on the 2007 OATM than their peers. This is consistent with findings in research studies done by Desimone et al. (2002), Lowden (2005), and the National Research Council (1999) that show a correlation between professional development and student achievement. The finding in this study should be used by school districts to support the investment of funds in targeted, sustained professional development at a time when they are faced with ever increasing financial constraints. Setting aside money to invest in teacher growth is often difficult to defend, but these findings can be interpreted to support the expenditure.

The fact that most of the teacher participants in this study voluntarily attended the professional development sessions at no cost to themselves or at a minimal cost to their school districts must be discussed in light of the above outcome. The professional development through the SMART Consortium was available to many teachers in the school districts, yet only 33 of the 69 teacher participants attended 90 or more hours of professional development over the three year period. This may be due to several factors. Teachers in low performing districts are often mandated to attend professional development sessions sponsored by their own school district as a reaction to low test scores on state tests. With most of these mandated sessions scheduled to occur during school hours, teachers and administrators soon reach a point where they believe

continued days out of the classroom may negatively affect the students and the learning process. When this occurs choices must be made, and very often non-district sponsored professional development opportunities are passed over. Another factor may have been revealed through the interview data which showed that teachers prefer professional development geared toward addressing their immediate needs with regard to the daily challenges of working with their students. This might be a reason some of the participants attend some sessions but opt not to attend other sessions if they feel their needs are not being met. A third factor may be that some teachers who are not certified in mathematics or do not have a strong background in mathematics, may feel uncomfortable being immersed in mathematics content. This discomfort, sometimes accompanied by a fear of being embarrassed in front of colleagues, may be why some teachers choose not to attend sessions where they will feel challenged in the subject area.

Teacher experience proved to be a significant predictor in the model. The increased student performance associated with this variable might suggest that teachers with higher years of experience are more familiar with the Ohio Achievement Test format, rigor, levels of complexity, and alignment to the benchmarks. Teachers with greater years of experience have had more opportunities to review released test items, to practice using scoring rubrics, and to review and utilize student test data to plan for instruction. Teachers with fewer years of experience may have to spend more time learning their trade so to speak, and organizing for instruction. These findings are consistent with Darling-Hammond (2000), Rivkin et al. (2005), and Hanushek et al. (2005) who found that teachers with less years of experience, especially those with less than three years of experience, generally have a neutral or even a slightly negative effect

on student achievement. Of greater interest here is the finding that although student performance was predicted to be higher for students assigned to teachers with more years of experience, when these more experienced teachers also participated in extensive professional development, this was associated with even higher levels of student performance. This provides further evidence to support the belief that there is a definite link between professional development and student achievement.

Teacher experience was associated with a widening of the gap between male and female students when the level of improvement in standard scores on the OATM from 2006 to 2007 was considered. The level of improvement for female students was greater when their teachers had more years of experience than that of their male peers. This finding shows that female students appeared to benefit from a teacher with greater years of experience more so than the male students. Research in the area of the effect of teacher gender on student performance has been limited and filled with contradictions, but Dee (2006) used the NELS:88 data and found that female students demonstrate better performance when they are assigned to female teachers, and boys when they are assigned to male teachers. Dee (2005) also found that student achievement generally decreases when the student is assigned to a teacher of the opposite sex. In this study since about half of the students were males but only 29% of the teachers were males (49 female; 20 male) this dynamic may have contributed to this finding.

Another outcome of the study showed that teacher certification in mathematics was a predictor of student standard scores for 2007 at a significant level, and was associated with a narrowing of the gender gap with regard to the level of improvement for students. Research done by Darling-Hammond (2001), Goldhaber and Brewer

(2001), and Wayne and Youngs (2003) with regard to the importance of teacher certification support these findings. This suggests that teachers who are not certified to teach mathematics may not have a strong enough understanding of mathematical content and the pedagogy necessary to help students reach a proficient level. Teachers who are certified in mathematics may have a deeper understanding of essential mathematical concepts as well as how students learn and effectively use mathematics. The finding indicates that a teacher's pedagogical and content knowledge are important factors in student learning (Ma, 1999). Another finding from this study proved to contradict the above finding in that it showed teacher certification was associated with a widening of the minority achievement gap with regard to level of improvement from 2006 to 2007.

The findings from the study indicate that teacher participation in professional development was a significant predictor for narrowing the gap in level of improvement in student scores between male and female students. Participation in professional development was also associated with a narrowing of the gender and minority-achievement gaps with regard to individual student scores in 2007, though not at statistically significant levels. These findings might suggest that teachers who have participated in extensive professional development may have a better understanding of how male and female students view learning mathematics. Through professional development opportunities these teachers may have been exposed to research, studies and national or local test data illustrating and discussing the gap in performance between male and female students, as well as students of different races (Coley, 2001; U.S. Department of Education, 2001). Heightened awareness on the part of teachers should result in more focused instruction and the implementation of a variety of teaching

strategies to help promote increased student achievement for students of both genders and all races.

The qualitative data provided additional insights into the findings from the quantitative analyses. Hargreaves (2005) found that teachers are skeptical of the "flavor of the month" reforms and this generally translates into a reluctance to embrace change. The teachers interviewed in this study questioned how most of the district professional development initiatives they had experienced have supported them in improving instruction to increase student achievement. They expressed a lack of understanding about how these initiatives relate to the day to day instruction students need in order to be successful on the state tests. To them, professional development opportunities designed at the district level are often fragmented, superficial, and not relevant to the challenges they face on a daily basis with their students. They prefer professional development sessions that are focused on actual activities that can be replicated for use in their classrooms. This finding is consistent with research that has found this to be true for teachers in most districts (Ball, 1999; Bredeson, 2002; Hargreaves, 2005; Killion, 2002b).

The administrators, however, seemed to embrace the belief that systemic change is possible only if professional development is designed to address district goals instead of individual teacher interests. They generally agreed with the findings of Jacob and Lefgren (2004) that a critical step must be to examine the nature and quality of the professional development to make the links necessary to support student achievement in an effort to promote systemic change. Since administrators generally have the responsibility for designing district professional development plans, however, it might be

that their views tend to inadvertently limit the amount of targeted, sustained professional development offered to teachers.

A sad commentary on the state of education in society today can be inferred from the comments of the teachers and the administrators who were all essentially focused on improving student performance on the Ohio Achievement Tests. This was an overriding factor in the interviews and a source of stress for all the interviewees. The interviewees commented about aligning the curriculum, creating short cycle assessments geared toward OATM type questions, reviewing test items with students, "teaching to the test", and providing for additional practice using released test items. Little mention was made of the need to foster a love of mathematics in students or to create a deeper understanding of the real value of mathematics in today's world. The focus in schools today appears to be on test preparation and remediation to meet minimum standards for proficiency, instead of on the long-term effects of quality instruction. It would appear as though the provisions of NCLB and the current measures of accountability dictated by the state of Ohio are consistently at the forefront in the minds of many educators.

Implications and Recommendations for Practice

The results of this study showed that teacher participation in sustained, targeted professional development was associated with increased student achievement. One implication from this study should be that any district or building level continuous improvement plan should include provisions for designing, implementing and sustaining high quality professional development opportunities for teachers. Providing teachers with opportunities to be learners themselves, to deepen their own understanding of

mathematics content, to discuss how students learn, and to explore effective instructional strategies should be a secured line item in a school district budget. Professional development can promote the use of effective teaching strategies designed to provide for the delivery of more focused instruction. If the sessions are sustained over time, teachers will have opportunities to try new things, reflect on their instruction, share their experiences, and commit to making long-term changes in their instructional strategies. With this in mind, school districts should invest in their teachers by providing them with job-embedded opportunities to take their mathematics knowledge to a deeper level and to more fully understand the dynamics of working with students in a focused effort to increase achievement in mathematics.

The findings showed that gains in student outcomes associated with a teacher's possession of a major or minor in mathematics were even more pronounced when the same teacher also participated in 90 or more hours of quality professional development. This suggests that professional development should be provided to all teachers, even those with a solid background in mathematics. All teachers can benefit from further exploration of mathematical concepts, student misconceptions, test data, and the sharing of resources and instructional strategies. School districts should take professional development to the next level by including time for personal reflection, action planning to redesign instruction, evaluation of student work products, and collaboration with colleagues. Well designed, high quality professional development can create cognitive dissonance within teachers and prompt them to rewrite their teaching scripts. There is reason to believe that during these rapidly changing times in the face of heightened

accountability, teachers must continue to explore new ways to meet the needs of all students.

Coupled with this need for a continued investment in professional development is the necessity to involve teachers in the planning of these opportunities so that they can more fully understand the value of sustained, targeted professional development. Teacher comments provided during the interviews made it clear that not all professional development sessions are appreciated equally by all teachers. Moving teachers away from a preference for "make-it, take-it" sessions and toward investing in long-term change will support efforts to increase student achievement. Creating teacher awareness of the positive link between professional development and student achievement, and involving them in the research and planning of sessions will help them understand the need for opportunities to be targeted and sustained over time. This will also encourage teachers to reflect upon their own learning and collaborate with colleagues to strengthen instruction for all students. It is important that teachers and administrators in a school district eventually come to common ground on this issue.

The limited proportional variance accounted for by participation in professional development opens the door for school districts to further explore the relationship between student achievement and any other set of student-related variables. Primary among these variables might be student socioeconomic status.

School districts should make every attempt to hire teachers for the middle level grades who possess a strong background in mathematics and are certified to teach mathematics. These two characteristics appear to be more powerful together and support the belief that a background in mathematics should be coupled with a firm understanding

of how students learn mathematics in order to promote increased student achievement. These teachers should then be provided with quality professional development opportunities to increase their content knowledge, pedagogical knowledge, and ultimately their effectiveness over time.

Finally, an investment in sustained professional development may also prove to be a contributing factor in narrowing the gender and minority achievement gaps by increasing teacher knowledge about mathematics content as well as strategies for the differentiation of instruction, and increase their knowledge of general learning theory. Reducing the gender and minority achievement gaps will prove to be beneficial in meeting yearly AYP requirements under NCLB, and will help all students achieve at the proficient level or above. Providing every student with a highly qualified, knowledgeable mathematics teacher can be one step toward leveling the playing field for students from all backgrounds and races.

Limitations of the Study

The following limitations of this research study should be considered when interpreting the results:

(1) The teacher sample was not randomly selected from the population across the state, so the ability to generalize results to the population is limited. The sample was initially limited by utilization of the SMART Consortium database to generate a list of possible study participants. Most of the teachers included in this database attended professional development sessions voluntarily so they may not be representative of the general teaching population. The dynamic of voluntary participation should be considered as a confounding variable. It may indicate a

teacher is motivated to participate in professional development as a growth opportunity, or it may reflect a teacher's desire to be out of the classroom and away from their students for the day. Either case would be important to take into consideration for analysis.

(2) Superintendent approval to retrieve student test history data from school districts, and the fact that some of the smaller school districts use A-sites to store their student and teacher data proved to be factors that limited the success of data retrieval efforts.

(3) The survey instrument may not have provided for an accurate and/or comprehensive insight into the totality of professional development the teachers in the sample had attended outside of that provided through the SMART Consortium. This variable was self-reported by teachers.

(4) The teachers in the study worked in 11 different school districts and this should be seen only as representative of a small cross-section of the region. It would be problematic to generalize the results of this study to other school districts.

(5) The study design did not examine other moderating or mediating external variables that may be associated with student achievement in mathematics such as: student socioeconomic status, classroom grouping for instruction, course leveling (ex: algebra, pre-algebra, integrated mathematics, general mathematics), length of classroom period for instruction, student attendance at private tutoring or after school help sessions, etc. The dynamics of each teacher's schedule with regard to teaching honors classes, inclusion classes, or remedial classes was also

not included in the study. This might have had a defined effect on the student scores and growth trajectories.

(6) The current Ohio Achievement Test for Mathematics test history data provides only two years of scores for students in grades 4, 6, 7 and 8 due to the scheduled roll-out of tests at the various grade levels. This effectively limited the predictive value of the study.

(7) The usefulness of the interview data to support the quantitative findings might be limited in that the relationships the researcher has enjoyed with the administrator interviewees could have led to some degree of unwillingness to speak honestly and openly. The administrators tended to give more politically acceptable answers using a "public" voice. The administrators and superintendents were all long-standing colleagues of the researcher. By virtue of the researcher's previous roles in public education and current status as a regional provider of professional development, there has been a regular and consistent level of interaction with these colleagues as representatives of their school districts. Therefore, caution must be taken in interpreting the comments from the superintendents and administrators. The teachers selected for the interview process seemed to speak openly and shared their views freely. The two teachers interviewed during the "pilot" phase were teachers with whom the researcher has enjoyed a collegial relationship for many years. The four teachers selected for the subsequent interviews were acquaintances with limited prior interaction with the researcher. It did not appear as though this dynamic had a noticeable impact on the teacher

interviews. This interview information should not be generalized to other superintendents, administrators or teachers outside of the sample.

Recommendations for Further Research

(1) Solicit teachers for participation in the study through professional groups, graduate school course, local district professional development committees, or through the Ohio Department of Education. This would generate a sample that is representative of a larger cross-section of teachers in the region or state, and would serve to provide insight into a wider sample from the population. If this is done, however, one issue that must be addressed is how the researcher will be able to determine that the professional development attended by the participants was of high quality, targeted, and sustained over time. This factor will then be based on subjective interpretation by a host of people and might present an additional challenge to the researcher. It is suggested that the sample include teachers who participated in professional development sessions voluntarily and those who participated when required to do so by their school district in order to explore differences that may be related to this issue.

(2) Revise the survey instrument to avoid confusion around the issue of certification to teach mathematics. Include questions to gather anecdotal information relative to each teacher's personal experiences with professional development.

(3) Request expanded student demographic data for use in the study that might include student socioeconomic status, and specific course labels (algebra, pre-algebra, gifted, etc.) or course tracking delineations.

(4) Provide for more extensive clarification of the quantitative research findings with qualitative research such as: in-depth interviews, classroom observations, and case studies. Working with teachers using a case study methodology could provide for a more in-depth understanding of the relationship between participation in professional development and student achievement. This technique could lead to valuable data that might not be obtained through other methods. Additional information about the role of professional development in supporting student achievement can be obtained by shadowing participants as they attend sessions in an effort to observe their level of participation and to document their reactions. Classroom observations could be done to gather data indicative of changes teachers make in their instructional strategies as a result of participation in professional development opportunities.

(5) Enhance the study design to determine the specific nature of professional development that might be associated with increased student achievement on state tests. Case studies, in-depth interviews, and classroom observations can be included in this design.

(6) Examine the relationship between teacher participation in professional development and other measures of student achievement.

(7) Consider the socioeconomic status of the school district in selecting the teacher participants for the study. Include districts with varying percentages of students identified as economically disadvantaged to allow for the possibility that this might be a confounding variable in the study.

Conclusion

This study was designed to investigate the relationship between sustained, targeted professional development in mathematics and student performance on the Ohio Achievement Test for Mathematics. The quantitative format of the study used an analysis of variance and level-2 hierarchical linear models to examine the relationships between teacher-level variables and student outcomes. Qualitative data provided additional insight into the quantitative findings. Results of the study indicate that this type of professional development is associated with increased student achievement in mathematics and should have implications for district continuous improvement plans.

The No Child Left Behind Act shines a spotlight on student achievement in mathematics with a goal that all students will be proficient by the year 2014. To realize this goal teachers must continue to deepen their own knowledge of mathematical concepts, increase their understanding of how students learn mathematics, and expand their repertoire of instructional strategies. Teaching may be a cultural activity, but when teachers are provided with opportunities for high quality professional development they can effectively rewrite their scripts to provide all students with a quality education. This should prove to be a vital step in promoting systemic change in our schools.

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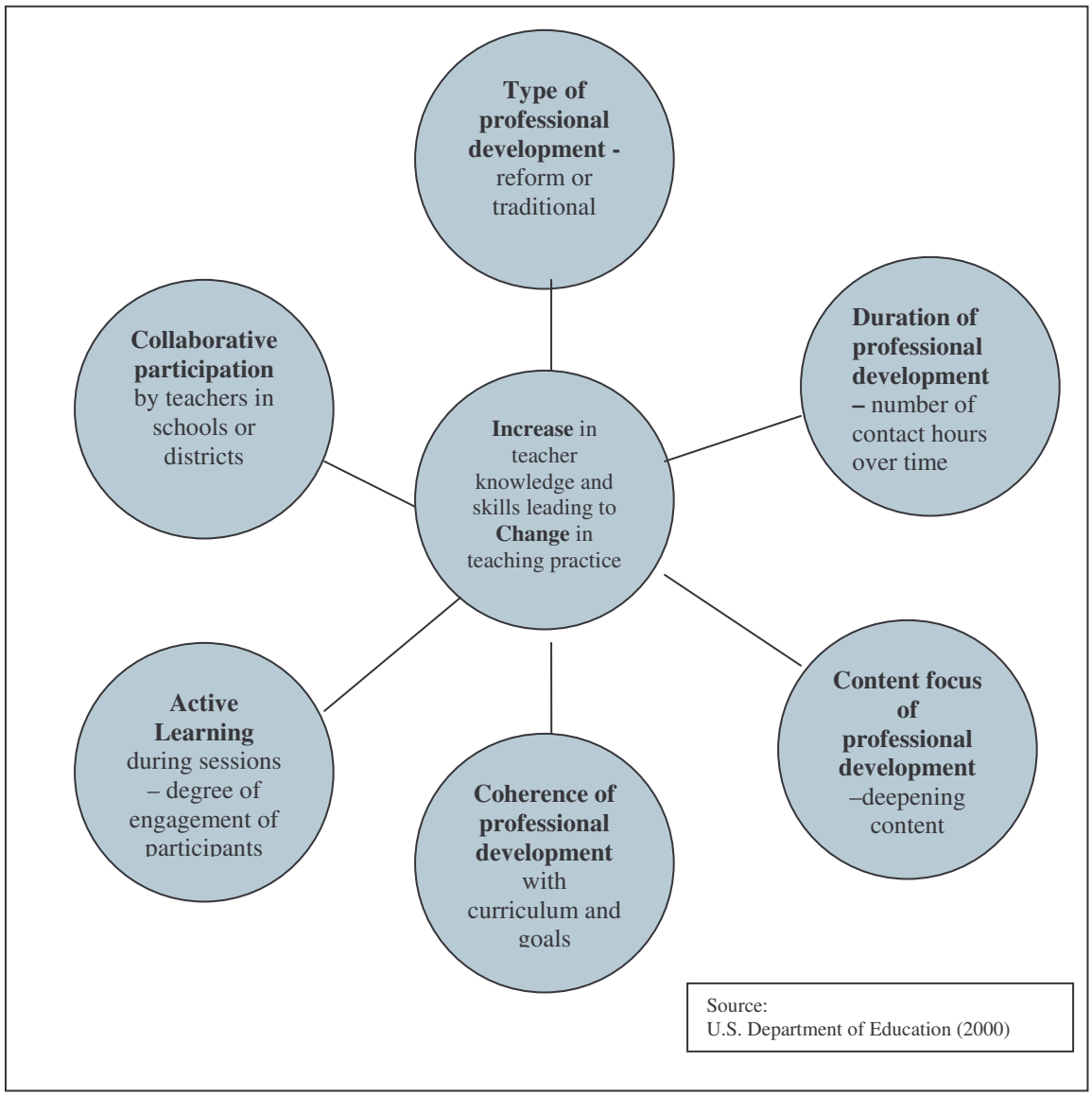
APPENDICES

APPENDIX A

Professional Development Cycle



APPENDIX B

Professional Development Standards

National Staff Development Council – *Standards for Staff Development* (2001)	National Council of Teachers of Mathematics – *Professional Standards for Teaching Mathematics* (1991)	Consensus View of Effective Professional Development in *Bridging the Gap Between Standards and Achievement* (Wenglinsky, 2002)
Context: • Organize learning communities and align goals with school and district. • Require school and district personnel to become leaders. • Provide necessary resources to support adult learning and collaboration.	**Standard 1**: Experiencing good mathematics teaching • Model good mathematics teaching by engaging teachers in mathematical discourse. **Standard 6**: Teachers' role in professional development • Encourage teachers to take an active role in their own professional development by accepting responsibility for reflecting on learning and teaching individually and with colleagues.	• Embodies a clearly articulated theory or model of adult learning. • Develops, reinforces, and sustains group work through collaborative practice with in schools and in networks across schools. • Involves active participation of school leaders and staff. • Sustains focus over time to address continuous improvement.
Process: • Use student data to determine learning priorities, monitor progress and help sustain improvement. • Use multiple sources for evaluation. • Select learning strategies appropriate to the	**Standard 3**: Knowing students as learners of mathematics • Provide multiple perspectives on students as learners of mathematics by developing teachers' knowledge of research on how students learn mathematics.	• Focuses on a well-articulated mission or purpose anchored in student learning of core disciplines and skills. • Derives from analysis of student learning of specific content in a specific setting. • Models effective

intended goal. • Apply learning theories. • Collaboration among content and education specialists.	**Standard 4**: Knowing mathematical pedagogy • Develop teachers' knowledge of and ability to use and evaluate ways to represent mathematics concepts and procedures. **Standard 5**: Developing as a teacher of mathematics • Provide teachers with opportunities to examine and revise their assumptions about the nature of mathematics, how it should be taught, and how students learn mathematics.	practice consistent with a message of continuous improvement and excellence.
Content: • Prepare teachers to provide equitable learning experiences for students. • Improve the quality of teaching by deepening teacher content knowledge; modeling research-based instructional strategies, and preparing teachers to use various forms of classroom assessment. • Provide educators with knowledge and skills to involve families and other stakeholders.	**Standard 2**: Knowing mathematics and school mathematics • Develop teacher knowledge of the content and discourse of mathematics; including mathematical concepts and procedures and the connections among them.	• Focuses on specific issues of curriculum and pedagogy derived from research and exemplary practice. • Connected with specific issues of instruction and student learning of academic disciplines and skills in the context of actual classrooms • Uses assessment and evaluation through active monitoring of student learning to provide feedback on teacher learning and practice.

APPENDIX C

Consent Form

Dear Colleague,

Many of you know me as "TAB", the Director of Professional Development for the SMART Consortium. I am a doctoral student in Urban School Administration at Cleveland State University. I am investigating the relationship between teacher participation in sustained, targeted professional development in mathematics and student achievement on the Ohio Achievement Test for Mathematics.

I will be using a sample of teachers for inclusion in my study who have participated in professional development sessions offered through the SMART Consortium during the last three school years, and student test data. It is my hope that this study will show a distinct link between professional development and increased student achievement, in an effort to encourage district funding for such support.

There are no potential risks associated with participants included in this study. Participation is voluntary and you may withdraw at any time. There is no reward for participating or consequence for not participating.

Your participation in this study will require completion of the attached survey. It should take less than 10 minutes of your time. Please return the form to me via email (atabernik@wviz.org), fax (216-916-6435) or U.S. Mail (SMART Consortium/ Ideastream, 1375 Euclid Avenue, Cleveland, 44115) by December 20, 2007. All information will be kept confidential and names will not be used in the study. The final data will be shared in aggregate form.

A subgroup of participants, along with select principals and superintendents or supervisors will be selected for an individual interview session that should take about 45 minutes. These sessions will be audiotaped. Your name, school district and other identifying information will not be used in the study, and privacy will be guaranteed. I will be the only person reviewing the audiotapes and detailed notes from the interview sessions. All information obtained during this interview will be kept confidential

If you have any questions or would like more information, please contact me at 216-916-6434, or my advisor, Dr. Paul Williams, at 216-687-3693. If you have any questions about your rights as a research subject, you may contact the CSU Institutional Review Board at 216-687-3630.

Your completion and return of this survey will be considered as consent to be a participant in the study and agreement to be audiotaped if selected for the interview process. Thank you for your help.

Sincerely,
Anna Maria Tabernik

APPENDIX D

Teacher Survey

PLEASE PRINT ALL INFORMATION

Name: _____

School: _____ **School District**: _____

Grade level you taught LAST year: _____ **This year**: _____

Subject area(s) you taught LAST year: _____

Type of certification/licensure you hold: _____ provisional

_____ professional _____ permanent

Are you a National Board Certified Teacher? _____ yes _____ no

Please list the year in which you received your NPBTS certification: _____

Total number years of teaching experience(through 6/30/07): _____

Are you certified to teach mathematics? _____ yes _____ no

Does your college transcript indicate a: _____ major in mathematics?

_____ minor in mathematics? _____ limited study in mathematics?

Please indicate the *number of hours* you participated in mathematics professional development between July 1, 2004 and April 30, 2007 *excluding* sessions sponsored by the SMART Consortium and PROM/SE.
(please specify the number of hours, such as 45 hours, 10 hours)

Number of hours of participation in:

OMAP training = _____

TeacherLine (online) coursework = _____

Lesson Lab (online) coursework = _____

i-Discovery coursework = _____

"Partnering for Success" training = _____

Other – specify name of session(s) and number of hours = _____

_____

Alternate e-mail address: _____

Return completed form by December 20, 2007 ……..

via ***FAX***, which comes directly to my computer, **216-916-6435**

e-mail (atabernik@wviz.org) or

U. S. Mail to: A.M. Tabernik, SMART Consortium/Ideastream,
1375 Euclid Avenue, Cleveland, Ohio 44115

APPENDIX E

Tentative Interview Questions

(subject to change after review of Irving Seidman's book)

(1) Please describe "high quality" mathematics professional development?

(2) What are the components of this type of professional development and why are they important?

(3) What role do you think professional development plays in promoting increased student achievement in mathematics?

(4) Describe the relationship you believe exists between teacher participation in sustained, targeted professional development in mathematics and the percentage of their students who score at the proficient level or above on the Ohio Achievement Test for Mathematics?

(5) Describe the relationship you believe exists between teacher participation in sustained, targeted professional development in mathematics and their students attaining higher individual student scaled scores on the 2007 Ohio Achievement Test for Mathematics when compared to their individual scaled score on the 2006 Ohio Achievement Test for Mathematics?

(6) Describe the role professional development plays in the district's continuous improvement plan?

(7) Describe the role professional development plays in your own professional growth plan?

APPENDIX F

Letter to Superintendent Requesting Permission to Retrieve Student Data

December 12, 2007

Superintendent
School District
XXXXX, Ohio 440XX

Dear XXXX,

I have been working with you and teachers throughout your school district as the Director of Professional Development for the SMART Consortium. In my other life, I am a student in the Cleveland State University Doctoral Program for Urban Administration, working on my dissertation.

For my dissertation I am studying the possible relationship between teacher participation in mathematics professional development through SMART, and their students' scores on the Ohio Achievement Test for Mathematics. My hope is that this research will provide you and other superintendents with valuable information relative to supporting professional development for teachers to impact student achievement.

I will be using a sample of teachers who have participated in mathematics professional development through the SMART Consortium. I will only be selecting teachers of grades 4, 5, 6, 7, 8 - and **only a limited number of teachers in any one school district** (probably no more than 10 teachers in any one district). All subjects will be assigned an ID number and no names will be used in the study.

For each teacher in my study, I would need to ask the respective school district for the demographic information and testing history (individual student scaled score *ONLY* for the Ohio Achievement Test for Mathematics) for all the students assigned to these **selected** teachers for mathematics instruction during the 2006-2007 school year. Students must be identified only using your district's randomly generated ID number, not the state testing ID or social security number. Teacher names will not be used in the study as I will assign random identification numbers during the data analysis process.

This is a possible template for organizing my data:

Student Identifier (assigned by school district)	**Teacher Name**	**Grade Level in May '07** (Ex: 04, 05, 06, 07, 08)	**Gender**	**Ethnicity** (as listed on State reports)	**LEP (yes/ No)**	**IEP in Math (yes/ No)**	**Individual Student Scaled Score for math OAT '07**	**Individual Student Scaled Score for math OAT '06**
								*****include individual student scaled score for math OAT '05 if available**

My timeline would necessitate retrieving student test score data within two to three weeks of this letter. I have attached a copy of an email from the Cleveland State University IRB (Institutional Review Board) granting me approval to collect data for my study. This letter will serve as a formal request to retrieve student data. Please let me know if I have been granted permission, by you, to obtain student test data for use in my study

If you have any questions, please feel free to contact me via email: atabernik@wviz.org; or phone: 216-916-6434 (cell: 440-241-7090). My CSU committee chair is Dr. Paul Williams and he can be reached at 216-687-3693 if you have additional questions.

Thank you so much for your assistance. I am looking forward to completing my study and hope the results will prove to be useful to participating school districts.

Sincerely,

Anna Maria Tabernik

Please complete this form and fax it to: TAB at **216-916-6435**

or send it via USMail to:

Anna Maria Tabernik
SMART Consortium/ideastream
Ideacenter
1375 Euclid Avenue
Cleveland, Ohio 44115

Approval is granted to Anna Maria Tabernik to request student test history and demographic data ____yes ____no

School District: _____

District data contact person: _____

Data contact person's phone number: _____

Data contact person's email address: _____

Superintendent's Signature: _____

APPENDIX G

Letter to District Data Contact Requesting Student Data

January 15, 2008

XXXX
School District
XXXXX, Ohio 440XX

Dear XXXX,

I am contacting you as recommended by your superintendent, XXXX, to retrieve student test history data for use in my dissertation study. I am studying the possible relationship between teacher participation in mathematics professional development through SMART, and their students' scores on the Ohio Achievement Test for Mathematics. My hope is that this research will provide school district superintendents with valuable information relative to supporting professional development for teachers to impact student achievement.

I have obtained written consent from the teachers listed in the chart below. Since I am interested in linking the teacher with their students from the 2006-2007 school year, I have listed the grade level the teacher taught last school year (some teachers have changed for this year). An asterisk next to the grade indicates the teacher is assigned to a different grade level this school year.

TEACHER NAME	SCHOOL	GRADE LEVEL or record in May, 2007

Teacher names will not be used in the study as I will assign random identification numbers during the data analysis process.

Your superintendent has granted me written permission to ask you for the demographic information and testing history (individual student scaled score *ONLY* for the Ohio Achievement Test for Mathematics) for all the students assigned to the

above listed teachers for mathematics instruction during the 2006-2007 school year. Students must be identified only using your district's randomly generated ID number, not the state testing ID or social security number, and must be "linked" to their 06 - 07 mathematics teacher. **This link is critical to maintain.**

This is a template for organizing my data:

Student Identifier (assigned by school district)	**Teacher Name**	**Grade Level in May '07** (Ex: 04, 05, 06, 07, 08)	**Gender**	**Ethnicity** (as listed on State reports)	**LEP (yes/ No)**	**IEP in Math (yes/ No)**	**Individual Student Scaled Score for math OAT '07**	**Individual Student Scaled Score for math OAT '06**
								*****include individual student scaled score for math OAT '05 if available**

My request is for student scaled scores for the mathematics Ohio Achievement Test **ONLY**, for the 2006-2007, 2005-2006 school years…..and for students who were in the 5th grade last year (due to testing implementation) please also include the mathematics scaled score for the 2004-2005 testing cycle.

I would appreciate if you could retrieve the above mentioned student test history data for the selected teachers in your school district, send it to me via email (atabernik@wviz.org) as an excel spreadsheet similar to the sample above. If possible, please also burn the information to a CD for my use. The CD will serve as a backup so I won't have to bother you again should the file attached to the email not open properly. If you would call me when the CD is ready (216-916-6434 or 440-241-7090 cell), I can pick it up from your central office, or feel free to send it to my home: A.M.Tabernik; 6623 Woodhawk Drive, Mayfield Hts., Ohio 44124.

I indicated to your superintendent that my timeline would necessitate retrieving student test score data by February 1st. Please let me know via email or phone if this date is problematic for you. If you have any questions, please feel free to contact me via email: atabernik@wviz.org; or phone: 216-916-6434 (cell: 440-241-7090). .

Thank you so much for your assistance. I am looking forward to completing my study and hope the results will prove to be useful to participating school districts.

Sincerely,

Anna Maria Tabernik
Director of Professional Development
SMART Consortium

APPENDIX H

Statistical Summary Information for the Ohio Achievement Tests in Mathematics

Grade Level	N	Scaled Score Mean	Min. Scaled Score	Max. Scaled Score	Scaled Score Standard Deviation	Scaled Score SEM	Reliability
2007							
Grade 4	128,135	420.11	231	584	32.93	11.63	0.88
Grade 5	128,730	409.16	240	552	34.50	11.04	0.90
Grade 6	132,776	423.11	232	587	38.25	12.67	0.89
Grade 7	135,991	414.00	273	569	27.09	10.32	0.85
Grade 8	139,826	412.77	278	550	25.63	9.76	0.85
2006							
Grade 4	129,087	421.70	249	549	32.70	10.99	0.89
Grade 5	132,254	407.38	247	547	30.94	10.51	0.88
Grade 6	135,645	416.15	233	579	34.98	12.19	0.88
Grade 7	141,030	410.29	271	560	30.07	10.24	0.88
Grade 8	141,290	412.51	290	534	26.75	9.25	0.88
2005							
Grade 3	129,490	414.86	239	520	29.99	10.47	0.88

Percentage of students at or above the proficient level for performance in mathematics:

Grade Level of Test	2007	2006	2005
3	NA	NA	70.19
4	76.7	76.9	
5	60.7	62.4	
6	73.7	68.2	
7	70.9	63.0	
8	71.2	68.4	

Grade 3 Ohio Achievement Test for Mathematics

Year	Grade Max Raw Score	Grade Raw Score Mean	Grade Max Scaled Score	Grade Min Scaled Score	Grade Scaled Score Mean	Proficient Cut Score; Scaled Score of 400 = ?	Number of Students Tested
2007	52	38.61	523	241	424.27	31/52 (59.6%)	129,977
2006	52	38.26	520	239	418.43	34/52 (65.4%)	128,911
2005	52	35.27	520	239	414.86	31/52 (59.6%)	129,490

Grade 4 Ohio Achievement Test for Mathematics

Year	Grade Max Raw Score	Grade Raw Score Mean	Grade Max Scaled Score	Grade Min Scaled Score	Grade Scaled Score Mean	Proficient Cut Score; Scaled Score of 400 = ?	Number of Students Tested
2007	52	31.61	584	231	420.11	26/52 (50%)	128,135
2006	52	32.51	549	249	421.70	25/52 (48.1%)	129,087
2005	N/A						

Grade 5 Ohio Achievement Test for Mathematics

Year	Grade Max Raw Score	Grade Raw Score Mean	Grade Max Scaled Score	Grade Min Scaled Score	Grade Scaled Score Mean	Proficient Cut Score; Scaled Score of 400 = ?	Number of Students Tested
2007	52	27.65	552	240	409.16	25/52 (48.1%)	128,730
2006	52	27.12	547	247	407.38	24/52 (46.2%)	132,254
2005	N/A						

Grade 6 Ohio Achievement Test for Mathematics

Year	Grade Max Raw Score	Grade Raw Score Mean	Grade Max Scaled Score	Grade Min Scaled Score	Grade Scaled Score Mean	Proficient Cut Score; Scaled Score of 400 = ?	Number of Students Tested
2007	50	29.98	587	232	423.11	20/50 (40%)	132,776
2006	5	25.37	579	233	416.15	20/50 (40%)	135,645
2005	N/A						

Grade 7 Ohio Achievement Test for Mathematics

Year	Grade Max Raw Score	Grade Raw Score Mean	Grade Max Scaled Score	Grade Min Scaled Score	Grade Scaled Score Mean	Proficient Cut Score; Scaled Score of 400 = ?	Number of Students Tested
2007	50	21.46	569	273	414.00	16/50 (32%)	135,991
2006	50	20.48	560	271	410.29	16/50 (32%)	141,030
2005	N/A						

Grade 8 Ohio Achievement Test for Mathematics

Year	Grade Max Raw Score	Grade Raw Score Mean	Grade Max Scaled Score	Grade Min Scaled Score	Grade Scaled Score Mean	Proficient Cut Score; Scaled Score of 400 = ?	Number of Students Tested
2007	46	21.39	550	278	412.77	16/46 (34.8%)	139,645
2006	46	21.30	534	290	412.51	16/46 (34.8%)	141,290
2005	N/A						

Source: Ohio Department of Education website: www.ode.state.oh.us