THE IMPACT OF PROFESSIONAL DEVELOPMENT ON STUDENT ACHIEVEMENT AS MEASURED BY MATH AND SCIENCE CURRICULUM-BASED ASSESSMENTS

Deidre A. Parish, Ph.D.

Dissertation Prepared for the Degree of

DOCTOR OF EDUCATION

UNIVERSITY OF NORTH TEXAS

August 2013

APPROVED:

Jimmy Byrd, Major Professor
Mark Davis, Minor Professor
John Brooks, Committee Member
Linda Stromberg, Committee Member
Nancy Nelson, Chair of the Department of Teacher Education and Administration
Jerry Thomas, Dean of the College of Education
Mark Wardell, Dean of the Toulouse Graduate School

Parish, Deidre A. *The Impact of Professional Development on Student Achievement as Measured by Math and Science Curriculum-Based Assessments.* Doctor of Education (Educational Administration), August 2013, 81 pp., 11 tables, references, 63 titles.

The purpose of this study was to explore the impact of teacher professional development on student achievement measured by scores on curriculum-based assessments, CBAs. The participants in the study included 260 3rd, 4th, and 5th grade math and science teachers. Teacher participation in professional development courses was collected for curriculum, instruction, differentiation, assessment, technology integration, and continuous improvement credit types. Achievement data for 8,454 students was used: 2,883 in 3rd grade, 2,752 in 4th grade, and 2,819 in 5th grade.

The dependent variable of student achievement was dichotomized at the median: half of the student participants scored above the median and half of the students scored at and below the median. A series of logistic regression models were fit to the data that included examining all main effects and interaction terms among all variables to determine the best fitting model.

The results of this study indicate that for 4th grade science, teacher professional development participation in curriculum, instruction, and differentiation credit strands increased the chances for students to score above the district median on CBAs. The larger number of professional development hours in a variety of credit strands had a negative impact on student achievement in 4th grade science. In 5th grade science, the students whose teacher spent more hours in professional learning for continuous improvement had an increased likelihood of scoring above the district median on CBAs.

ACKNOWLEDGMENTS

I would like to express my appreciation to Dr. Jimmy Byrd, the chairman of my Dissertation Committee, for the opportunity to research the professional development topic. I would also like to thank Dr. Mike Waldrip for crunching data and helping me with statistics. I could not have completed this Dissertation without the other members of my committee: Dr. Mark Davis, Dr. John Brooks, and Dr. Linda Stromberg. I sincerely appreciate your guidance and support.

I would like to thank the school district in which this research was conducted as well as the participants who took the time to answer the survey questions.

This dissertation would still be incomplete without the support from my family. I would like to thank Dr. Overton Parish IV, my husband, for his table contributions and unfailing support. I would also like to acknowledge Catherine and Isabella, our two precious teenage daughters, for their patience and understanding. My time belongs to you now.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

In many school districts, toward the end of the school year, teachers choose professional development sessions for the summer and for the upcoming school year. The sessions sometimes are chosen as a result of a summative conference and principal recommendation, but teachers often have a variety of choices. Attendance at the sessions could be a requirement for the teaching assignment or the sessions could be chosen because of title, interest, or preferred timing in the summer months. Despite the reason for the choices, in most cases, teachers must attend professional development sessions, not only for district professional development requirements, but also to meet the professional development state requirements for certification renewal. Does the random personal selection of professional learning have an impact on student achievement? Which types of professional development would be most likely to have a positive effect on student learning? To avoid haphazard and ineffective professional development, an “attempt to identify what instructional attributes of a method impact the effectiveness of that method for different training content” needs to be made (Arthur, Bennett, Edens, & Bell, 2003, p. 243).

Statement of Problem

“The implicit logic of focusing on professional development as a means of improving student achievement is that high quality professional development will produce superior teaching in classrooms, which will, in turn, translate into higher levels of student achievement” (Supovitz & Turner, 2000, p. 965). Methods and content for effective, high quality professional development must be identified. Darling-Hammond (1998) lists what teachers need to know in order to educate a very diverse student population. Teachers need to know and understand course content and the applicable content connections. They must deliver the content in a way that engages the learners. They must interpret learner statements, actions, and experiences so that they can support the students' growth in cognitive, social, physical, and emotional domains. They must understand the different ways students learn and they must use different strategies to address each learning style, all the while considering any specific student learning disability or need that might exist, including language acquisition. Teachers need to know and be able to access curriculum resources and technology applications relevant to student exploration and learning. They must nurture collaboration both for students and for themselves professionally. Furthermore, teachers must analyze, reflect, and assess their teaching practices and the impact their instruction has on students so that they can adjust and improve their lessons. Most importantly, while remembering the numerous and compounded aforementioned challenges, teachers also must motivate students to learn. Therefore, teachers must have powerful learning opportunities to develop the sophisticated teaching practice required for student learning (Darling-Hammond, 1998; Desimone, 2009).

Research conducted on the relationship between professional development, teaching practices, and student learning improvements is lacking (Hill, 2007; Huffman, Thomas, & Lawrenz, 2003; Guskey & Yoon, 2009; Johnson, Kahle, & Fargo, 2007; Loucks-Horsley & Matsumoto, 1999; Scher & O'Reilly, 2009). According to Guskey and Yoon (2009), the field of professional development practitioners needs "trustworthy, verifiable, replicable, and comparative data" collected from "small, carefully controlled, pilot studies designed to test [the professional development strategy] effectiveness" (pp. 498-499). Guskey and Yoon (2009) reviewed nine investigations and present the following findings. Workshops or summer institutes focused on research-based instructional practices with hands-on active learning experiences showed a positive relationship between professional development and student learning. Professional development involving outside experts, such as authors or researchers who shared their knowledge directly with teachers and then helped facilitate implementation, resulted in student learning. Specifically, train-the-trainer approach, peer coaching, and collaborative problem solving were not included in the successful practices, most likely due to the nonexistence of reliable evidence. The authors consider the essential element of time. Guskey and Yoon (2009) conclude that "effective professional development requires considerable time, and that time must be well organized, carefully structured, purposefully directed, and focused on content or pedagogy or both" (p. 497). In their analysis, no common set of professional development activities or designs were identified as having an impact on student learning outcomes.

Results from surveys presented by Hill (2007) suggest that content specific professional development is more common, but "the short duration of most teachers' professional development opportunities suggests that their experiences may be superficial or fragmented" (p. 17). However, Hill (2007) states that professional development can enhance teaching and learning and teacher learning can lead to increased student performance. She presents the following general principles:

1. Increasing the time invested pays off in terms of effects on teaching and learning.

2. Content that focuses on subject-matter-specific instruction and student learning, including student work or assessment results, matters.

3. Teachers' professional development should be aligned with and support the instructional goals, school improvement efforts, and curriculum materials in teachers' schools.

4. Collective participation of entire schools and "active" learning lead to improved teaching and student outcomes. (pp. 120-121)

Hill (2007) claims that there is little evidence that professional development has a positive effect on teaching and learning due to "the sheer paucity of data about outcomes…even more seldom do researchers investigate the effect on student learning" (p. 122). The capacity to perform rigorous evaluations is limited so districts are without data to drive professional development planning and opportunities. Hill (2007) also mentions the lack of effort shown by teachers to engage in professional learning, although they are required to attend the sessions.

Hill (2009) reports most teachers only attend the state or district's required minimum number of professional development hours. Teachers claim to have little use for their learning, which indicates the problem of transfer from their learning session to implementation in the classroom. The author also mentions the likelihood of too much professional development from varying sources leading to a decrease in instructional coherence as a result of dissonance between state and local district or presenter and campus initiatives. Hill recommends content based on empirical study and improved quality of experiences so that teachers perceive the benefit of the professional development. In fact, Hill (2007) states that "as more data from state, district, and formative assessments become available, continuing education can be crafted to fill gaps in teachers' knowledge and skills that can lead to poor student performance" (p. 124).

Theoretical Framework

Reeves (2010) identifies four areas that have the greatest impact on student achievement: teaching, curriculum, assessment, and leadership. High impact professional learning requires all four. The focus on teaching is about deliberate practice with the opportunity to apply feedback immediately for improved performance. Teachers are able to maximize student achievement when they are supported by school and system leaders who give them time, the professional learning opportunities, and the respect that are essential for effective teaching (Reeves, 2010). According to Reeves (2010), leaders must focus on three essential elements: (1) student achievement as the criterion for evaluating teaching, the curriculum, and assessment strategies; (2) equity of educational opportunity of common curriculum, assessments, and expectations; and (3) developing educational leaders through professional learning. Reeves (2010) states that, “sustained capacity building for high-impact learning depends on the development of teacher leadership” (p. 71). He defines high-impact professional learning with three essential characteristics: (1) a focus on student learning, (2) rigorous measurement of adult decisions about student learning, and (3) a focus on people and practices, not programs. Effective professional learning is intensive and sustained, is directly relevant to the needs of teachers and students, and provides opportunities for application, practice, reflection, and reinforcement (Reeves, 2010).

Schmoker (2012) claims professional learning must be focused on curriculum, literacy, and instruction. A coherent curriculum has the greatest impact on student success. Teachers must teach a guaranteed and viable curriculum to every student every day in every classroom. Student success is monitored by periodic common assessments. Curriculum is inseparable from literacy: “Curricula and literacy are linked inextricably; together, they are the keys to academic and career success and to informed, effective citizenship” (p. 20). Teachers must be comfortable with having students read and write in their classrooms regardless of the content area and must be able to defend the relevance of literacy to that content area. Schmoker (2012) describes a structured lesson as “a good lesson [when it] starts with a clear learning target that is derived from the curriculum and is often accompanied by an effort to stimulate student’s curiosity or existing knowledge about what is to be learned” (p. 21). Professional development must prepare teachers to focus on these elements and implement the coherent curriculum, engaging literacy, and good instruction consistently.

Professional development opportunities that build on one another can positively affect teachers’ work. Desimone (2011) claims that “a professional development activity is more likely to be effective in improving teachers’ knowledge and skills if it forms a coherent part of a wider set of opportunities for teacher learning and development” (p. 65). Her dimensions of coherence include professional learning that must build on what teachers already know and content aligned with national, state, and local standards, curriculum, and assessment. According to Desimone (2011), teachers struggle with professional development that is not coherent because they must deal with the frustration of learning things that are not consistent with received policy messages. Coherence contributes to professional development effectiveness, but without a clear direction from accountability, the professional learning has no impact on either teacher instruction or student achievement.

Blankstein (2010) provides an example of a school district using data to guide professional development. The Nebraska school district under study has developed a curriculum-based assessment system aligned with district and state standards. The district uses the results to guide teacher teams and to target professional development efforts. According to the book's quote by consultant Jay McTighe, the district's professional development programs are data-driven and focused on areas indicated by the scores on the assessments. The district is able to monitor and adjust professional learning in response to the data (Blankstein, 2010). In the Japanese Lesson Study process (Fernandez & Chokshi, 2002), the specific goal of the work is identified using student data collected from observations, interviews, test scores, and special assignments. Colleagues learn together, reflect, and grow professionally based on the needs of the students. The data are providing the professional development direction for the district.

Guskey (2012) describes the steps in a process for successful professional learning. In agreement with Blankstein, he says the key to professional learning endeavors is determining the appropriate student learning outcome for data collection. In a study Guskey conducted in 2007, he found that administrators perceived large-scale state assessments and nationally normed standardized exams to be valid indicators of student achievement; whereas, teachers valued classroom assessments, common formative assessments, and portfolios of student work as sources of evidence. Teachers thought that large-scale assessments did not show student achievement as they are based on once-a-year administration and delayed results. Teachers did not find the results from the large-scale assessments useful. Guskey (2012) concludes that results can be validated by using a comparison group similar to the district or campus, but not involved in the current study.

With a valid measure, professional learning can be purposeful and results-driven. According to Guskey (2005), the objectives of professional development are (1) to make a difference in teaching, (2) to help educators reach high standards, and (3) ultimately to have a positive impact on students. Guskey recommends evaluating professional development activities to determine if the goals of the activities are met. He presents five critical levels of information collected and analyzed as shown in Table 1.

The five levels move from simple to more complex. Although each level builds on the one before, evaluation can be done at any level to improve the quality of professional learning programs and activities. Guskey (2005) states, “tracking the program’s effectiveness at one level tells you nothing about the impact of the program at the next” (p. 16). He further claims that in planning professional development to impact student achievement, educators must backwards plan, starting with the final student learning outcome to be achieved. Determining what works best to achieve the desired student outcome “depends on where, when, and with whom” (Guskey, 2005, p. 17). Planning professional development must begin with what students are expected to know and be able to do. Suggested by Guskey (2005), measures of student learning in Level 5 can be assessment results, portfolio evaluations, marks or grades, and scores from standardized tests. In addition, he recommends affective measures and psychomotor outcomes, such as students’ self-concepts, study habits, school attendance, homework completion rates, and classroom behaviors.

Table 1

Five Levels of Professional Development Evaluation

EVALUATION LEVEL	WHAT QUESTIONS ARE ADDRESSED?	HOW WILL INFORMATION BE GATHERED?	WHAT IS MEASURED OR ASSESSED?	HOW WILL INFORMATION BE USED?
1. PARTICIPANTS' REACTIONS	Did they like it? Was their time well-spent? Did the material make sense? Will it be useful? Was the leader knowledgeable and helpful? Were the refreshments fresh and tasty? Was the room the right temperature? Were the chairs comfortable?	Questionnaires or surveys administered at the end of the session	Initial satisfaction with the experience	To improve program design and delivery
2. PARTICIPANTS' LEARNING	Did participants acquire the intended knowledge and skills?	Paper-and-pencil instruments Simulations Demonstrations Participant reflections (oral and/or written) Participant portfolios	New knowledge and skills of participants	To improve program content, format, and organization
3. ORGANIZATIONAL SUPPORT AND CHANGE	Were sufficient resources made available? Were problems addressed quickly and efficiently? Was implementation advocated, facilitated, and supported? Were success recognized and shared? Was the support public and overt? What was the impact on the organization? Did it affect organizational climate and procedures?	Minutes from follow-up meetings Questionnaires Structured interviews with participants and district or school administrators District and school records Participant portfolios	The organization's advocacy, support, accommodation, facilitation, and recognition	To document and improve organizational support To inform future change efforts

(*table continues*)

Table 1 (*continued*).

EVALUATION LEVEL	WHAT QUESTIONS ARE ADDRESSED?	HOW WILL INFORMATION BE GATHERED?	WHAT IS MEASURED OR ASSESSED?	HOW WILL INFORMATION BE USED?
4. PARTICIPANTS' USE OF NEW KNOWLEDGE AND SKILLS	Did participants effectively apply the new knowledge and skills?	Questionnaires Structured interviews with participants and their supervisors Participant reflections (oral and/or written) Participant portfolios Direct observations Video or audiotapes	Degree and quality of implementation	To document and improve the implementation of program content
5. STUDENT LEARNING OUTCOMES	What was the impact on students? Did it affect student performance or achievement? Did it influence students' physical or emotional well-being? Are students more confident as learners? Is student attendance improving? Are dropouts decreasing?	Student records School records Questionnaires Structured interviews with students, parents, teachers, and/or administrators Participant portfolios	Student learning outcomes Cognitive (performance and achievement) Affective (attitudes and dispositions) Psychomotor (skills and behaviors)	To focus and improve all aspects of program design, implementation, and follow-up To demonstrate the overall impact of professional development

Note: Guskey, 2005, p. 14.

Used formatively, Level 5 outcomes can help guide professional development design, implementation, and follow-up, and show the overall impact of professional learning.

Purpose of the Study

Teacher effectiveness influences student behavior more than any other factor (Sparks & Hirsh, 2000; Loucks-Horsley & Matsumoto, 1999). “Because teachers cannot teach content they have not learned, nor use methods that are unknown to them, the nation needs to expand opportunities for teachers to develop new knowledge and skills necessary to ensure the highest levels of student learning” (Sparks & Hirsh, 2000, p. 42). Sparks and Hirsh refer to a Texas study of 900 districts that found 40% of the difference in student achievement and most of the performance gap between White and African-American students could be explained by teacher expertise. The authors claim that “effective professional development makes the connection between subject matter and pedagogy” (Sparks & Hirsh, 2000, p. 42).

In Article III: Assessments for Learning in the Public Education Visioning Institute’s *Creating a New Vision for Public Education in Texas* (2008), several supporting premises are mentioned. The second premise reads as follows:

> Assessments used by teachers are the most critical for improving instruction and student learning, and to be effective must reflect certain characteristics, be interpreted properly in context, and reported clearly. Conducting good assessments is a part of the art and science of good teaching that results from teacher experiences and formal teacher professional development opportunities. (Visioning Institute, 2008, p.15)

The purpose of this study is to explore the impact of teacher professional development on student achievement measured by scores on teacher-made, district-wide, curriculum-based assessments. In the selected district used for this study, a variety of opportunities for professional development are offered for non-contract credit. Math and science teachers participate in courses hosted in-district or out-of-district, ranging from 3-hour sessions up to 30-hour institutes. Presenters are from in-district or out-of-district. Math and science teachers are required to have a minimum of 12 non-contract hours during the summer to exchange for the Monday and Tuesday contract days before the Thanksgiving holiday. Teachers choose their own professional development activities. This study explores the impact of the professional development sessions these teachers choose. The question is what professional development has the greatest impact on student achievement as measured by student scores on math and science curriculum based assessments. The answer to the question will provide more purpose and focus in planning professional learning. Not only will the study yield more valid evidence on the effectiveness of current activities, but will also inform the direction of future professional learning.

Summary

Effective professional learning that is focused on student learning can impact student achievement. Schmoker (2012) claims that “if we simplified professional development and focused it on the right priorities, educators would be poised to achieve swift, unprecedented gains in student learning” (p. 68). However, the lack of measurable evidence of the relationship between professional development and student achievement causes uncertainty when planning and implementing professional learning for teachers. Those responsible for providing professional development for teachers in a school district need a way to evaluate the impact of the offered sessions on student learning. According to Scher and O’Reilly (2009), “the ultimate policy question is whether a program improves student achievement. Thus, there is merit in understanding whether professional development programs influence student achievement outcomes, which programs are more or less effective, and for whom even if we don’t understand thoroughly the why of a program’s success” (p. 217). The results of this study will contribute to filling the research gap that exists concerning the relationship between teacher professional development and student achievement in math and science.

CHAPTER 2

REVIEW OF THE LITERATURE

According to Arthur, Bennett, Edens, and Bell (2003), individual development is "one of the most pervasive methods for enhancing the productivity of individuals and communicating organizational goals to new personnel" (p. 234). In the authors' meta-analysis of training and evaluation, the effectiveness of development was related to demands such as marketplace superiority, employee knowledge and skill level, and increasing outcomes. They claim that learned skills must be performed in order for the transfer of skills to occur from learning to demonstrating. The results from the study "suggest that the effectiveness of organizational training appears to vary as a function of the specified training delivery method, the skill or task being trained, and the criterion used to operationalize effectiveness" (Arthur et al., 2003, p. 243). Routman (2002) extends the emphasis on professional development to education: "when teachers are well informed – by learning theory and relevant research, as well as by careful reflection on their own experiences – they can make confident decisions about teaching practices" (p. 32). Productivity of teachers results in increased student achievement.

Professional Development Requirements for Educators in Texas

No Child Left Behind (2002) dictates that states ensure that their teachers receive high-quality professional development. In Texas, teacher certificate renewal and continuing professional education requirements are specified in the Texas Administrative Code (TAC), Title 19, Part 7, Chapter 232, Subchapter A. Subchapter A contains 13 rules concerning general certification provisions. Rule 232.1 states:

> All educators should model the philosophy of life-long learning; therefore, participation in professional development activities is expected of all educators. Activities must focus on the need of each educator to continually update his or her knowledge of current content, best practices, research, and technology that is relevant to his or her individual role as an educator. The State Board for Educator Certification (SBEC) shall ensure that requirements for renewal and continuing professional education are flexible to allow each individual educator to identify the activities he or she will complete to satisfy the SBEC's requirements. (TAC, 2012)

Based on the state expectation, during a five-year renewal period, teachers with a Standard Classroom Teacher Certificate must complete 150 clock-hours of continuing professional education (CPE), as stated in Rule 232.13. The continuing professional education hours can be earned through college classes taken from an accredited institution of higher education. However, 80% of the CPE hours must be directly related and focused on the standards required for the certificate being renewed. The professional development topics should include the following:

1. District and campus priorities and objectives
2. Child development, including research on how children learn
3. Classroom management
4. Applicable federal and state laws
5. Diversity and special needs of student populations
6. Increasing and maintaining parental involvement
7. Integration of technology into educational practices
8. Ensuring that students read on or above grade level
9. Diagnosing and removing obstacles to student achievement
10. Instructional practices (TAC, Rule 232.11)

Teachers are encouraged to choose activities based on results of summative appraisals required under Texas Education Code, Chapter 21, Subchapter H. According to Rule 232.15, acceptable types of continuing professional education activities include: institutes, workshops, seminars, conferences, interactive distance learning, video conferencing, online activities, and approved district in-service or campus staff development; undergraduate courses, graduate courses, or training programs taken through an accredited organization recognized by the Texas Higher Education Coordinating Board; independent study, not to exceed 20% of the CBE clock-hours; developing, teaching, or presenting a CPE activity, not to exceed 10% of the required clock-hours; and, acting as mentor to another teacher, not to exceed 30% of the CBE clock-hours. The independent study may include self-study of books, journals, periodicals, video and audio tapes, computer software, interactive distance learning, video conferencing, or online activities; developing curriculum; or authoring a publication (TAC, Title 19, Part 7).

Based on statutes that govern public education passed by the Texas Legislature, the Texas Education Code (TEC) also specifies staff development requirements, specifically in reference to standards developed by the district to improve education in the district. The TEC, Title 2, Subtitle D, Chapter 21, Subchapter A, Section 21.451 confirms that staff development may include training in technology, conflict resolution, discipline strategies, all aspects of bullying, and scientifically based research as defined by Section 9101, No Child Left Behind Act of 2001 (20 U.S.C. Section 7801) as related to students with disabilities. TEC Sections 21.454 and 21.455 specifically address mathematics training and development. The mathematics trainings are designed to help mathematics teachers gain expertise in curriculum and instructional approaches in order to improve student mathematics skills. The institutes in mathematics as identified in TEC Section 21.455 are for teachers who teach fifth through eighth grade mathematics. The institutes address alignment of mathematics skills taught at certain grade levels and proven, effective, mathematical instruction techniques. Selected teachers are invited to attend the state professional development institute in mathematics. In TEC Section 21.456, professional development for science teachers focuses on appropriate science curriculum and instructional approaches that will improve student science skills. The trainings for both mathematics and science are available to teachers through distance learning, mentoring programs, small group inquiries, computer-assisted training, and trainer-of-trainer models, as specified in the legislation (Texas Education Code).

Hill (2007) identifies two categories under the term continuing education: (1) graduate-level courses for credit and degrees and (2) “professional development” programs. Hill (2007) refers to several studies that “examine the effects of teacher characteristics on high school students’ mathematics achievement [and] find that [teachers] having a master’s degree in mathematics significantly predicts student gains” (p. 113). Teachers are two to three times more likely to participate in professional development offered by the district than to enroll in a college or university course (Little, 1989; Bigpond, 2006). Hill (2007) further explains that “professional development in the United States consists of a hodgepodge of providers, formats, philosophies, and content” (p. 114). The structure of learning opportunities and the content vary widely. Yoon, Duncan, Lee, Scarloss, and Shapley (2007) and Greiman (2010) contribute the finding that an average of 49 hours of continuing professional development in a year improved student achievement, but less than 14 hours had no effect on student learning. Wenglinsky (2002) claims that the amount of time spent in professional development is not significantly related to student achievement; however, professional learning in higher-order thinking skills, special populations, and hands-on learning were positively related to student achievement. In fact, students who were engaged in hands-on learning scored higher on the 1996 NAEP mathematics assessment.

Professional Development Standards

Learning Forward, formerly the National Staff Development Council released the revised standards for professional learning in 2011. The new standards require interactive, applicable, sustained, and job-embedded professional learning that relates to increased student learning. All of the standards begin the same way, “Professional learning that increases educator effectiveness and results for all students…” (Learning Forward, 2011). Then, the seven focal points are described:

1. Learning communities committed to continuous improvement, collective responsibility for student achievement, alignment, and accountability
2. Leadership builders who develop capacity, advocate, and create support systems for professional learning
3. Resources available, prioritized, monitored, and coordinated
4. Data from many sources used to plan, assess, and evaluate professional learning
5. Learning design based on theories, research, and models of adult and student learning to promote active engagement
6. Implementation and sustainment of support for long-term change by extending learning over time and providing constructive feedback

7. Outcomes based on the coherence of educator performance of appropriate strategies and student learning of curriculum standards (Learning Forward, 2011)

If the intention for professional learning is to build educator capacity and to increase student achievement, then the seven Learning Forward standards are mandatory.

Outcomes based on the guaranteed and viable curriculum for every student in every classroom every day cause teachers to engage in practical learning that will affect student behaviors and learning directly. Professional learning is more effective when the learning builds on previous professional learning and is followed up with more advanced learning later. The alignment builds a coherent progression of learning opportunities for ongoing professional development (Learning Forward, 2011).

Hirsh and Killion (2009) provide principles to consider for sustained professional development. The principles are strong, underlying beliefs that drive our actions. The authors base the principles on four assumptions: (1) context matters for sustainability; (2) capacity of the people involved matters; (3) learning informs actions directly related to student learning; and (4) not all content is the perfect solution for the specific challenge. Rather than providing steps to a process, Hirsh and Killion (2009) name eight principles for sustained professional learning focused on student achievement:

1. Principles shape our thoughts, words, and actions.
2. Diversity strengthens an organization and improves its results.
3. Leaders are responsible for building the capacity in individuals, teams, and organizations to be leaders and learners.
4. Ambitious goals lead to powerful actions and remarkable results.
5. Maintaining the focus of professional learning on teaching and student learning produces academic success.
6. Evaluation strengthens performance and results.

7. Communities can solve their most complex problems by tapping internal expertise.

8. Collaboration among educators builds shared responsibility and improves student learning.

The authors claim that the aforementioned principles must guide professional learning efforts so that professional learning impacts student learning.

The National Council of Teachers of Mathematics (NCTM) also established standards for the professional development of mathematics teachers. Martin (2007) presents the five standards identified by the council: (1) knowing mathematics content; (2) knowing school mathematics; (3) knowing students as learners of mathematics; (4) knowing mathematics pedagogy; and (5) developing as a teacher of mathematics. The emphasis is placed on the teachers' reflective practice and their effect on student learning.

The National Science Education Standards were published by the National Research Council (NRC) in 1996. The standards are goals for achievement for all members of the science education community. The four standards are: (1) learning science content through the perspectives and methods of inquiry; (2) learning to teach science by integrating knowledge of science, learning, pedagogy, and students; (3) building an understanding and ability for lifelong learning; and (4) programs must be coherent and integrated. The standards put more emphasis on inquiry, investigation, collaboration, and integration for increased student learning.

According to Darling-Hammond and McLaughlin (2011), professional development for teachers "must focus on deepening teachers' understanding of the processes of teaching and learning and of the students they teach" (p. 82). Teachers are responsible for student learning and professional development is responsible for building the teachers' professional capacity. Teachers must reflect critically on their practice and continually build new content and instructional knowledge. Professional development activities provide teachers with the skills needed to improve classroom instruction, which impacts student engagement and achievement (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Dalton, 2010).

Desimone (2009) presents core features of professional development based on extensive research consensus. The core features "that are critical to increasing teacher knowledge and skills and improving their practice, and which hold promise for increasing student achievement [are] (a) content focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation" (p. 183). For content focus, Desimone (2009) supports "the link between activities that focus on subject matter content and how students learn that content with increases in teacher knowledge and skills, improvements in practice, and, to a more limited extent, increases in student achievement" (p. 184). Active learning includes teachers "observing expert teachers or being observed, followed by interactive feedback and discussion; reviewing student work in the topic areas being covered; and leading discussions," and other activities where teachers are engaged in learning rather than listening passively. (p. 184) Coherence includes teacher learning that is (a) consistent with teachers' knowledge and beliefs and (b) consistent with school, district, and state reforms and policies. Duration of professional development sessions includes "both span of time over which the activity is spread (e.g., one day or one semester) and the number of hours spent in the activity" (p. 184). Collective participation sets up "potential interaction and discourse, which can be a powerful form of teacher learning" (p. 184). Along with the critical core features, Desimone (2009) proposes a model that relates the features of professional development with teacher knowledge and beliefs, classroom practice, and student outcomes. The links in the model suggest a framework for measuring the impact of professional development on student achievement. The No Child Left Behind Act of 2001 and the Teaching Commission report (2004) support the critical core features of professional development.

Math and Science Professional Development

Birman, Desimone, Porter, and Garet (2000) surveyed more than 1,000 mathematics and science teachers as part of the Eisenhower Professional Development Program to find the most effective way to “enhance the knowledge and skills of participating teachers and improve their classroom teaching [to serve] the ultimate goal of improved student learning” (p. 29). The survey responses together with the data from literature identify three “structural features” and three “core features” of professional development. Form, duration, and collective participation are the three structural characteristics that establish the context. Form includes traditional and reform approaches. The traditional approach includes institutes and single workshops. The reform approach includes teacher immersion, mentoring, coaching, or network activities over a longer period of time, often taking place during the regular school day (Garet, Porter, Desimone, Birman, & Yoon, 2001). Whether traditional or reform, the duration or length of time over which the professional development occurs affects the teachers’ learning experiences. Collective participation involves teachers from the same schools, department, or grade level who share common curriculum materials and assessments.

The common groups of teachers help sustain changes in practice over time. The core features of content focus, active learning, and coherence influence the processes during a professional development session. In the Birman et al. (2000) study, “the degree to which professional development focuses on content knowledge is directly related to teachers’ reported increases in knowledge and skills” (p. 30). Active learning for teachers includes observing others teaching and being observed teaching by others, engaging in rich dialogue, planning lessons, reviewing student work, and presenting for a group. Coherence requires activities that integrate teacher goals, district expectations, and state standards, usually involving discussions with other teachers and administrators. The structural features affect the core features and the core features affect teacher professional growth. The core features in Birman et al. (2000) encompass Learning Forward’s standards for professional learning (2011).

Garet et al. (2001) supports the Birman et al. (2000) findings of structural and core features. The results from the Garet et al. study, using the data from 1,027 math and science teachers, indicate that activity type or form has an influence on duration; specifically, “reform activities tend to span longer periods and to involve greater numbers of contact hours than traditional activities” (p. 930). In addition, reform activity has a modest direct positive effect on teacher enhanced knowledge and skills. Duration in time spent and in contact hours has a substantial positive influence on active learning and coherence, plus a moderately positive influence on content knowledge focus. Hence, Garet et al. (2001) state that, “professional development is likely to be of higher quality if it is both sustained over time and involves a substantial number of hours” (p. 933). Content focus and coherence have positive effects on enhanced knowledge and skills. “Activities that give greater emphasis to content and that are better connected to teachers’ other professional development experiences and other reform efforts are more likely to produce enhanced knowledge and skills” (p. 933). The results confirm the importance of focusing on math and science content for professional development. The data also support the relation of collective participation of groups of teachers from the same school, subject, or grade to coherence and active learning opportunities that lead to changes in classroom practice (Garet et al., 2001).

Supovitz and Turner (2000) “indicate that the quantity of professional development in which teachers participate is strongly linked with both inquiry-based teaching practice and investigative classroom culture” (p. 963). According to Supovitz and Turner (2000),data collected from teachers and principals as part of a local systemic change reveal that: (1) teachers with less than 40 hours of professional development had more traditional practices than did the average teacher; (2) teachers with between 40 and 79 hours of professional development had about average teaching practices; and, (3) teachers with approximately 80 hours of professional development “reported using inquiry-based teaching practices significantly more frequently – about two-tenths of a standard deviation – than the average teacher” (p. 973). With the two-level hierarchical models showing school-level influences, the study also reveals that “teachers in schools with high proportions of students on free and reduced lunch had, on average, significantly lower levels of both investigative culture and inquiry-based practices” (p. 975). Even considering the percentage of students in a school on lunch assistance, significant results emerge when the duration of professional development experiences is deeper and more sustained. Content preparation was the most powerful individual teacher factor apparent in the models, again emphasizing the importance of teacher content knowledge (Supovitz & Turner, 2000; Loucks-Horsley & Matsumoto, 1999).

Huffman, Thomas, and Lawrenz (2003) research different types of professional development and the achievement of students in eighth-grade math and science measured by state achievement test scores. With the rationale that teachers have the most direct effect on classroom instruction and the greatest opportunity to affect student achievement, Huffman et al. (2003) examined the five types of professional development identified by Loucks-Horsley, Hewson, Love, and Stiles (1998): (1) immersion; (2) curriculum implementation; (3) curriculum development; (4) examining practice; and (5) collaborative work. The workshops range from 3- to 5-days to longer summer institutes, with extended follow-up throughout the school year. State achievement test scores are used to measure school quality and performance of schools in the state where the research took place. Class mean scores on the achievement tests are used as the dependent variables in the study. According to Huffman et al. (2003), "for both science and math teachers [the study] found that curriculum development and examining practice were significant predictors of teachers' use of standards-based curriculum and instruction" (p. 382). However, for science teachers none of the types of professional development were significantly related to student achievement and for math teachers only curriculum development had an impact (Huffman et al., 2003). The authors propose the explanation that only selected and skilled teachers are involved in curriculum development, which "is coherent with the daily environment of schools…[and] may have produced more ownership on the part of teachers and better implementation and impact" (p. 384). Huffman et al. (2003) also claim that, "immersion is likely to have more of a long-term and amorphous effect, rather than relate directly to instruction or achievement. Collaborative work is also highly recommended; as with immersion, it can be more amorphous and unfocused" (p. 384). Huffman et al. (2003) conclude that there "appears to be only a weak relationship between these types of professional development and student achievement on state exams" (p. 385).

The findings from the Johnson, Kahle, and Fargo (2007) study "provide evidence that teacher participation in effective, sustained, professional development and their subsequent use of standards-based instructional strategies have a positive impact on their students' performance in science" (p. 784). The science teachers at a middle school participate in *Discovery* Institute's professional development program that immerses teachers in science curriculum and instruction for three years. Teachers attend 80 hours of professional development the first summer where they experience inquiry-based learning and standards-based instruction, "followed by 36 hours across each of the three academic years, for a total of 198 hours" (p. 778). The impact on student learning is measured by the *Discovery* Inquiry Test (DIT) in science taken by students in sixth grade the first year, seventh grade the second year, and eighth grade the third year, along with students at a comparison school whose teachers had not participated in the immersion program. The students at the immersion school were followed over the three years of the study; whereas, the students at the comparison school were randomly chosen to test by grade level. No significant difference in impact was shown the first year; however, in years two and three, there was an increase in student science achievement at the immersion school with significantly higher mean scores on the DIT.

Scher and O'Reilly (2009) use a meta-analysis to explore the effects of professional development on math achievement and on science achievement. The analysis includes studies performed since 1990, with nine studies on math and 11 studies on science. Measures for student achievement include norm-referenced achievement assessments, state criterion-referenced test scores, or researcher-developed outcome measures. The results suggest that the more intensive reform approach in professional development has a more positive impact on student achievement "than the more traditional one-shot programs" and "programs that include both content and pedagogy as part of their intervention have a larger positive impact on student achievement tha[n] those that focus only [on] content or only on pedagogy" (p. 235). The authors present the data as trends and springboards for future research.

Coe and Thompson (2010) performed a study on hands-on/inquiry-based professional development for teachers. On-site surveys from 433 participants highlight five most useful categories gained from the in-service. Although the 5th category contained the non-specific responses, the other four were (1) information received, (2) materials received, (3) written lessons received, and (4) inquiry-based training received. The hands-on focus was revealed as the most useful followed by written lessons and then lesson materials provided. From the results of an anonymous follow-up survey in order to determine transfer of the training into the classroom, "no statistically significant difference between the identified categories (lesson usage, materials and/or information) was found" (p. 59). Coe and Thompson (2010) state that the findings “highlight the potential of this interwoven nature of the lessons, information and materials to produce a large rate of transfer into classrooms” (p. 59). Professional development for teachers must incorporate information and materials while modeling hands-on/inquiry-based science pedagogy in order to deepen teacher content mastery and increase transfer of learned components into the classroom.

Falk (2012) describes the powerful impact of formative assessment on teachers’ pedagogical content knowledge, as well as student achievement. Eleven fourth grade teachers were involved in multiple professional development sessions with collective participation. The professional development “framework includes four aspects of teachers’ formative assessment practice: (1) articulating goals for learning and assessment, (2) designing or analyzing assessment tasks, (3) interpreting student responses to tasks, and (4) designing or analyzing instruction” (p. 267). The formative assessment activities can support content knowledge development through eight 3-hour sessions, one session per week for eight weeks. Half of the time was devoted to student work analysis and the other half to science investigation. The teachers’ ongoing engagement in formative assessment created opportunities for them to construct new content knowledge to use in subsequent practice.

Grigg, Kelly, Garmoran, and Borman et al. (2012) examine two professional development initiatives designed to increase the amount of inquiry-based science instruction in elementary classrooms. “Science Immersion” was introduced in Summer 2- and five-day Immersion institutes involving two teachers from randomly selected schools each year. Teams of university faculty, district science instructional leaders, and science teachers facilitated the institutes. The participants engaged in lessons from a student perspective and reflected as a teacher. Not all schools in the district were included. The second initiative was the adoption of the Full Option Science System (FOSS) curriculum including at least one day of professional development required for all elementary teachers in the district. The one-day workshops "emphasized use, maintenance, and coordination of the [prefabricated] FOSS kits rather than providing teachers with an authentic learning experience as the Immersion institutes attempted to do" (Grigg et al., 2012, p. 46). The Immersion institutes addressed life science for fourth grade teachers and earth science for fifth grade, requiring teacher facilitation of open-ended questions; whereas, the FOSS kits provided guided inquiry for all components of each grade. The results of the study show that "there was more evidence of science inquiry observed in lessons from the schools that were randomly selected to send teachers to the Immersion institutes" (Grigg et al., 2012, p. 51), yet students "in the Immersion schools performed worse on standardized tests than students in the comparison schools in the first year of study" (p. 52).

Blank, de las Alas, and Smith (2008), representatives for the Council of Chief State School Officers and supported by a grant from the National Science Foundation, authored a study on the professional development evaluation findings from programs for mathematics and science teachers in 14 states. The authors claim that effective math and science professional development have common characteristics, including content focus, coherence with standards for learning, sustainment over time, and active, hands-on methods for teacher learning. Hill's (2009) research on math teachers' impacts on student achievement shows that teachers' math knowledge predicts increased student achievement; thus, professional development focused on math content impacts student learning gains. To support the teaching and learning of mathematics and science, Loucks-Horsley, Stiles, Mundry, Love, and Hewson (2010) describe 16 specific professional development strategies divided into four clusters:

- Immersion in content, standards, and research
    - Curriculum topic study
    - Immersion in inquiry in science and problem solving in mathematics
    - Content courses
- Examining teaching and learning
    - Examining student work and thinking
    - Demonstration lessons
    - Lesson study
    - Action research
    - Case discussion
    - Coaching
    - Mentoring
- Aligning and implementing curriculum
    - Instructional materials selection
    - Curriculum implementation
- Professional development structures
    - Study groups
    - Workshops, institutes, and seminars
    - Professional networks
    - Online professional development (p. 167)

The authors suggest that professional development programs combine the strategies to achieve specific outcomes based on needs.

Curriculum Based Assessment (CBA) as Criterion for Impact

Klieger and Bar-Yossef (2011) claim large-scale assessment is necessary for collecting data on student achievement. In Israel, three main large-scale assessments are administered by the state: the Growth and Effectiveness Measures for Schools (GEMS), the Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA). The findings on these large-scale assessments were used to construct a professional development system for the science teachers. One of the main problems identified with this design "was a gap between the structure and style of the external tests and the tests constructed by the teachers" (Kleiger & Bar-Yossef, 2011, p. 787). Implications of professional development on student achievement in math and science can differ, according to Kennedy (1999). General student outcomes are measured by traditional standardized achievement tests for math; however, because science content is not normally included in standardized achievement tests for all grade levels, science researchers are likely to identify their own outcome measures.

Standardized testing has limited use for teachers as they plan daily instruction. Gickling and Thompson (1985) raise questions concerning the relevance of standardized tests to actual teaching in the schools. The authors favor curriculum-based assessments (CBAs) because CBAs provide readily available information with specificity for instructional guidance. The CBA is "an alternative to traditional standardized assessment practices… [due to] the need to align assessment practices with what is taught in the classroom" (Gickling & Thompson, 1985). The authors continue by claiming that the individualized power of CBAs will lead to improved student attitudes and achievement. As a methodology, Gickling and Thompson (1985) define CBA as "a procedure for determining the instructional needs of students based on the student's ongoing performance in existing course content" (p. 206).

Hintze, Christ, and Methe (2006) use a general approach to a CBA as "developed by conceptualizing the major curricular or learning components of an academic construct and selecting items or tasks across the broad spectrum that the domain is intended to represent" (p. 45). The purpose of the CBA is "to be able to evaluate students' skill development across the entire curriculum" (Hintze et al., 2006, p. 45). The authors present the differences between four different models of CBAs. The four models are (1) CBA for instructional design (CBA-ID), (2) criterion-referenced CBA (CR-CBA), (3) curriculum-based evaluation (CBE), and (4) curriculum-based measurement (CBM). CBA-ID assessments measure what is actually taught in the classroom, using materials in the classroom, starting with what the student knows. CBA-ID is focused on filling gaps in student knowledge and then striving for individual student mastery learning. CR-CBAs are used for teachers to choose the most appropriate instructional materials for instructional planning and implementation. The CR-CBA occurs over several days and acceptable performance is determined by normative sampling procedures. The purpose of the CR-CBA is to determine the instructional level for a student. The CBE begins with a survey-level assessment to determine the student's general understanding of the curriculum. Following the survey, the student takes specific-level criterion-referenced tests to align instruction and assessment. The CBM differs from the other forms of CBAs because the CBM focuses on continually assessing long-term goal objectives, which allow for retention and generalization of learning. The CBM allows for comparison of student scores by specifying measurement and evaluation procedures used across the district. Despite the different approaches, CBAs can be used for formative and summative assessment needs (Hintze et al., 2006).

Data from the study by Shapiro, Keller, Lutz, Santoro, and Hintze (2006), shows that the CBM could potentially predict student performance on statewide assessments in math computation. The correlations were statistically significant for the relationships of math CBM to state assessment outcomes. The results of the standardized tests were used to measure the effectiveness of educational efforts based on curriculum standards. In addition, Shapiro et al. (2006) claim that the CBM “depicts academic growth because it is a classroom-based method that provides repeated samples of performance” (p. 20). The standardized procedure of the CBM, administered repeatedly over time, can provide information related to student achievement, satisfying Guskey’s (2005) level 5 professional development evaluation criteria.

Loucks-Horsley et al. (2010), propose that “the purpose of analyzing student learning and other data is to identify specific targets for improving student learning that will determine the goals for teacher learning and form the basis for professional development program clearly focused on results for students” (p. 34). They continue with emphasis on “a comprehensive local assessment system that complements high-stakes tests with more formative assessments tied to local standards and curriculum…[that] can provide teachers with timely and relevant feedback on the extent to which students are mastering agreed-on standards" (p. 34), also referred to as curriculum-based assessments. The multiple measures in "The Data Pyramid" from Love, Stiles, Mundry, and DiRanna (2008) show the administration of benchmark common assessments (end-of-unit, common grade-level curriculum-based assessments reported at item level) to be quarterly or at the end of each unit. The summative state assessments (State of Texas Assessments of Academic Readiness, (STAAR); Texas Assessment of Knowledge and Skills, (TAKS) are given annually. Loucks-Horsley et al. (2010) claim the summative state assessments "do not provide adequate evidence of [student] achievement" (p. 36). With common grade-level curriculum-based assessments, "teachers become actively involved in analyzing results and reflecting on how they can be enhanced. When teachers embrace the problems and identify potential solutions they are more willing participants in the professional development programs designed to solve them" (p. 36).

Impact of PD on Student Achievement

1. The Standards for Professional Learning (Learning Forward, 2011) establish the cyclic relationship between professional learning and student results: When professional learning is standards-based, it has greater potential to change what educators know, are able to do, and believe.
2. When educators' knowledge, skills, and dispositions change, they have a broader repertoire of effective strategies to use to adapt their practices to meet performance expectations and student learning needs.
3. When educator practice improves, students have a greater likelihood of achieving results.
4. When student results improve, the cycle repeats for continuous improvement. (p. 16)

The cycle works for continual improvement and reflection of teacher practice and student learning. When the teacher learns, the student learns.

Holloway (2003) proclaims that administrators are using data to plan professional development that will improve classroom instruction. Data-based decision making results in intentional learning experiences for teachers that culminate with noticeable benefits for students. Murphy (2005) proposes that schools should analyze data to find out where their students are not succeeding and then develop professional development plans to address the needed areas of teaching and learning. Thus, schools can measure the impact by gathering evidence of change in teacher practice and student learning outcomes. Educators can then analyze the impact of professional development on students. Evidence of student learning, collected from formative and summative assessments, can be a purposeful guide for professional development and teacher collaboration. By using data, educators focus their time and resources on achieving specific teacher and student behaviors, which can lead to success for all students (Holloway, 2003; Holloway, 2006).

Some of the reports included in the Blank et al. (2008) study focus heavily on the effects of professional development on student outcomes. In the seven studies with measurable effects on student outcomes, the key characteristic is the specific measure used to determine student learning. The measure determines the confidence and validity of the findings. Five of the studies used data from statewide student assessment programs to document change by year. One study used a teacher survey and a class observation protocol to analyze student engagement in class. The last study, called the Weaver study, designed an outcome measure for student discourse and intended outcome of professional development curriculum. The authors claim that the statewide assessments have an advantage by providing the opportunity for longitudinal analysis by teachers that does not require additional test design for data collection. In addition, student data can be tracked as well and compared from year to year. On the other hand, the statewide assessment may not be specific enough to detect content area or instructional knowledge gained in teacher professional development.

The conclusions from the Blank et al. (2008) study identify ten key areas:

1. One-third of evaluation studies reported measurable effects of teacher professional development with emphasis on increasing teacher content knowledge.

2. The significant effects of professional development for math and science teachers include programs with a focus on content knowledge plus training and follow-up in pedagogical content knowledge. The programs with significant effects totaled 50 hours of training or more.

3. Purposeful evaluations that yield measurable effects must be planned and implemented across more programs.

4. If the intention of the study is to link professional development to student achievement, then valid, tested instruments must be built into the evaluation design.

5. If the use of student assessment scores and tracking change over time is for evaluation, then the school-based model for professional development, rather than teacher-based design, should be used for facilitation of scheduling, alignment and implementation of follow-up activities.

6. Resource allocation is important for evaluation efforts with measurable outcomes from the professional development.

7. Access to data collection instruments or data systems and advanced planning with school officials should be included in the scientific evaluation design. "[T]he role of evaluation has to be carefully explained as providing larger benefits for school systems due to evidence that will be gained, and how it will ensure better decision-making in the future" (Blank, et al, 2008, p. 27).

8. Linking teacher knowledge gains to change in classroom practices can be accomplished by establishing a baseline point when the teacher begins her learning and measuring after implementation has been experienced.

9. Results from evaluations need to be communicated to key decision-makers at specific points along the course of the program.

10. Partnerships between higher education institutions and school districts have not generally added to the professional development capacity. Key partners are school district decision-makers and state education agency officials.

The key underpinning of the findings is the access to data records for teachers and students. Tracking of professional development depends on the accessibility of the data.

Ross, Hogaboam-Gray, and Bruce (2006) corroborate the claim that there exists little research on the effects of shorter and less intensive professional development that is typically available to teachers. Less intensive professional learning is superficial learning as compared to deeper learning in more rigorous professional development. The authors recognize, “PD that simultaneously focuses on teachers’ practice, their cognitions about mathematics teaching, and their knowledge of mathematics increases implementation of key elements of standards-based teaching” (p. 552). In this study, student achievement is measured by a performance assessment comparable to mandated assessments, except that the performance assessment was shorter, contained less mathematical content, and was created by a teacher team. The professional development employed active learning by teachers, examples from classroom practice, collaborative activities, modeling of effective practices, opportunities for reflection and feedback, and focus on content. Overall, the study shows teacher professional development to have no significant effect on student achievement, despite the modest improvement in student achievement on external assessments (from 50% to 54%). The researchers provide two interpretations: (1) the PD was not effective, or (2) the PD program was evaluated prematurely. To determine program effectiveness, the program must reach mature implementation and demonstrate viability in ideal conditions. The variability in the test could have contributed to the insignificance as well. However, district capacity can provide professional development that makes contributions to increments in student achievement (Ross et al., 2006).

A meta-analysis performed by Blank and de las Alas (2009) focuses on completed studies of effects of professional development for kindergarten through twelfth grade teachers of science and mathematics, in addition to the key characteristics of design of professional development programs, based on resulting measurable student outcomes. The meta-analysis includes 16 studies with high quality professional development defined by content-focused, active learning, coherence, duration/frequency, and collaborative participation. Twelve studies reported on math and four reported on science professional development and student achievement effects. Eleven of the studies used national or statewide assessments and five used assessments specific to the professional development initiative. The number of students assessed varied from 63 to 936, including elementary, middle, and high school students. Resulting modest effect sizes may be due to the use of standardized assessments to capture measurable student outcomes as related to professional development initiatives. Blank and de las Alas (2009) claim that the large-scale tests "may not be fine-tuned to capture the areas that the professional development initiatives are intending to impact" (p. 17). Another study included in the analysis found that students whose teachers participated in targeted content professional development performed with greater understanding of the skills on a posttest only design, as compared to their counterparts whose teachers did not receive the professional development, with an effect size of 0.13. From their analyses, the authors found an inconsistent pattern in the relationship of time and duration to effects on student outcomes unless the teachers received over 100 hours of professional development. The mean effect size for 11 studies that used local post-analysis achievement tests was .05, which was a statistically significant finding but an average the authors claim as indicating less educational importance. They also found that studies focused on elementary grades had larger mean effect sizes than studies involved with middle or high school grades. Overall, the meta-analysis results show cross-study evidence that teacher professional development in math does have significant positive educational effects on student achievement. The results also identify the key characteristics of effective professional development programs, which include designs that are:

1. Consistent with the teacher's school curriculum or learning goals for students and/or aligned with state or district standards for student learning or performance
2. Congruent to the day-to-day operations of schools and teachers
3. Compatible with the instructional practices and knowledge needed for the teachers' specific assignments (Blank & de las Alas, 2009)

A study conducted by Telese (2012) supports the emphasis on teachers' content knowledge. In middle school mathematics, the number of certified mathematics teachers considered highly qualified by No Child Left Behind (NCLB, 2002) is low. He acknowledges the relationship between teachers' subject matter knowledge and increased student achievement, although the data on the relationship are relatively new and scarce (Telese, 2012; Borko, 2004; Desimone, 2009). The two purposes for this study were (1) to determine which type of knowledge is the best predictor for student achievement and (2) to determine the impact of certain professional development activities on student achievement based on the National Association of Educational Progress (NAEP) mathematics assessment. A limitation of the study was the existence of unmeasured variables that form a relationship with student achievement. Telese (2012) confirms that

1. Teachers' content courses are a better predictor of student achievement;
2. Students of teachers who received a small extent of professional development performed better than students whose teacher received moderate to a large extent of training
3. Training in content standards, the available curriculum materials, instructional methods for teaching mathematics, and effective use of calculators in mathematics instruction was positively correlated to student achievement
4. Students whose teachers received more than a small amount of training in methods for assessing students had lower achievement
5. Students from diverse backgrounds produced lower student achievement levels if their teacher had received any training in strategies compared to teachers who received no training in diversity at all. (p. 109)

Despite the limitations of using a large-scale assessment as the student achievement measure, Telese (2012) suggests that when planning professional development for middle school mathematics teachers, focus to a small extent should be on topics that have the greatest potential to raise student achievement.

Summary

Overall, content focus is the central predictor of student benefit compared to program form and structure. Programs need to focus first on student behavior and benefits, such as subject matter knowledge and student learning, rather than teacher behaviors. Professional development that helps teachers learn how students learn the subject matter is most successful in improving student achievement (Kennedy, 1998;

Loucks-Horsley & Matsumoto, 1999). The program effects for short-term studies may appear larger than those of longer-term studies simply because of differences in study length. Kennedy (1999) emphasizes that “a program whose content is not valuable will not be improved by increasing the number of contact hours” (p. 6). Kennedy (1999) also highlights that “effective professional development in mathematics and science treats teachers as professionals” (p. 6).

Desimone (2010) reiterates the focus for professional development in math and science to be on math and science content and how students learn the content. Thus, for math and science, professional development should focus on subject-matter content. Since curriculum-based assessments test the content exclusively, then CBAs should be aligned to professional development. In theory, when using CBAs as the student achievement measure, the content taught, learned, and assessed would be the same.

More research should be done on the impact of professional development on student achievement. Professional development is a requirement for all educators. Professional development standards and guidelines are published for high-impact professional learning. Curriculum-based assessments can measure student performance. Math and science content can be assessed and instructional practices can be related using the Level 5 CBA measure. Blank and de las Alas (2009) summarize the findings of the effects of teacher professional development with the following recommendations: (1) “measures of implementation of professional development are critical to evaluation design in order to document and measure activities to reinforce and extend learning for teachers in their school setting” and (2) “data systems are structured so that data on teacher development initiatives can be linked to student achievement measures, and these data can be effective for evaluation" (p. 29).

CHAPTER 3

METHODOLOGY

Participants

A study was conducted to find the impact of professional development on student achievement as measured by math and science curriculum-based assessments. The participants in the study included 260 third, fourth, and fifth grade math and science teachers from a selected public school district. In this district, 82% of elementary math teachers also teach science. A total of 125 teachers teach thirdgrade math and science, 68 fourth grade teachers teach both math and science, and 19 fifth grade teachers teach both subjects. The average years of experience for the third grade teachers are eight in the state and five in the selected school district. The average years of experience for the fourth grade teachers are the same as the third grade teachers, eight in the state and five in the district. The average years of experience increase for the fifth grade math and science teachers. Fifth grade math teachers average 11 years in the state and six years in the district. Fifth grade science teachers average ten years in the state and six years in the district. Demographic characteristics of the teachers in this study are included in Table 2. As shown in Table 2, the majority of the teachers were White, followed in number by African American or Hispanic. Gender of the participants was reported as 77% female and 23% male.

The study also included achievement data for 8,454 students: 2,883 students enrolled in third grade, 2,752 in fourth grade, and 2,819 in fifth grade. In third grade, more than 60% (60.2%) of participating students were identified as White.

Table 2

Demographic Characteristics of Math and Science Teachers

Grade and Subject	Number of Teachers	% American Indian/ Alaskan	% Asian	% Black/ African American	% Hispanic	% Native Hawaiian/ Pacific Islander	% Two or more Races	% White
3rd Math	126	.8 (1)	2.4 (3)	4.8 (6)	3.2 (4)	0	2.4 (3)	86.5 (109)
3rd Science	125	0	2.4 (3)	4.8 (6)	2.4 (3)	0	2.4 (3)	88.0 (110)
4th Math	75	0	1.3 (1)	9.3 (7)	2.7 (2)	0	2.7 (2)	84.0 (63)
4th Science	68	0	1.5 (1)	10.3 (7)	0	0	2.9 (2)	85.3 (58)
5th Math	39	0	0	5.0 (2)	0	0	0	95.0 (38)
5th Science	39	2.5 (1)	0	2.5 (1)	10.0 (4)	0	0	85.0 (34)

Note: Number of teachers in parenthesis.

Additionally, 7.6% of the students were identified as African American, 14.0% of the participating students were identified as Hispanic, and 14.8% were identified as Asian. A total of 10.1% of students were economically disadvantaged and 12% were considered gifted and talented. Gender was reported as 51.5% female and 48.5% male. Limited English proficient (LEP) students made up 7.6% of all students participating in the study. In fourth grade, more than 58% (58.6%) of participating students were identified as White. Additionally, 9.3% of the students were identified as African American, 14.1% of the participating students were identified as Hispanic, and 14.6% were identified as Asian. 11.7% of students were economically disadvantaged and 14.4% were considered Gifted and Talented. Gender was reported as 49.5% female and 50.5% male. Limited English Proficient (LEP) students made up 6.2% of all students participating in the study. In fifth grade, more than 59% (59.4%) of participating students were identified as White. Additionally, 8.9% of the students were identified as African American, 14.5% of the participating students were identified as Hispanic, and 14.5% were identified as Asian. 10.6% of students were economically disadvantaged and 15.8% were considered Gifted and Talented. Gender was reported as 50.2% female and 49.8% male. Limited English Proficient (LEP) students made up 4.9% of all students participating in the study. Table 3 shows demographic characteristics of the elementary students in this study.

Table 3

Demographic Characteristics of Students in 3rd, 4th, and 5th Grades

Grade	Number of Students	% American Indian/ Alaskan	% Asian	% Black/ African American	% Hispanic	% Native Hawaiian/ Pacific Islander	% Two or more Races	% White
3rd	2883	.6 (17)	14.8 (426)	7.6 (219)	14.0 (403)	.1 (3)	2.7 (79)	60.2 (1736)
4th	2752	.5 (14)	14.6 (403)	9.3 (256)	14.1 (387)	.2 (6)	2.6 (72)	58.6 (1614)
5th	2819	.4 (12)	14.5 (408)	8.9 (251)	14.5 (409)	.2 (5)	2.1 (60)	59.4 (1674)

Note: Number of students in parenthesis.

In the Academic Excellence Indicator System (AEIS) of the Texas Education Agency (TEA), an At-risk student is a student who is identified as at risk of dropping out of school based on state-defined criteria located in the Texas Education Code Section 29.081. Gifted and Talented, GT, students are identified based on identification by the district and aptitude test scores. Special Education, SPED, refers to the population served by programs for students with disabilities. Economically Disadvantaged, ECO.DIS, is calculated as the sum of students coded as eligible for free or reduced-price lunch or eligible for other public assistance, divided by the total number of students. Limited English Proficient, LEP, students are identified by the Language Proficiency Assessment Committee (LPAC) according to criteria established in the Texas Administrative Code

Variables Examined

Dependent Variable

The dependent variable in the study will be student achievement as measured by the district median score on curriculum-based assessments, CBAs. The CBAs are products of the selected school district, designed to measure math and science knowledge of students. The assessment scores range from 0-100, derived from percentage of correct responses among students. CBAs have been created for math and science units of study starting with first grade and continuing through high school math and science courses. Subject-specific, grade level teams of teachers responsible for writing curriculum for the district created the assessments based on the learning standards for Texas students called the Texas Essential Knowledge and Skills, known as the TEKS. The teachers selected questions for the assessments from available purchased test banks according to subject standards. The assessments range in number of questions depending on grade level and content. Students record their answers on bubble sheet answer documents. The documents are then electronically scanned to score the correct responses. Student scores on curriculum-based assessments for math grades three through five and science grades three through five were included in this study. The data for CBAs administered from September to December 2012 were considered. For third grade, the data included seven math CBAs and six science CBAs. For fourth grade, the data included seven math CBAs and six science CBAs. For fifth grade, the data included six CBAs for math and five CBAs for science.

Independent Variable

Teacher participation in professional development was retrieved from the district database to capture dichotomous information – participated (1); did not participate (0). Participation was related to the credit types of courses chosen by teachers during the summer months and the number of hours teachers participated in each credit type. The teachers participated in courses between June 4^{th} and August 10^{th}, 2012. The credit types of professional development courses are defined and examples are provided below:

- Curriculum – What we teach, including the plan, design, sequence, and pacing of content. Examples included math problem solving and math work stations, science curriculum update, science literacy, and scientific spelling;
- Instruction – How we teach, including the delivery and strategies used. Examples included technology skills with hands-on experiences, educational apps, classroom management, and math reasoning skills.
- Differentiation – How we teach varied learners, including the plan to individualize learning. Examples included creating a Moodle site and flipping the math and science classrooms.

- Assessment – How we measure what we teach, including formative and summative tools. An example was writing for formative assessment.
- Technology integration – How we blend learning with technology, including innovative technological opportunities to engage student learning. Examples included math technology integration, grade level websites in Google sites, and Google tools.
- Continuous improvement – What we do as educators to monitor and refine practices. Examples included math collaborative planning, student engagement, math quality questioning, journaling, math parent communication, teacher leader academy, and mentor training.

Procedure

Student academic performance data on math and science curriculum-based assessments conducted during the fall of 2012 and teacher participation in non-contract professional development during summer 2012 data were obtained from the selected public school district and formatted for use. The research team merged the professional development data with the student performance data using teacher name, grade level, and campus name as the common variables. Descriptive measures were calculated to ensure there were no erroneous data entries and to study the distribution and shape of the variables. Based on the initial findings and the nature of the data, the dependent variable was dichotomized at the median, where half of the student participants scored above the median, and half of the students scored at and below the median. Due to the dichotomized dependent variable, logistic regression was utilized. A series of logistic regression models were fit to the data that included examining all main effects and interaction terms among all variables to determine the best fitting model.

Data Analysis

Logistic regression is used for predicting the outcome of a categorical dependent variable (a dependent variable that can take on a limited number of values, whose magnitudes are not meaningful but whose ordering of magnitudes may or may not be meaningful) based on one or more predictor variables. That is, it is used in estimating empirical values of the parameters in a qualitative response model. The probabilities describing the possible outcomes of a single trial are modeled, as a function of the explanatory (predictor) variables, using a logistic function.

Regarding the effect size, there is no widely accepted direct analog to ordinary least squares (OLS) regression's R2. This is because an R2 measure seeks to make a statement about the "percent of variance explained," but the variance of a dichotomous or categorical dependent variable depends on the frequency distribution of that variable. For a dichotomous dependent variable, for instance, variance is at a maximum for a 50-50 split and the more lopsided the split, the lower the variance. This means that *R*-squared measures for logistic regressions with differing marginal distributions of their respective dependent variables cannot be compared directly, and comparison of logistic *R*-squared measures with R2 from OLS regression is also problematic. Nonetheless, a number of logistic *R*-squared measures have been proposed that include Nagelkerke's *R*-Square. This measure of effect size varies from 0 to 1 and is the most reported effect size measure in the literature related to logistic regression. Therefore, Nagelkerke's R-

Square was reported in the current study in addition to the likelihood ratio test of overall goodness-of-model fit and confidence intervals to place the results into proper context. SPSS® (http://www.ibm.com) version 20 was used for all analyses. The study was performed one time in a short timeframe, which could prove as limitations to the research. The results of the study are reported in Chapter 4.

CHAPTER 4

FINDINGS

Third Grade

Math

Table 4 presents the parameter estimates and odds ratios for the impact of professional development on student achievement in third grade math, which suggests that teachers participating in professional development focused on instruction could have an effect on the class of students scoring above the district median. However, the coefficient for instruction is not statistically significant (0.059). The overall model was not statistically significant based on the likelihood test (X2 =7.623, *df* = 6, *p* = .267), and explained approximately 8% of the variance in the dependent variable (Nagelkerke *R* Square =.080). Therefore, the significance of this variable should not be interpreted.

Table 4

Logistics Regression Results Examining the Impact of Professional Development on Student Achievement in 3rd Grade Math

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	Assessment	.928	.547	2.881	1	.090	2.530	.866	7.386
	Cont.Imp	.553	.473	1.367	1	.242	1.738	.688	4.390
	Curriculum	.036	.695	.003	1	.959	1.036	.265	4.047
	Differentiation	-.098	.561	.030	1	.862	.907	.302	2.725
	Instruction	1.035	.547	3.577	1	.059	2.816	.963	8.233
	Technology	.162	.385	.177	1	.674	1.176	.553	2.499
	Constant	-1.590	.580	7.522	1	.006	.204		

Note: Overall model evaluation – Likelihood ratio test 7.623; *df* =6; *p* =.267

Science

Table 5 presents the parameter estimates and odds ratios for the impact of professional development on student achievement in third grade science. The overall model was not statistically significant based on the likelihood test (X2 = 2.731, *d f* = 6, *p* = .842), and explained approximately 3% of the variance in the dependent variable (Nagelkerke *R* Square=.030). Therefore, the significance of this variable should not be interpreted.

Table 5

Logistics Regression Results Examining the Impact of Professional Development on Student Achievement in 3rd Grade Science

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Assessment	.628	.552	1.296	1	.255	1.874	.635	5.529
Cont.Imp	.110	.497	.049	1	.825	1.116	.421	2.958
Curriculum	.034	.745	.002	1	.964	1.035	.240	4.454
Differentiation	.251	.573	.191	1	.662	1.285	.418	3.950
Instruction	-.501	.617	.658	1	.417	.606	.181	2.031
Technology	-.097	.394	.060	1	.806	.908	.420	1.964
Constant	-1.221	.559	4.767	1	.029	.295		

Note: Overall model evaluation – Likelihood ratio test 2.731; df = 6; *p* = .842

Fourth Grade

Math

Table 6 presents the parameter estimates and odds ratios for the impact of professional development on student achievement in fourth grade math. The overall model was not statistically significant based on the likelihood test (X2 = 4.532, *df* = 6, *p* = .605), and explained approximately 8% of the variance in the dependent variable

(Nagelkerke *R* Square = .078). Therefore, the significance of this variable should not be interpreted.

Table 6

Logistics Regression Results Examining the Impact of Professional Development on Student Achievement in 4th Grade Math

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	Assessment	-.168	.597	.080	1	.778	.845	.262	2.721
	Cont.Imp	-.163	.576	.080	1	.777	.849	.274	2.629
	Curriculum	.231	.719	.103	1	.748	1.259	.308	5.153
	Differentiation	1.158	.906	1.635	1	.201	3.184	.540	18.792
	Instruction	.658	.724	.827	1	.363	1.931	.468	7.977
	Technology	.602	.496	1.478	1	.224	1.827	.692	4.825
	Constant	-.364	.583	.391	1	.532	.695		

Note: Overall model evaluation – Likelihood ratio test 4.532; df =6; p =.605

Science

The results displayed in Table 7 revealed that in fourth grade science classrooms where the teachers participated in professional development for technology integration, then the students were 8.426 times more likely to score above the district median (p<.001). The overall model was statistically significant based on the likelihood test (X2 = 13.937, *df* = 6, *p* < .05), and explained approximately 27% of the variance in the dependent variable (Nagelkerke *R* Square =.270).

Table 8 displays the predicted probability of students scoring above the median in fourth grade science classes based on the teacher participation in summer non-contract professional development in specific credit strands. For example, in classrooms where the teacher participated in professional development with focuses on curriculum and differentiation, the students had a 68% (.683) chance of scoring above the district median on the math curriculum-based assessments; whereas, students whose teacher did not participate in documented professional development had a 2% (.024) chance of scoring above the district median.

Table 7

Logistics Regression Results Examining the Impact of Professional Development on Student Achievement in 4th Grade Science

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	Assessment	.861	.838	1.056	1	.304	2.365	.458	12.219
	Cont.Imp	.648	.702	.851	1	.356	1.912	.482	7.574
	Curriculum	-.056	.890	.004	1	.949	.945	.165	5.407
	Differentiation	.188	1.042	.033	1	.857	1.207	.157	9.310
	Instruction	-.026	.936	.001	1	.978	.974	.156	6.100
	Technology	2.131	.646	10.900	1	.001	8.426	2.378	29.862
	Constant	-2.937	.924	10.094	1	.001	.053		

Note: Overall model evaluation – Likelihood ratio test 13.937; *df* = 6; *p* <.05

Teacher Professional Development Credit Hours

The results in Table 9 show the hourly teacher participation in specific credit strands of professional development including teachers based on the ten highest and the ten lowest predicted probabilities of students scoring above the median on fourth grade science curriculum-based assessments. In Table 9, the teachers are sorted according to rank order of predicted probabilities from low to high. In the lower predicted probabilities, the total number of professional development credits is higher and the distribution of credit strands is more varied.

Table 8

Predicted Probability of 4th Grade Science Students Scoring above the District Median CBA Score Related to Teacher Participation in Professional Development

Probability of Student Scoring Above the Median	Assessment	Cont. Imp	Curriculum	Differentiation	Instruction	Technology
0.047	X	X	X	X	X	X
0.050	-	-	-	-	-	-
0.058	-	X	X	X	X	X
0.088	X	-	-	X	X	X
0.110	-	X	X	X	X	X
0.111	-	X	X	X	-	X
0.142	-	X	X	-	X	X
0.144	-	X	X	-	-	X
0.194	-	-	-	X	X	X
0.196	-	-	X	X	-	X
0.244	-	-	X	-	X	X
0.306	X	X	X	X	X	-
0.307	X	X	-	X	X	-
0.352	-	X	X	X	X	-
0.462	X	-	-	X	X	-
0.462	X	-	X	X	X	-
0.523	-	X	X	X	X	-
0.526	-	X	X	X	-	-
0.527	-	X	-	X	-	-
0.595	-	X	X	-	X	-
0.680	-	-	X	X	X	-
0.683	-	-	X	X	-	-

Note: X=Teacher participated in focus area; “-“=Teacher did not participate.

Students whose science teacher participated in the most credit hours (49) with the most hours in each of the credit strands had a 5% (.047) chance of scoring above the median on curriculum-based assessments. As the predicted probabilities increase, the number of hours and the diversity of credit strands decrease per teacher.

Table 9

Teacher Professional Development Hours by Credit Strand Sorted by Predicted Probabilities of 4th Grade Science Students

Science Predicted Probabilities	Total PD Credit Hours	Assessment	Cont. Imp	Curriculum	Differentiation	Instruction	Technology
0.047	45	3	3	6.5	20	7.5	5
0.047	49	1.5	28.5	6.5	3	6.5	3
0.047	39	3	3	13.5	12	4.5	3
0.047	22	3	1	4.5	4.5	6	3
0.058	31	0	13	4.5	6	4.5	3
0.088	18	2	0	0	6.5	8	1.5
0.088	15	3	0	0	4.5	3	4.5
0.088	36	3	0	3	18	9	3
0.088	27	7	0	6	5	7	2
0.11	14	0	2	1.5	4.5	4.5	1.5
0.523	12	0	3	3	3	3	0
0.523	12	0	3	1.5	3	4.5	0
0.526	13	0	7	3	3	0	0
0.527	11	0	5	0	6	0	0
0.59	0	0	0	0	0	0	0
0.595	14	0	8	4.5	0	1.5	0
0.68	9	0	0	1.5	3	4.5	0
0.68	18	0	0	3	12	3	0
0.68	12	0	0	6	3	3	0
0.683	12	0	0	6	6	0	0

The teacher whose students had a 59% chance of scoring above the median participated in counseling professional development. Because so few teachers participated in counseling professional development, the counseling credit strand was not included in the study. Students with the highest chance of scoring above the median (68%) had the teacher who concentrated the professional development time in three credit strands, specifically curriculum, differentiation, and instruction.

Fifth Grade

Math

Table 10 presents the parameter estimates and odds ratios for the impact of professional development on student achievement in fifth grade math. The overall model was not statistically significant based on the likelihood test (X2 = 3.052, *df* = 5, *p* = .692), and explained approximately 11% of the variance in the dependent variable (Nagelkerke *R* Square = .112). Therefore, the significance of this variable should not be interpreted.

Table 10

Logistics Regression Results Examining the Impact of Professional Development on Student Achievement in 5^{th} Grade Math

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Assessment	-.537	1.138	.223	1	.637	.584	.063	5.441
Cont.Imp	1.305	.872	2.240	1	.134	3.688	.668	20.367
Curriculum	-.702	1.389	.255	1	.613	.496	.033	7.536
Instruction	-.048	1.043	.002	1	.963	.953	.123	7.362
Technology	-.136	1.213	.012	1	.911	.873	.081	9.408
Constant	-1.106	1.076	1.056	1	.304	.331		

Note: Overall model evaluation – Likelihood ratio test 3.052; *df* =5; *p* =.692

Science

Table 11 presents the parameter estimates and odds ratios for the impact of professional development on student achievement in fifth grade science, which suggests that student's, whose teacher participated in continuous improvement professional development, were 8.381 times more likely to score above the district median on the science CBA. The overall model was not statistically significant based on the likelihood test (X2=9.126, *df* = 6, *p* = .167), and explained approximately 27% of the variance in the dependent variable (Nagelkerke *R* Square=.274). Therefore, the significance of this variable should not be interpreted.

Table 11

Logistics Regression Results Examining the Impact of Professional Development on Student Achievement in 5th Grade Science

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Assessment	.786	1.061	.549	1	.459	2.195	.274	17.563
Cont. Imp	2.126	.908	5.485	1	.019	8.381	1.415	49.653
Curriculum	-.799	1.082	.545	1	.460	.450	.054	3.751
Differentiation	-.041	1.199	.001	1	.973	.960	.091	10.077
Instruction	-.524	.835	.394	1	.530	.592	.115	3.044
Technology	.339	.945	.129	1	.719	1.404	.220	8.946
Constant	-1.254	.963	1.695	1	.193	.285		

Note: Overall model evaluation – Likelihood ratio test 9.126; df =6; p =.167

CHAPTER 5

DISCUSSION

The purpose of this study was to explore the impact of teacher professional development on student achievement measured by median scores on teacher-made, district-wide, curriculum-based assessments, thereby contributing to filling the research gap that exists concerning the relationship between teacher professional development and student achievement in math and science. The study analyzed the effects of assessment, continuous improvement, curriculum, differentiation, instruction, and technology integration strands of professional development in determining the likelihood of aggregate class median scores falling above or at and below the district median scores using teacher-level data.

The results of the study indicated that teachers who participated in professional development increased class median student achievement on fourth grade science curriculum-based assessments as measured by the dichotomized outcome variable (i.e., above or at and below the district median score).

Regarding the individual grade levels, the results revealed that teachers participating in one credit strand only for their non-contract hours would have different odds of impacting student achievement than those who participated in combinations of credit strand classes. In this study, teachers participated in more than one credit strand for their non-contract professional development hours. To gain insight into the statistically significant findings, the researcher examined the content of the professional learning. The continuous improvement strand focused on learning through collaboration and leadership. The differentiation strand actually involved sessions on how to differentiate instructionally for students using technology integration, such as the Moodle online format and flipping techniques for instruction. The majority of the district's professional development sessions were assigned more than one credit strand per session. Problem solving and work stations in math involved curriculum and instruction. Technology integration sessions addressed instruction by incorporating interactive websites, technology tools, curriculum integration, and flipping instructional techniques. The results underscore the benefits of professional development in the following *Standards for Professional Learning*: learning communities, leadership, and learning designs. These statistically significant results corroborate the findings of other studies, which report the benefits and necessity of combining credits in curriculum, instruction, leadership, collaboration, and technology integration (Hirsh & Killion, 2009; Reeves, 2010; Loucks-Horsley, Stiles, Mundry, Love, and Hewson, 2010; Telese, 2012).

Furthermore in fourth grade science classrooms, teacher participation in technology integration alone gave the students a statistically significant 8.426 times greater likelihood of scoring above the district median on science CBAs. With assessment, the teacher's class was 2.365 times more likely to score above the district median on the science CBAs. Considering combinations of credit strands, the results for fourth grade science students revealed that the class had over a 68% chance in science to score above the district median on the CBAs if their teacher attended professional development sessions in the areas of curriculum, instruction, and differentiation. Continuous improvement classes for fourth grade teachers involved science vocabulary and science literacy, including journaling. Fourth grade teachers with students who had a 68% chance of scoring above the median on math and science CBAs participated in professional development sessions for nine to eighteen hours in curriculum, instruction, and differentiation credit strands. This research supports the literacy findings of Schmoker (2012) with the importance of reading, speaking, and writing, along with the collaboration impetus found in Huffman, Thomas, and Lawrenz (2003) and Loucks-Horsley, Hewson, Love, and Stiles (1998). The study supports findings from many other researchers who have shown that curriculum and instruction should be the focus of professional development. Teachers must have exposure to the curricular content and instructional strategies in order to affect student achievement (Martin, 2007; National Research Council, 1996; Hill, 2009; Blank, de las Alas, & Smith, 2008; Scher & O'Reilly, 2009; Ross, Hogaboam-Gray, & Bruce, 2006; Guskey & Yoon, 2009). Again, teacher learning yields student learning (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Dalton, 2010; Huffman et al., 2003; Learning Forward, 2011; Supovitz & Turner, 2000; Sparks & Hirsh, 2000; Loucks-Horsley & Matsumoto, 1999). Teachers may not gain the learning they need to support student achievement when they do not attend professional development sessions on curriculum and instruction. Superficial knowledge of the teacher will not nurture and guide the deep learning for the student.

The results for fifth grade science students revealed when considered individually, continuous improvement professional development increased the likelihood 8.381 times for students to score above the district median on the science CBA. Continuous improvement is the context aspect of professional development sessions. Collaboration is one of Learning Forward's *Standards for Professional Learning*. Sessions also focused on communication with parents. Quality questioning (Grigg, Kelly, Garmoran, & Borman, 2012) and student engagement sessions provided guidance for teachers to build on best practices. Journaling was included to build science literacy skills. Sessions on leadership were used to empower teachers in their roles (Hirsh & Killion, 2009; Reeves, 2010).

In general, the results of this study indicate that the more hours of teacher professional development in each of a larger variety of credit strands, the lower the chances are for students to score above the median on math and science CBAs. This finding supports the research of Hill (2009), which states that too much professional development from varying sources leads to a decrease in instructional coherence. In fourth grade science, the more credit hours a teacher spends in professional development for curriculum, instruction, and differentiation, the higher the chances are for their students to score above the median science CBAs. In the fifth grade science, the students whose teacher spends more hours in professional development for continuous improvement have a greater likelihood of scoring above the median on CBAs. The large number of professional development hours had a negative impact in fourth grade.

One source of potential impact to the data in this study included differentiation for gifted and talented (GT) students. To teach gifted and talented students, the teacher must attend thirty hours of gifted education modules one time and then continue with six hours of differentiation each year as an update. If the teacher does not complete the update for five years, then he or she must repeat the thirty-hour training. The study's professional development data on professional development hours for fifth grade teachers included seven teachers who needed their GT hours, thus the score for their students were included in the predictive probabilities. The scores could have impacted the rankings of the professional development credits.

Another potential source of impact on our student achievement data is the opportunity for teachers to write curriculum for the district. The CBAs are written by teacher curriculum teams, which involve 25% of the teachers (based on survey responses, see Appendix B). The curriculum writing teams spend three days to three weeks together analyzing standards and appropriate instructional and assessment approaches. The teachers' expertise grows based on the content discussion and collaboration with other teachers. The members of the writing teams have the potential for increased content knowledge based on their experiences with curriculum. Huffman et al. (2003) studied the impact of math curriculum development.

The results of this study support the core features for professional development (Desimone, 2009; Birman, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001) and the Learning Forward's standards for professional learning (2011). The content focus in the curriculum credit strand is based on the standards and the district data indicating content areas of focus. Active learning is included in the continuous improvement, instruction, and technology integration strands. Active learning is collaborative and hands-on. Engaging students in their learning requires active learning. Teachers must participate in professional development that models how students learn. Learning designs, resources, and implementation standards encompass the active learning feature revealed in the aforementioned credit strands. Coherence is included in continuous improvement, curriculum, and instruction strands. The continuity and integration of materials and best practices must be identifiable and practically tangible.

When teachers see the connectivity of literacy skills to math skills, for example, then students will begin to see relevance in skills learned across curricular areas. Coherence requires collaboration and leadership. Professional development must be intentionally planned to address the standards in order to align with the ultimate outcome of student achievement. Building teacher capacity has the greatest impact on student achievement. High quality professional development leads to effective teaching which results in increased student achievement (Darling-Hammond & McLaughlin, 2011; Supovitz & Turner, 2000; Sparks & Hirsh, 2000).

For the professional development practitioner, this study showed that focusing on fewer credit strands impacts student achievement on curriculum-based assessments. Providing professional learning courses in curriculum and instruction credit stands should be routine. Collaboration and communication need to be included in the curriculum and instruction discussions. Collaborative groups could be the vehicles for the discussions. Technology integration is essential in differentiating instruction for students. Technology provides the hands-on, interactive aspect to instruction. Teachers must continually learn so that their students continually learn.

As stated by Mizell, Hord, Killion, and Hirsh (2011), “School systems that invest in professional learning and build coherence throughout the system demonstrate commitment to human capital development and acknowledge that investment in educator learning is a significant lever in improving student achievement” (p. 14). The study herein leads to future research:

- Determine the effect of number of hours in each of the professional development strands as measured by student scores on curriculum-based assessments;

- Extend the study to other districts to see if the results can be generalized;

- Examine the efficiency of professional development offered for non-contract professional development sessions (Hill, 2007).

APPENDIX A

SURVEY CONSENT NOTICE

University of North Texas Institutional Review Board

Informed Consent Notice

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: The impact of professional development on student achievement as measured by district performance on math and science Curriculum Based Assessments.

Student Investigator: Deidre Parish, Ph.D., University of North Texas (UNT) Department of Teacher Education and Administration. **Supervising Investigator**: Dr. Jimmy Byrd.

Purpose of the Study: You are being asked to participate in a research study which involves data from noncontract professional development sessions offered June 4 – August 10, 2012, and scores on math and science CBAs given in the fall 2012. The intent of the study is to guide the structure and design of professional development for the greatest impact on student achievement. The collection dates do not include New Teacher week, August 13-17, or returning teacher contract days, August 21-14.

Study Procedures: You will be asked to respond to 30 questions asking specifics about the hours and types of noncontract professional development sessions for which you earned noncontract professional development credit during June 4 – August 10, 2012. This survey will take about 15 minutes of your time.

Foreseeable Risks: No foreseeable risks are involved in this study.

Benefits to the Subjects or Others: We expect the project to benefit you by focusing summer district-wide noncontract professional development on relevant, effective, and productive sessions.

Compensation for Participants: None.

Procedures for Maintaining Confidentiality of Research Records: Survey Monkey® (http://www.surveymonkey.com) maintains the anonymity of the participant. Individual data will not be collected. The confidentiality of district information will be maintained in any publications or presentations regarding this study.

Questions about the Study: If you have any questions about the study, you may contact Dr. Deidre Parish at parish@friscoisd.org or Dr. Jimmy Byrd at jimmy.byrd@unt.edu.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

Research Participants' Rights:

Your participation in the survey confirms that you have read all of the above and that you agree to all of the following:

- Deidre Parish has explained the study to you and you have had an opportunity to contact her with any questions about the study. You have been informed of the possible benefits and the potential risks of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You understand you may print a copy of this form for your records.

APPENDIX B

SURVEY

Survey for math and science teachers grades 3-11

Please include non-contract Professional Development hours from June 4 – August 10, 2012. Do NOT include new teacher week Aug 13-17 or contract days Aug 21-24.

1. What do you teach?
Science
Math
Both

2. What grade do you teach? Check all that apply.
3rd
4th
5th
6th
7th
8th
9th
10th
11th

3. What level of course do you teach? Check all that apply.
Resource
On-level
PreAP
AP

4. What course do you teach? Check all that apply.
3rd grade
4th grade
5th grade
6th grade
7th grade
8th grade
IPC
Biology
Chemistry
Physics
Algebra I
Algebra II
Geometry

5. How many years of experience do you have?
0-3
4-8
9-13
14-18
19-24
25+

6. How many years in Frisco ISD?
0-3
4-8
9-13
14-18
19-24
25+

7. How many hours of professional development noncontract credits did you earn from June 4-August 10, 2012?
0
1
2
3
4
5
6
7
8
9
10
11
12
13+

8. How many professional development hours were provided in-district?
0
1
2
3
4
5
6
7
8
9
10
11

12
13+

9. How many professional development hours were provided out-of-district?
0
1
2
3
4
5
6
7
8
9
10
11
12
13+

10. From which of the following did you gain your credits? Please mark all that apply.
Summer institute
Conference of an Association
3-hour sessions
6-hour sessions
Same session over multiple days
College/University course

11. When did you take the sessions for noncontract credit hours? Check all that apply.
June 18-21
July 23-26
Aug 6-9
Other, please specify

12. What courses did you take? Please list all that you attended during June 4 – August 10, 2012.

13. Was the presenter(s) for the in-district sessions from
In-district
Out-of-district
Not applicable

14. Was the out-of-district professional development session(s) provided by
Service Center
Summer Institution
Conference of a professional association
College/University faculty

Other, please specify
Not applicable

15. How many hours of your earned professional development sessions did you choose according to your own personal continuous improvement?
0
1
2
3
4
5
6
7
8
9
10
11
12
13+

16. How many hours of your earned professional development sessions were required by the district for your teaching assignment?
0
1
2
3
4
5
6
7
8
9
10
11
12
13+

17. How many hours were content specific?
0
1
2
3
4
5
6
7

8
9
10
11
12
13+

18. How many hours were focused on instructional strategies?
0
1
2
3
4
5
6
7
8
9
10
11
12
13+

19. How many hours of your earned professional development sessions included technology?
0
1
2
3
4
5
6
7
8
9
10
11
12
13+

20. How many hours of your earned professional development sessions were interactive and hands-on?
0
1
2
3

4
5
6
7
8
9
10
11
12
13+

21. Were you a curriculum writer for your grade and content?
Yes
No

22. How many days did you write curriculum with your team?
0, I was not a curriculum writer as I indicated in #21.
3-5
6-10
11-15
16+

23. Did you teach summer school?
Yes
No

24. Were you involved in summer STAAR/STAAR EOC remediation?
Yes
No

25. Did you present a professional development session this past summer?
Yes
No

26. Was your presentation in your content area?
Yes
No, my presentation was not in my content area
No. As I said, I did not present.

27. Are you a lead teacher for your grade and content?
Yes
No

28. Are you a campus Instructional Coach for your content area?
Yes
No

29. What is your gender?
Male
Female

30. What is your race/ethnicity?
African American
Hispanic
American Indian
Asian
Pacific Islander
White
Two or more

REFERENCES

Arthur, W., Bennett, W., Edens, P. S., & Bell, S. T. (2003). Effectiveness of training in organizations: A meta-analysis of design and evaluation features. *Journal of Applied Psychology*, *88*(2), 234-245.

Bigpond, K. (2006). *Does one school district's professional development model lead to improved student academic achievement?* (Doctoral dissertation). Retrieved from *ProQuest Dissertations and Theses*, 130-130 p. Retrieved from http://search.proquest.com/docview/305299692?accountid=7113(305299692)

Birman, B. S. (2000). Designing professional development that works. *Educational Leadership*, 57(8), 28.

Blank, R. K., de las Alas, N., & Smith, C. (2008, February). *Does teacher professional development have effects on teaching and learning? Analysis of evaluation findings from programs for mathematics and science teachers in 14 states.* Washington, DC: Council of Chief State School Officers.

Blank, R. K., & de las Alas, N. (2009, June). Effects of teacher professional development on gains in student achievement: How meta analysis provides scientific evidence useful to education leaders. Washington, DC: Council of Chief State School Officers.

Blankstein, A. M. (2010). *Failure is not an option: 6 principles for making student success the only option*. Thousand Oaks, CA: Corwin Press/HOPE Foundation/National Education Association.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3-15. doi: 10.3102/0013189X033008003

Coe, A., & Thompson, R. (2010). The right stuff: inquiry training, teaching & transfer for content mastery in the sciences. *Academic Leadership, 8*(4), 59. (15337812)

Dalton, E. A. (2010). *Relationship between professional development expenditures and student achievement*. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 759077426)

Darling-Hammond, L. (1998). Teacher learning that supports student learning. *Educational Leadership*, *55*(5), 6-11.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). State of the professional: Study of measures status of professional development. *Journal of Staff Development*, *30*(2), 42-50.

Darling-Hammond, L., & McLaughlin, M. W. (2011). Kappan Classic: Policies that support professional development in an era of reform. *Phi Delta Kappan*, *92*(6), 81-92.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181-199. doi: 10.3102/0013189X08331140

Desimone, L. (2010). *Multilevel and longitudinal modeling with IMB SPSS: Quantitative methodology series.* Routledge: New York, NY.

Desimone, L. (2011). Outcomes: Content-focused learning improves teacher practice and student results. *Journal of Staff Development*, *32*(4), 63-68.

Falk, A. (2012). Teachers learning from professional development in elementary science: Reciprocal relations between formative assessment and pedagogical content knowledge. *Science Education*, *96*(2), 265-290, doi:10.1002/sce.20473

Fernandez, C., & Chokshi, S. (2002). A practical guide to translating lesson study for a U.S. setting. *Phi Deltan Kappan*, *84*(2), 128-134.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001, Winter). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Gickling, E. E., & Thompson, V. P. (1985). A personal view of curriculum-based assessment. *Exceptional Children*, *52*(3), 205-218.

Greiman, B. (2010). What can be done to support early career teachers? *Agricultural Education Magazine*, *82*(6), 4-10.

Grigg, J., Kelly, K., Garmoran, A., & Borman, G. D. (2012). Effects of two scientific Inquiry professional development interventions on teaching practice. *Educational Evaluation and Policy Analysis*, *35*(1), 38-56. doi: 10.3102/0162373712461851

Guskey, T. R. (2005). Taking a second look: Strong evidence reflecting the benefits of professional development is more important than ever before. *Journal of Staff Development*, *26*(1), 10-18.

Guskey, T. R. (2007). Multiple sources of evidence: An analysis of stakeholders' perceptions of various indicators of student learning*. Educational Measurement: Issues and Practice*, *26*(1), 19-27.

Guskey, T. R. (2012). The rules of evidence. *Journal of Staff Development*, *33*(4), 40-43.

Guskey, T., & Yoon, K. (2009). What works in professional development? *Phi Delta Kappan*, *90*(7), 495-500.

Hill, H. (2007). Learning in the teaching workforce. *The Future of Children*, *17*(1), 111-127).

Hill, H. (2009). Fixing teacher professional development. *Phi Delta Kappan*, *90*(7), 47-476.

Hintze, J. M., Christ, T. J., & Methe, S. A. (2006). Curriculum-based assessment. *Psychology in the Schools*, *43(*1), 45-56. doi:10.1002/pits.20128

Hirsh, S., & Killion, J. (2009). When educators learn, students learn: Eight principles of professional learning. *Phi Delta Kappan*, *90*(7), 464-469.

Holloway, J. H. (2003). Linking professional development to student learning. *Educational Leadership*, *61*(3), 85-87.

Holloway, J. H. (2006). Connecting professional development to student learning gains. *ScienceEducator*, *15*(1), 37-43.

Huffman, D., Thomas, K., & Lawrenz, F. (2003). Relationship between professional development, teachers' instructional practices, and the achievement of students in science and mathematics. *School Science & Mathematics*, *103*(8), 378-387.

Johnson, C. C., Kahle, J., & Fargo, J. D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching*, *44*(6), 775-786.

Kennedy, M. M. (1998, April). *The relevance of content in in-service teacher education.* Paper presented at the annual meeting of the American Educational Research Association. San Diego, CA.

Kennedy, M. M. (1999). Form and substance in mathematics and science professional development. *NISE Brief*, *3*(2), 1-7. Madison, WI: National Institute for Science Education, University of Wisconsin.

Klieger, A., & Bar-Yossef, N. (2011). Professional development of science teachers as a reflection of large-scale assessment. *International Journal of Science & Mathematics Education*, *9*(4), 771-791. doi:10.1007/s10763-010-9216-5

Learning Forward. (2011). *Standards for Professional Learning*. Oxford, OH: Author.

Little, J. W. (1989). District policy choices and teacher's professional development opportunities. *Educational Evaluation and Policy Analysis, 11*(2), 165-179.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics*, *99*(5), 258-271. doi: 10.1111/j.1949-8594.1999.tb17484.x

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics* (3rd ed.). Thousand Oaks, CA: Corwin.

Love, N., Stiles, K. E., Mundry, S., & DiRanna, K. (2008). *The data coach's guide to improving learning for all students: Unleashing the power of collaborative inquiry*. Thousand Oaks, CA: Corwin.

Martin, T. (Ed.). (2007). *Mathematics teaching today: Improving practice, improving student learning* (2nd ed.). Reston, VA: National Council of Teachers of Mathematics.

Mizell, H., Hord, S., Killion, J., & Hirsh, S. (2011). New standards put the spotlight on professional learning. *Journal of Staff Development*, *32*(4), 10-14.

Murphy, S. (2005). Changing perspectives in professional development. *Science Educator*, *14*(1), 9-15.

National Committee on Science Education Standards and Assessment & National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press. Retrieved from: www.nap.edu

No Child Left Behind Act of 2001, Pub. L. No. 107-110, H.R. 1, 115 Stat. 1425 (2002, January 8).

Public Education Visioning Institute. (2008, May). *Creating a new vision for public education in Texas: A work in progress for conversation and further development*. Austin, TX: Texas Association of School Administrators/Texas Leadership Center.

Reeves, D. B. (2010). *Transforming professional development into student results*. Alexandria, VA: Association of Supervision and Curriculum Development.

Ross, J. A., Hogaboam-Gray, A., & Bruce, C. (2006). The impact of a professional development program on student achievement in grade 6 mathematics. *Journal of Mathematics Teacher Education*, *9*(6), 551-577. doi:10.1007/s10857-006-9020-x

Routman, R. (2002). Teacher talk. *Educational Leadership*, *59*(6), 32.

Scher, L., & O'Reilly, F. (2009). Professional development for K-12 math and science teachers: What do we really know? *Journal of Research on Educational Effectiveness*, *2*(3), 209-249. doi: 10.1080/19345740802641527

Schmoker, M. (2012). Refocus professional development. *Phi Delta Kappan*, *93*(6), 68-69.

Schmoker, M. (2012, November). Time to focus. *Principal Leadership*, *13*(3), 18-21.

Shapiro, E. S., Keller, M. A., Lutz, J., Santoro, L., & Hintze, J. M. (2006). Curriculum-based measures and performance on state assessment and standardized tests: Reading and math performance in Pennsylvania. *Journal of Psychoeducational Assessment*, *24*(1), 19-35. doi:10.1177/0734282905285237

Sparks, D., & Hirsh, S. (2000). Strengthening professional development. *Education Week*, *19*(37), 42.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching*, *37*(9), 963-980.

Teaching Commission. (2004). *Teaching at risk: A call to action*. New York: Author.

Telese, J. A. (2012). Middle school mathematics teachers' professional development and student achievement. *Journal of Educational Research*, *105*(2), 102-111. doi:10.1080/00220671.2010.521209

Texas Administrative Code. Retrieved from http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC

Texas Education Code. Retrieved from http://www.statutes.legis.state.tx.us/Index.aspx

Wenglinsky, H. (2002). The link between teacher classroom practices and student academic performance. *Education Policy Analysis Archives*, *10*(12). Retrieved from http://epaa.asu.edu/ojs/article/view/291/417

Yoon, K. S., Duncan, T., Lee, S. W.Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues & Answers Report, REL 2007-No. 033). Washington, DC:

U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest.