ELEMENTARY TEACHERS' PERSPECTIVES ON THE IMPACT THAT LESSON STUDY PARTICIPATION HAD ON THEIR MATHEMATICAL CONTENT AND PEDAGOGICAL-CONTENT KNOWLEDGE

by

Gail Siragusa Yamnitzky

B.S. Slippery Rock State College, 1979

M. Ed. University of Pittsburgh, 2002

Submitted to the Graduate Faculty of

the School of Education in partial fulfillment

of the requirements for the degree of

Doctor of Education

University of Pittsburgh

2010

UNIVERSITY OF PITTSBURGH

SCHOOL OF EDUCATION

This dissertation was presented

by

Gail Siragusa Yamnitzky

It was defended on

October 12, 2010

and approved by

Mr. Samuel Shaneyfelt, K-12 Project Director, Math/Science Partnership for Southwestern Pennsylvania

Dr. Margaret Smith, Professor, Instruction and Learning

Dr. Charlene Trovato, Associate Professor, Administrative and Policy Studies

Advisor and Dissertation Chair: Dr. Cynthia A. Tananis, Associate Professor, Administrative and Policy Studies

ELEMENTARY TEACHERS' PERSPECTIVES ON THE IMPACT THAT LESSON STUDY PARTICIPATION HAD ON THEIR MATHEMATICAL CONTENT AND PEDAGOGICAL-CONTENT KNOWLEDGE

Gail Siragusa Yamnitzky, Ed.D

University of Pittsburgh, 2010

The purpose of this study was to examine elementary teachers perspectives on the impact that Lesson study participation had on their knowledge and teaching of mathematics. The study explored teachers perspectives of how Lesson study participation affected their mathematical content knowledge and pedagogical-content knowledge.

Lesson study is a professional development practice with roots in Japanese schools. It has shown great promise in improving the quality of teaching mathematics in ways that are sustainable and generative in nature. Essentially, Lesson study is a collaborative method of goal setting, instructional planning, assessing its impact, and reflection and refinement of teaching. It is iterative in nature and requires that teachers participate for extended periods of time to reap the benefits.

This study of elementary teachers from western Pennsylvania revealed that teachers perceived a positive impact on both their mathematical and pedagogical content knowledge. Specifically, these teachers reported changes in how prepared they felt to teach math, their understanding of core math concepts, how they understood the connections between math concepts, and how prepared they felt to effectively plan for instruction. When reporting their perceptions of the impact that Lesson study had on their pedagogical-content knowledge, teachers cited the greatest impact in their understanding of student misconceptions in math, how

prepared they felt to teach concepts rather than skills, and how often they understood how children learn math.

This study examined the challenges and/or enabling factors encountered while participating in Lesson study and the findings suggest that *time* was a major challenge—both scheduling time to meet and the amount of time needed to devote to Lesson study. The amount of administrative support the teachers received was both a major challenge and major factor enabling success. The most frequently cited major factor enabling success was the size and make-up of the Lesson study group.

Overall, the findings in this study suggest that a majority of the teachers believed that Lesson study helped them become a better math teacher, and that it was an effective way to continue their professional development. A majority also reported that they plan to continue Lesson study participation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

This educational journey on which I have traveled for many years has finally reached this milestone—the completion of my doctoral studies. While I am filled with great pride, I am mostly humbled by the love, dedication, friendship and guidance that was offered to me as I traveled this journey. Hand-in-hand, I traveled, first and foremost, with my best friend and life partner, James. There are no words to describe what your love and support have meant to me throughout this process—you learned to braid hair, make rice krispie treats and read endless paragraphs of educational jargon, among so many other things, so that I could make this journey. I love you and am forever grateful.

My children, Jessica, Alexa and J.J. have been my source of inspiration and my greatest supporters and cheerleaders. Hand-in-hand you three have traveled alongside me, offering your love and support—now it's your turn to continue the journey—learn much and often. It will be worth the effort.

My parents, Vince and Carol Siragusa, are responsible for starting me on this journey. By your example and guidance, I came to understand how important it was to pursue my dreams, and your continued love and support have made all the difference. Thank you for planting the seed so many years ago. This journey would not have been possible without you. Thank you, also, to my brothers and sisters, Jim, LeeAnn, Bob, Sharon and Barb. Each of you has supported me through this journey and inspired me throughout my life. Family is everything.

Three friends and colleagues, Sam Shaneyfelt, Linda Brecht, and Sandy Fowler, are also a great inspiration to me. Through his great leadership, Sam, the fisherman, inspired me to seek out ways to be the best teacher I could be—and never let me off the hook. Linda, my friend and colleague, I couldn't have done this without your friendship and support—along the way, I may have blamed you for getting me into this position—now, I have no words to thank you. And, Sandy, an inspiring educational leader, who helped me to understand what great leaders look like—you made me want to be the best educational leader I could be.

Tammy Andreyko and Jeff Taylor have walked alongside me in this journey offering support, help, guidance, a friendly ear and a few laughs. I can't thank you both enough for the time we spent together in our study group. Our work together has made all the difference—press on.

I owe great thanks to Dr. Cindy Tananis, my advisor, dissertation chair and friend. Your help, guidance and support throughout this journey are immeasurable. By your lead, I learned the value of scholarly work and what it means to be part of a true learning community. I will forever treasure our work together—you have been an inspiration to me and an invaluable part of my journey.

I'd also like to extend my sincere thanks to my committee members, Dr. Sean Hughes, Mr. Samuel Shaneyfelt, Dr. Margaret Smith and Dr. Charlene Trovato. You have been an important part of my journey offering your wisdom, insights and guidance.

1.0 INTRODUCTION

This study examined elementary teachers' perceptions of the effect that participating in Lesson study had on their math content knowledge and pedagogical content knowledge. This study also examined the perceived challenges and enabling factors that elementary math teachers noted relative to their successful participation in this professional development endeavor. This study involves a professional development (PD) model called Lesson study. First developed in Japan, it has shown great promise in improving the quality of teaching mathematics in ways that are sustainable over time and generative in nature. Essentially, Lesson study is a collaborative method of goal setting, planning for instruction, assessing its impact, and reflecting on and refining those teaching methods. Equally important, on a personal level, this study is a culmination of my own search for effective ways to assist teachers in developing their practice as professionals. Through a variety of experiences as both a teacher and an administrator, I came to understand the impact that a highly effective professional development program, such as Lesson study, had on my own practice.

I was invited to participate in Lesson study as relatively new teacher. Through that participation, I developed a heightened sense of awareness about the importance of careful, thoughtful planning for instruction. I also experienced the value of collaborating with talented, knowledgeable colleagues and benefitted from examining my practice, closely. Later, as a building principal, I became the facilitator of that same Lesson study group, acquiring a new set

of experiences from an administrative perspective. As the facilitator, my role was to assist in removing the barriers for teachers so that they could successfully engage in Lesson study. Additionally, I served as a resource person, providing research and guidance to assist with planning for instruction.

During the same time period, I became more familiar with Lesson study through workshops with other practicing teachers and administrators. I had the opportunity to invite very experienced members of other Lesson study groups to round-table discussions and benefitted from their successes and challenges. I was also fortunate to visit and observe Lesson study being conducted by Japanese teachers in a Japanese school in Greenwich, Connecticut. During my visit there, I met to discuss these practices with leading researchers in the field including: Catherine Lewis, Tad Watanabe, Akito Takahashi, Makota Yoshima, Leiping Ma, Patsy Wang-Iverson, and experienced Lesson study practitioners, Bill Jackson and Lynn Liptak. As a result of these unique experiences, I have developed a deep curiosity about the role that Lesson study might play in assisting mathematics teachers in improving their practice in ways that are sustainable.

1.1 A GLOBALLY COMPETETIVE NATION

In the 21st century, the world's leading nations will attain the mathematical prowess necessary to solve complex problems, to remain financially solvent, to develop a healthy and technological citizenry, to protect and defend themselves, and to prepare for their future. This will be achieved because each nation's prosperity and the prosperity of each citizen are dependent upon it. The United States, once a global leader in math and science, is no longer positioned to be one of the world's leading nations in mathematics or science. And, in relinquishing its place among math

and science leaders across the world, the quality of life for all U.S. citizens is at risk—our economic stability, our ability to retain a viable workforce, the safety and security of the nation, and our overall prosperity (National Mathematics Advisory Panel, 2008). To regain this important position, it is imperative that we come to understand how, why and under what conditions the higher performing nations are attaining these important levels of mathematical prowess. And, of equal importance, what role does education play in the development of these globally competitive nations?

International studies of mathematics achievement show that American students fall behind their counterparts significantly. In 1995, the Third International Mathematics and Science Study (TIMSS) was conducted comparing mathematics performance in 4^{th}, 8^{th} and 12^{th} grades. TIMSS revealed that U.S. 4^{th} graders performed well in math compared to other nations, 8^{th} graders performed near the international average, but 12^{th} graders scored below the international average. U.S. twelfth-graders were amongst the lowest performing students in general and advanced mathematical knowledge (Gonzales et al., 2001). More currently, in 2007 the TIMSS was conducted with slightly better results. However U.S. students were still outperformed by several of our international counterparts, including Japan and Singapore (Gonzales et al., 2008). According to the TIMSS 2007, both U.S. 4^{th} and 8^{th} graders raised their scores compared to the TIMSS 1995 by eleven and sixteen points respectively (Gonzales et al., 2008). Although U. S. students have improved their performance in mathematics based on TIMSS data, we are still not amongst the leading nations in either math or science.

Concurrently, the Organisation for Economic Co-Operation and Development (OECD) collaborated with member countries to generate an assessment of student literacy in reading, math and science. This assessment, the Programme for International Student Assessment (PISA),

first administered in the year 2000 across forty three countries, was administered again in 2003 and 2006 with forty-one and fifty seven countries participating, respectively (Baldi, Jin, Skemer, Green, & Herget, 2007). Its purpose was to measure the acquisition of knowledge and skills deemed essential for success in adulthood. The PISA surveys were administered to 15 year-olds across the globe with participating countries accounting for nearly 90% of the world's economy. In addition to measuring subject matter knowledge in math, science and reading, the surveys were also designed to examine additional areas including student motivation to learn, their beliefs about themselves, and about their own learning strategies (Baldi, Jin, Skemer, Green, & Herget, 2007). Based on the findings from the year 2000, students in eight countries scored statistically significantly higher than U.S. students on the math portion of the PISA (Mariann Lemke et al., 2001). Additionally, fifteen countries scored about the same as the United States and seven countries scored significantly lower. Japanese and Korean students were the top performers in mathematics in 2000. Overall, U.S. students performed comparably to the OECD average. These findings tend to be similar to the TIMSS 1999 findings (Mariann Lemke et al., 2001).

The PISA administered in 2003 produced less positive results. Fifteen year-old U.S. students performed below the OECD average in mathematics, and were outperformed by students in twenty three countries in statistically ways (M. Lemke et al., 2004). The results from the 2006 administration of the PISA remain statistically the same as the 2003 results for U.S. students. These fifteen year-olds scored below the OECD average (Baldi, Jin, Skemer, Green, & Herget, 2007).

Based on the findings from both the TIMSS and PISA, U.S. students scored below the international average of their global counterparts and are continually outperformed by Japan and

Korea, at the very least. It was hypothesized that an examination of the teaching practices and professional development employed in the highest performing countries would provide some insight into ways that U.S. teachers can improve their practice, ultimately improving student performance. Furthermore, by finding ways to educate our youth so that they can become globally competitive, we can regain our position amongst the world's mathematics leaders, setting a new course for a healthy, safe and fiscally independent country. These hypotheses formed the basis for this study of Lesson study.

1.2 A STUDY OF PROFESSIONAL DEVELOPMENT FOR TEACHERS

Generally, effective teachers are prepared, knowledgeable and well-supported by their profession. Additionally, research suggests that effective teachers account for substantial differences in students' mathematical achievement; sometimes reaching 14% variability between students of ineffective teachers and students of effective teachers in one elementary school year (National Mathematics Advisory Panel, 2008). Student achievement is further impacted quite dramatically when those students are taught repeatedly by either effective or ineffective teachers (National Mathematics Advisory Panel, 2008). There is a significant relationship between quality teaching and student achievement in mathematics. Given the exceptional achievement in mathematics, according to TIMSS 1995, TIMSS 2007 and PISA 2000, 2003 and 2006 of the highest performing nations, it is imperative that U.S. educators come to understand how the teachers in these countries are prepared and supported professionally.

The professional development, or PD, offered to teachers throughout their careers is an important means for improving instruction, when it is implemented effectively (Barth et al.,

2005; Sparks & Hirsh, 2000). Many different forms of PD are offered across school districts, states and nations. However, PD that has been deemed the most effective, offering teachers opportunities to deepen their knowledge of mathematics, includes these features: it is collaborative, job-embedded, differentiated, content-specific and reflective (Barth et al., 2005). A PD *practice* that has consistently been linked to the current theories about effective professional development and student achievement, throughout the research and the literature, is the implementation of a *learning community* (Barth et al., 2005). A learning community is "an organization that is able to transform itself by acquiring new knowledge, skills, or behaviors. In successful learning communities, individual learning is continuous, knowledge is shared, and the culture supports learning" (Wald & Castleberry, 2000). In Japan, one of the highest performing countries in math and science, teachers regularly participate in a form of a learning community known as *Lesson study*, and this participation has often been cited as having a impact on the mathematics performance of their students (Stepanek, Leong, & Barton, 2008; Stigler & Hiebert, 1999).

Lesson study, or *jugyou kenkyuu*, is a PD practice that appeals to educators longing to collaborate with their peers in meaningful ways to improve their own practice (Stepanek, 2001; Weeks, 2001). It is a complex and iterative practice with roots in the Japanese culture (Stepanek, 2001; Stigler & Hiebert, 1999). The broad-ranged and shared goal is to assist teachers in developing the skills necessary to see real evidence of student learning, student engagement and student achievement—a new way of seeing children (Lewis, 2002). This practice does share some cultural norms of U.S. educators. Conversely though, Lesson study also embodies some qualities of teachers that are common in Japan, but rare amongst U.S. teachers—cultural barriers

that have been noted as by some and easily removed by others (M. Fernandez, 2005; Hiebert & Stigler, 2000; Lewis, 2002; Lewis, Perry, Hurd, & O'Connell, 2006; Stigler & Hiebert, 1999).

1.3 A STATEMENT OF THE PROBLEM

The purpose of my study was to examine teachers' perceptions of the extent to which participation in Lesson study impacted their elementary mathematics instruction. Although Lesson study incorporates many characteristics of PD employed by U.S. teachers and deemed effective through the most current research, it also embodies several cultural aspects. These cultural characteristics often pose as barriers to success in this country (Fernandez, 2005; Hiebert & Stigler, 2000; Lewis, 2002; Lewis, Perry, Hurd, & O'Connell, 2006; Stigler & Hiebert, 1999). It is important to come to understand how, why and under what conditions Lesson study is effective in improving the teaching of math in U.S. schools. More specifically, my study conceptualized the *perceived impact*, by teachers, that participation in this practice had on mathematics instruction, specifically teacher content knowledge, teacher pedagogical knowledge and teachers' understanding of student mathematical thinking; all important and necessary by-products of effective professional development (Carpenter, Fennema, & Franke, 1996). Also, this study examined the degree to which the Lesson study process, as it was used by these study participants, was commensurate with the research-based definition of effective professional development (Darling-Hammond, 1997; Fullan, 2001). Lastly, this study examined teachers' perceptions of the challenges they faced when engaging in Lesson study, and the enabling factors supporting the successful implementation of this professional development endeavor.

1.4 STUDY QUESTIONS

1. To what extent are the characteristics of Lesson study implementation in this study, consistent with research-based definitions of quality professional development?
2. What are teachers' perceptions of their participation in Lesson study and its impact on their content knowledge of elementary mathematics?
3. What are teachers' perceptions of their participation in Lesson study and its impact on their pedagogical-content knowledge of elementary mathematics?
4. What are teachers' perceptions of the challenges and/or enabling factors for sustaining participation in Lesson study?

1.5 SIGNIFICANCE OF THE PROBLEM

Over the past decade, research has emerged that provides insight into "high-quality" professional development (Desimone, Smith, & Ueno, 2006). This research suggests that professional development will be successful in changing teacher practice in important and positive ways when it focuses on a teacher's content knowledge, and on an understanding of how children learn that content (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Researchers argue that Lesson study fulfills these characteristics (Chokshi & Fernandez, 2005; Fernandez, 2005; Hiebert et al., 2003). Research also suggests that this PD model, regularly practiced in Japanese schools, poses some barriers due to its cultural nature (Lewis, 2002; Masami & Reza, 2005;

Stigler & Hiebert, 1999; Watanabe, 2002; Weeks & Stepanek, 2001). Regardless of the barriers that exist in implementing Lesson study in U.S. schools, a change in PD practices is imperative for student achievement to increase. Cited in the literature, the most common barriers to implementing Lesson study across the U. S. include: lack of shared long-term goals across staffs, lack of curricular coherence, lack of strong content knowledge, teacher isolation and the lack of shared planning time (Chokshi & Fernandez, 2004; Lewis, 2002; Stigler & Hiebert, 1999). Fernandez and Cannon (2005) argue that another important barrier to implementing Lesson study is grounded in U.S. teachers' view of teaching; their focus on teacher behaviors rather than student behavior (p. 482). Moreover, U.S. teachers' attitudes toward collaborative, in-depth planning of lessons and self-reflective teaching practices also differ from Japanese teachers in ways (Fernandez & Cannon, 2005). Despite these differences, there is widespread agreement that Lesson study offers great promise for teachers in the United States (Chokshi & Fernandez, 2004, 2005; Fernandez, 2005; Fernandez & Cannon, 2005; Hiebert & Stigler, 2000; Lewis, 2000, 2002; Masami & Reza, 2005; Stepanek, 2001; Weeks, 2001)

However, unlike Japanese teachers, most U.S. teachers experience a great deal of autonomy when engaging in PD—they are often free to choose the kinds of PD in which they will participate (Guskey & Sparks, 2002). And, PD in this country has been described by Richardson (1994) as a *hit and miss* approach. It has also been characterized as an action in which teachers were generally forced to engage and viewed as just a *means to an end* (Fullan, 2001). Garet (2001) suggests that the traditional and commonplace workshop format has been consistently criticized as being ineffective in providing teachers with the necessary knowledge to change practice and it was rarely linked to any marked difference in student achievement (Bean, Swan, & Morris, 2002; Coble, 2002; Creasy, 2005; Darling-Hammond, 1999; Darling-Hammond

& Baratz-Snowden, 2007; Darling-Hammond & et al., 1992; R. DuFour & R. Eaker, 1999; R. Elmore, 2000; R. F. Elmore & Burney, 2000; Fullan, 1998, 2001; Fullan & Hargreaves, 1996; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000; Guskey & Sparks, 2002; Lambert, 2003).

When U.S. teachers are generally free to select the kinds of PD in which they will engage, it is imperative to gain an understanding of their perspectives related to the impact their choices have on any improvement in their knowledge, or any change in their practice. Specifically, it is important to understand their perspectives on the impact that their choice of participating in Lesson study had on their knowledge of math or any change in their teaching of it. Furthermore, when an understanding of their perspectives is illuminated, it can assist in identifying the qualities and characteristics of this practice that might sustain it; especially given the review of literature that suggests that Lesson study is an effective PD endeavor that will improve teacher content knowledge and pedagogical content knowledge of mathematics.

Given the complexities of this practice, the cultural barriers that need to be overcome for successful implementation, and the uniqueness of the teaching and learning interplay, I believe that studying teachers' perceptions of the extent to which Lesson study impacts mathematics instruction was an important study.

2.0 A REVIEW OF THE LITERATURE

The relationship between student achievement in the school setting and the quality of instruction a child receives has been studied from many perspectives for a long period of time. Research continues to support the notion that a clear and positive linkage exists between the kinds and quality of instruction a student receives and his or her subsequent achievement in the classroom (American Institutes for Research, 2007). Moreover, it is *the* most influential element of academic success within the school setting (Coble & Piscatelli, 2002). A teacher's knowledge, and how he or she is able to convey it, has a direct impact student learning (Sparks & Hirsh, 2000). While research has identified many key qualities and characteristics of high quality instruction, the most , historically, is the linkage between high quality instruction and the effective PD in which teachers engage (Cohen & Ball, 1999; DuFour, DuFour, Eaker, & Many, 2006).

This review of the literature outlines the interrelatedness of PD practices, high quality mathematics instruction, and specifically, professional learning communities as a PD tool. More specifically, it examines Lesson study, a *kind* of professional learning community, and its relationship to improved teacher quality. This examination of the literature also explores how PD has evolved over time and how it has been linked historically to high quality teaching. It examines current trends and practices in PD and current reform-based initiatives related to mathematics instruction. Lastly, this review of the literature examines Lesson study as it relates

to both mathematics instruction and PD. I recognize that these topics are both broad and complex. Therefore, I have identified the nature and scope of these topics, and have provided a rationale for the further investigation of effective PD models that might improve student achievement in mathematics. The following four questions guided my review of the literature:

1. What is the nature of current practice in professional development?
2. What is the nature of professional development as a *theory of action* in education?
3. What is the nature of *Lesson study,* as it relates to mathematics instruction, from a cultural perspective?

2.1 THE NATURE OF CURRENT PRACTICE IN PROFESSIONAL DEVELOPMENT

The current nature of PD for teachers in the U.S. as outlined in the literature has a more important role than ever before. It is a powerful force in improving student achievement and is a key component of current reform initiatives (Barth et al., 2005; Sparks & Hirsh, 2000). The term continuing *professional development,* or PD*,* was coined in the late 1960s to define the study and practice in one's field. Historically, PD, also known as staff development, has had many purposes, and has been characterized in a variety of ways. Most important is the shared assumption that professional development in any field results in some form of positive change—sustainable change that generates new learning of one's profession would be the gold standard (Darling-Hammond, 1997). Guskey (2000) defines PD as "processes and activities designed to enhance the professional knowledge, skills and attitudes of educators so that they might, in turn, improve the learning of students" (p. 16). It is an opportunity for states and school districts to

impart the knowledge and skills to teachers deemed important by that entity (Wald & Castleberry, 2000).

Professional development has taken many forms over the years. It was often external to a school or district and was provided by staff developers who had little understanding of the institution's culture and climate: a traditionally *hit and miss* approach (Richardson, 1994). In the literature, it has been characterized as an action in which teachers were generally forced to engage, and it was viewed as just a *means to an end*: collecting hours, collecting certificates or maintaining certification (Fullan, 2001). Teachers participated in workshops to accrue required hours to retain their professional certification (Guskey, 2000). In some cases, staff development was viewed by many stakeholders as a necessary component for teaching to be labeled *a profession*. In others, teachers were required to participate in PD activities to acquire particular traits often associated with teaching (Diaz-Maggioli, 2004). Garet (2001) suggests that the traditional and commonplace workshop format has been consistently criticized as being ineffective in providing teachers with the necessary knowledge to change practice. Lastly, the literature suggests that many PD opportunities in the past failed to take into consideration the differences among teachers, as well as the complexities of their jobs (Fullan & Hargreaves, 1996). Historically, PD was rarely linked to any marked difference in student achievement (Bean, Swan, & Morris, 2002; Coble, 2002; Creasy, 2005; Darling-Hammond, 1999; Darling-Hammond & Baratz-Snowden, 2007; Darling-Hammond & et al., 1992; R. DuFour & R. Eaker, 1999; R. Elmore, 2000; R. F. Elmore & Burney, 2000; Fullan, 1998, 2001; Fullan & Hargreaves, 1996; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000; Guskey & Sparks, 2002; Lambert, 2003).

As early as ten years ago in the U.S., almost all literature defined staff development as workshops, conferences or meetings lasting one day or less. These PD activities showed little effect in enhancing teaching in positive ways (Weiss & Pasley, 2006). Although teachers reported participating in more than 42 hours of PD in a year, less than half reported receiving any release time to participate in these activities, and almost one-quarter reported feeling as if they received no support, time or credit for their participation (Sparks & Hirsh, 2000). Only two in five teachers reported that they were fully prepared to use their new learning in their classrooms and just one in five felt prepared when their PD involved technology (Sparks & Hirsh, 2000). The application of new learning acquired through the many hours spent participating in PD has been rare (Darling-Hammond, 1999; R. DuFour & R. Eaker, 1999).

Additionally, the research suggests that teachers enjoyed a very high level of autonomy in the decision making regarding PD—a characteristic often associated with *ineffective* professional development. Hatch and Shulman (2005) attribute this autonomy and disconnect between PD and teacher practice to the historical development of the U.S. public education system. They note, “formal education has taken place behind closed doors” and they suggest that little has changed (p. 1). They also argue that “few reform efforts reach directly into the classroom to look carefully at what teachers do” (p. 2). The discontinuity between *what* PD was afforded to teachers and *what* those teachers were supposed to do with their newly acquired knowledge make PD an ineffective endeavor for many teachers.

At the federal level, the No Child Left Behind Act of 2001 (NCLB) and its subsequent reauthorization in 2007 requires that school districts maintain a staff of *highly qualified teachers*. To achieve its goals, NCLB is guided by four general principles: stronger accountability for results, increased flexibility and local control, expanded options for parents, and an emphasis on

teaching methods that have been proven to work. And, although it does not outline specific requirements for professional development, NCLB does require that all teachers of core academic subjects in the classroom be highly qualified. This is determined by three essential criteria: (1) attaining a bachelor's degree or better in the subject taught; (2) obtaining full state teacher certification; and (3) demonstrating knowledge in the subjects taught. As such, states hold the authority to determine the requirements for individuals wanting to acquire teacher certification.

From this national perspective, guidelines exist to inform what teachers must know and be able to do, but past trends in professional development were fragmented and ineffective (Guskey & Sparks, 2002). There was no agreement across states about the quantity and quality necessary for sustained improvement in teaching, and ultimately student achievement. While forty states identified standards for PD, only fifteen states set aside time for it, and only 31 states offered some financing of professional development to all of its districts (National Center for Educational Statistics, 2007). Given the economic impact that high-quality teachers can have on producing a high-performing and globally competitive citizenry, it is interesting to note the discrepancies in how much PD is required and funded across the country.

Although, the literature strongly suggests that a relationship exists between student achievement and teacher knowledge, the impact of current PD practices on teacher knowledge varies widely (Barth et al., 2005; Darling-Hammond, 1999; Darling-Hammond & et al., 1992; R. F. Elmore & Burney, 2000; Fullan & Hargreaves, 1996; Guskey, 2000; Richardson, 2000; Sparks & Hirsh, 2000; Stigler & Hiebert, 1999; Weiss & Pasley, 2006). Richardson (2000) speculates that schools and districts in the past have opted *not* to implement research based effective PD, at least in part, because it is expensive both in time and money (p. 2). She, as well

as others, also identify cultural norms as a construct that explains why PD has been ineffectively implemented, despite the bodies of current research that exist (Fullan & Hargreaves, 1996; Hiebert et al., 2003a; Richardson, 2000; Stepanek, 2001; Stigler & Hiebert, 1999). Stepanek (2001) agrees, "Teaching is a cultural activity. [Which] explains why teaching has been so resistant to change" (p. 2). Teacher autonomy and "individualism" have existed in public schools since the "one-room school house" of the 17th century (Fullan & Hargreaves, 1996). Schmoker (2006) argued that these trends listed above: lack of purposeful, research-based opportunities, too much autonomy, no agreement nationally on high quality professional development, a hit-and-miss approach, and a lack of systemic design support essentially tells teachers "feel free to be an effective teacher, but it is not a requirement" (p. 27).

Conversely, in the field of mathematics, the results of longitudinal studies assessing the effects of specific kinds of PD on teachers' instruction, is promising. As a result of this body of literature, an emerging consensus suggests that high quality PD contains specific characteristics. These characteristics include a collaborative focus on subject-matter content and how students learn this content, active learning opportunities, leadership roles in which teachers can engage and, PD that is extended in duration (Desimone, 2009). More specifically, Carpenter, Fennema and Franke (1996) argue that teachers' knowledge of mathematics and the development of the knowledge base related to that are important characteristics of effective professional development. They further argue that in addition to a knowledge of subject matter, pedagogy and pedagogical content, a knowledge of students' thinking is an essential element for an improvement in teaching (Carpenter, Fennema, & Franke, 1996). Understanding the conceptions, preconceptions and misconceptions that students possess about specific content assists teachers in developing their own knowledge; a key component to effective instruction (Carpenter,

Fennema, & Franke, 1996). Professional development that focuses on developing skills to better understand students' thinking provides important opportunities for teachers to improve their practice (Carpenter, Fennema, & Franke, 1996; Desimone, 2009).

2.2 RELATIONSHIP BETWEEN PROFESSIONAL DEVELOPMENT AND STUDENT ACHIEVEMENT

Education reform initiatives abound across the country as districts and schools scurry to meet the legislative requirements of NCLB. By the year 2014, one hundred percent of American students attending public schools must demonstrate proficiency in reading and math. High-quality professional development is almost always an important component of the varied reform initiatives, and the need for such continues to be pressing (Guskey, 2000). In a review of the literature surrounding student achievement, researchers continually cite the clear and relationship between quality teaching and improvements in student learning (Richardson, 2000), Noyce, (2006) firmly argues that "the reason we do professional development is so that students will learn more" (p. 45). Furthermore, improving the quality of teaching through effective PD is essential to raising student achievement (Sparks & Hirsh, 2000). Citing four different research studies, Coble (2002) states that evidence points to the notion that "the quality of teaching students receive is the single most influential determinant…of their academic success" (p. 1). Additionally, Elmore (1998) suggests that there is agreement among "educational reformers" that improvement in teacher instruction, ultimately leading to greater student achievement, is directly linked to effective PD (p. 2). Accordingly, the need for effective professional development has never been greater. Teachers come to the profession with varied formal education and

experience; some with no experience at all (Darling-Hammond & Baratz-Snowden, 2007). Hence, PD containing research-based characteristics identified as best practices, has become paramount to improving student achievement.

Many current research studies have generated a causal relationship between *effective* PD and student achievement. Ferguson, for example, analyzed large-scale data sets and accounted for 40 percent of the variation being directly linked to teacher knowledge, as measured by such items as their education, teacher exam scores and experience (Coble, 2002; Coble & Piscatelli, 2002; Darling-Hammond & Ball, 1998). The Third International Mathematics and Science Study-Revisited (TIMSS-R) data was recently analyzed to determine whether students performed differently depending on their teacher's educational background. In looking at student performance in mathematics classrooms in Delaware schools, Cwikla (2002) found that the top 40 student performers were attributed to the 13 most highly educated teachers. In a three year study of student performance on state exams in Tennessee, Sanders and Rivers found that students of 'good' teachers showed a increase in achievement while students of ineffective teachers showed an equally decrease (Coble, 2002). When looking at factors other than home and family, a 1991 study of student achievement in Texas identified a teacher's ability as the next largest factor in that achievement (Coble & Piscatelli, 2002). Greenwald, Hedges, and Laine reviewed 60 studies and determined that increases in student achievement were directly linked to teacher education, ability and experience (Darling-Hammond & Ball, 1998). Another 1992 study by Hanushek, showed that the difference between having a 'good' teacher and a 'bad' teacher can exceed one year's growth in student achievement (American Institutes for Research, 2007).

Researchers have also examined the relationship between professional development designed specifically for mathematics teachers and student achievement. These researchers

concur that while the relationship is complex, evidence of a positive relationship between specific kinds of professional development and increased student achievement does exist. Kennedy (1999) reviewed 93 studies that examined the effectiveness of professional development as defined by its benefits to students. These ninety three studies were categorized into four distinct categories: 1) programs that prescribe a set of teaching behaviors that are expected to apply generically to all school subjects; 2) programs that prescribe a set of teaching behaviors that seem generic, but are proffered as applying to one particular school subject, such as mathematics or science; 3) programs that provide general guidance on both curriculum and pedagogy for teaching a particular subject; and 4) programs that provide knowledge about how students learn particular subject matter (Kennedy, 1999). Of those 93 studies, it was concluded that 10 included some benefit to students. Kennedy, (1999) concluded that the professional development programs fitting into Categories 3 and 4, are very different from those in Categories 1 and 2, and are similar to one another in important ways (Kennedy, 1999). As a result of her research, Kennedy (1999) hypothesized that programs in Categories 3 and 4 focused on student understanding of mathematical concepts, student learning and thinking about mathematics, and on particular mathematics that students learn. Overall, she concluded that professional development that focuses on both subject matter knowledge and knowledge of how students think and learn about mathematics are more likely to benefit students (Kennedy, 1999).

Carpenter, Fennema, Peterson, Chiang and Loef (1989) examined the relationship between professional development that increased a teacher's knowledge of how students think about mathematics and student achievement. Their study examined 20 first grade teachers who participated in professional development that was designed to increase a teacher's understanding of how student thinking about a particular math concept develops (Carpenter, Fennema,

Peterson, Chiang, & Loef, 1989). Specifically, these teachers participated in a 4-week workshop, Cognitively Guided Instruction (CGI), which was devoted to helping teachers understand how children developed a conceptual understanding of a particular mathematics concept, and how teachers might use this new understanding to guide instruction (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). As a result of this study, researchers concluded that when teachers were provided with explicit knowledge about how students think conceptually, they used this knowledge to more effectively evaluate their students' thinking and understanding, and were able to make more informed decisions about mathematics instruction. Ultimately, student achievement increased as a result (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989).

Professional development for teachers has become a cornerstone of the mathematics reform effort and, ultimately, an improvement in student achievement in mathematics (Desimone & LeFloch, 2004; R. F. Elmore & Burney, 2000). The implications of NCLB and its requirement that all teachers become *highly-qualified* further strengthen the need for effective professional development. And, most importantly, although the causal relationship between PD and student learning is quite complex and multi-faceted, there is agreement across the literature that an important positive relationship exists (Guskey, 2000).

2.3 QUALITIES AND CHARACTERISTICS OF EFFECTIVE PROFESSIONAL DEVELOPMENT

Current research, both qualitative and quantitative, has identified common themes related to effective PD. These are summarized in the National Board of Professional Teaching Standards (2006), and help to guide the kinds and qualities of PD through their identification. The National

Board of Professional Teaching Standards (2006) outlines what teachers need to do in order to improve student learning. The points presented by NBPTS (2008) are:

Teachers are committed to students and their learning

Teachers know the subjects they are teaching and how to teach those subjects to students

Teachers are responsible for managing and monitoring student learning

Teachers think systematically about their practice and learn from experience

Teachers are members of learning communities

Professional development, when effective, offers teachers opportunities to deepen their knowledge, and supports the perspective that PD must be collaborative, job-embedded, differentiated, content-specific and reflective. Guskey (2002) contends that the emphasis NCLB places on the accountability of teachers has had an impact on what is viewed as effective professional development. There appears to be a shift in the purposes and kinds of PD over time, and a change in what experts deem as best practices. Many researchers have identified what characterizes the kind PD that is linked to improved student achievement. Guskey (2000) outlines the *defining characteristics* of PD, as evidenced through his research. He notes:

It is intentional

It is an ongoing process

It is a systemic process (p. 16)

Elmore (2000) identifies the characteristics of successful professional development as:

It focuses on concrete applications of ideas

It exposes teachers to actual practice

It involves observation, critique and reflection

It is collaborative

It involves deliberative evaluation and feedback (p. 2)

Sparks & Hirsch (2000) identify similar characteristics in their summary of research. They suggest that effective professional development is:

Results-driven and job-embedded

Focused on helping teachers become deeply immersed in subject matter and teaching methods

Curriculum-centered and standards-based

Sustained, rigorous, and cumulative

Directly linked to what teachers do in their classrooms (p.5)

Hiebert (1999) argues that effective PD shares specific core components; they are: (a) ongoing (measured in years) collaboration of teachers for purposes of planning with; (b) the explicit goal of improving students' achievement of clear learning goals; (c) anchored by attention to students' thinking, the curriculum, and pedagogy, with; (d) access to alternative ideas and methods and opportunities to observe these in action and to reflect on the reasons for their effectiveness (p. 15).

Garet (2001) supports this view. He further stresses that PD that takes place during the day, or is job-embedded, is much more likely to assist teachers in connecting their learning to their own teaching, and it has shown to be sustained over time. Overall, a collaborative approach with a focus on “teaching rather than teachers” is strongly suggested throughout the literature (Stigler & Hiebert, 1999).

Fullan and Hargreaves (1996) note, however, that there are many barriers to this approach. They, too, place teacher collaboration at the center of improving student achievement, but identify “individualism” and isolation as the greatest challenges to effective PD. They argue that schools need to “crack the walls of privatism” to bring about successful change (p. 39). The

TIMSS (1995) revealed that 60 percent of teachers in the United States reported that they never had an opportunity to observe, or be observed by another colleague (Gonzales et al., 2001). Conversely, Rosenholz observed that teacher collaboration in *effective* schools was part of the norms and culture, noting that there appeared to be an assumption that improvement in student achievement was a collective enterprise (Rosenholz, 1989 as cited in Fullan & Hargreaves, 1996). Furthermore, Fullan suggests that all stakeholders within a school system must possess shared beliefs and cultural norms that support effective PD in order to generate a positive impact on student achievement (2001). Darling-Hammond and Ball (1998) conclude that "teacher expertise is one of the most important factors in determining student achievement" (p. 1).

In addition to PD being collaborative and job-embedded, much of the literature suggests that PD must be content specific and standards-based. The content, or core tasks of teaching, when mastered, provide teachers with the necessary skills to make important decisions about their students' progress (Darling-Hammond & Ball, 1998). In 1994, this premise was codified by two pieces of legislation regarding a standards-based focus for all student performance in 1994: Goals 2000: Educate America Act (P.L. 103-227, 108 Stat. 125-191, 200-211, 280-296) and the Improving America's Schools Act of 1994, or IASA, (P.L. 103-382, 108 Stat. 3518), reauthorizing the Elementary and Secondary Education Act of 1965 (ESEA).

The Goals 2000: Educate America Act (P.L. 103-227, 108 Stat. 125-191, 200-211, 280-296) was signed into law in March of 1994. This legislation was based upon the premise that a commitment to high academic standards in the core subjects would generate improved student achievement. Additionally, this legislation laid the groundwork for the implementation of state assessments and more rigorous requirements for professional development for educators (Craig, 2007).

The Elementary and Secondary Education Act (ESEA) included new requirements for teacher certification, most specifically, "promote ongoing professional development for teachers" (Hill, 2002). This reauthorization required that states receiving Title I, Part A funding develop a plan to ensure that all of their teachers are *highly-qualified* by the end of the 2005-2006 school year if teaching in a core academic subject. ESEA further offered provisions for funding professional development opportunities when it improved the knowledge of teachers in (Hill, 2002):

One or more of the core academic subjects they teach

Effective instructional strategies

The use of state academic content standards, achievement standards and assessments

How to teach students with disabilities, special learning needs and those with limited English proficiency

Methods of improving student behavior

Involving parents in their child's education

Understanding and using data and assessments to improve classroom practice and student learning

Sparks and Hirsch (2000) clearly support the work of ESEA in identifying national standards. They argue that a National Center on Professional Development would enable states and districts to learn from policy research while the Center could generate relationships between K-12 schools and research universities, and ultimately link practitioners to researchers (p. 7). In addition to defining national standards, ESEA outlines a very specific definition of what professional development is and what it is not. ESEA states that professional development activities:

1. Improve and increase the knowledge of the academic subjects teachers teach
2. Enable teachers to become highly qualified
3. Are an integral part of school and district improvement plans
4. Give teachers, principals and administrators the knowledge and skills to help students meet challenging state academic content and achievement standards
5. Improve classroom management skills
6. Are high-quality, sustained, intensive and classroom-focused
7. Support the recruiting, hiring and training of highly qualified teachers, including those who enter the profession through alternative routes
8. Advance teacher understanding of effective instructional strategies
9. Provide training for teachers and principals in the use of technology
10. Are regularly evaluated for their impact on increased teacher effectiveness and improved student achievement
11. Are aligned and directly related to state academic content standards, achievement standards and assessments
12. Include instruction in the use of data and assessments (Hill, 2002)

ESEA also unequivocally noted that "one-day or short-term workshops or conferences are not acceptable professional development activities…." (Hill, 2002).

The literature overwhelmingly suggests that improving student achievement through effective PD is both imperative and possible with a change in the kinds and qualities of PD afforded to teachers. It calls for a shift away from the externally provided, one-size-fits-all paradigm. Instead, it strongly urges a move toward PD that is collaborative, engaging and tailored to the specifics strengths and weaknesses of the teacher. Most importantly, the literature

confidently asserts that PD which focuses on teaching, rather than teachers, and evidence of student learning, rather than just the student will be an effective tool in improving student learning (Stigler & Hiebert, 1999).

2.4 THE ROLE OF THE ADMINISTRATOR IN LESSON STUDY

It is also important to acknowledge here that a key component of educational reform that is sustainable and generative is effective leadership. Research-based leadership practices that support the kind of cultural shift necessary to implement new models of professional development are cited throughout the literature. However, the nature of Lesson study as it was originally implemented in Japan purposefully limits the role of educational leaders and administrators—it is a teacher-led practice by design. The current research related to the role of the administrator in Lesson study suggests that it remain minimal with the focus on teachers as leaders. Therefore, while acknowledging the very important role that leaders have in affecting sustainable change in U.S. teachers' practice, I have purposefully refrained from including a review of the literature related to leadership practices. The comprehensive review of the literature related to Lesson study presented here is limited to the original model as it is implemented in Japan, and the subsequent adaptations that have developed during its implementation in the United States. Most important to note here, though, is that throughout the current research and literature on the development on Lesson study within the U.S., questions arise as to the role the building administrator *should* play (Chokshi & Fernandez, 2004, 2005; M. L. Fernandez, 2005; Maria L. Fernandez & Robinson, 2006; Lewis, Perry, Hurd, & O'Connell, 2006; Lewis, Perry, & Murata, 2006).

2.5 THE NATURE OF PROFESSIONAL DEVELOPMENT AS A THEORY OF ACTION IN EDUCATION

Today, research overwhelmingly supports the notion that professional development, or PD, must be a *theory of action* as opposed to just an activity (Ball & Forzani, 2007; Barth et al., 2005; Cwikla, 2002; Darling-Hammond & Baratz-Snowden, 2007; Diaz-Maggioli, 2004; R. DuFour & R. Eaker, 1999; R. Elmore, 2000; Fullan, 2001; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000; Guskey & Sparks, 2002; Reeves, 2004; Sparks, 2002; Stepanek, 2001). Argyris and Schon (1978) argued—the perspective that specific actions in which organizations engage to effect change are *theories of action* when those actions are grounded in theory with a clear intended purpose or result (p. 10). Professional development then, as a theory of action, must be structured to ensure that teachers are able to generate a causal link between PD and their instruction in ways that are deep and meaningful. This also suggests that educators must move away from the present discontinuity in how PD is applied; some may use what they learned, some may not—this is the necessary change (Guskey, 2000). It also suggests that teachers be required to apply their new learning in ways that improve student achievement.

Essentially, as a *theory of action,* PD provides teachers with opportunities to engage in the kinds of learning that can and must inform their teaching. The kinds and qualities of PD, as cited in this review of the literature, and typically offered to teachers, do not support this perspective often enough. Therefore PD must change, so that teachers can regularly embed into their teaching practice those things learned during PD activities (R. DuFour & R. Eaker, 1999). Once achieved, PD fits the definition of a theory of action. In support of that, professional learning communities have been cited throughout the literature as a practice that has research-based links to improved student achievement (Barth et al., 2005).

2.6 PROFESSIONAL LEARNING COMMUNITIES: AN EFFECTIVE PROFESSIONAL DEVELOPMENT PRACTICE

A professional development *practice* for teachers that consistently employs the qualities and characteristics often equated with effective professional development is participation in professional learning communities (Barth et al., 2005). A *learning community* has been defined as an organization that is able to transform itself by acquiring new knowledge, skills, or behaviors. In successful learning organizations, or *communities*, individual learning is continuous, knowledge is shared, and the culture supports learning (Wald & Castleberry, 2000). Moreover, a different kind of thinking is nurtured, and a collective shared vision is at the center of the work that teachers do collaboratively in these communities (P. Senge, 2000). Employees are encouraged to think critically and take risks with new ideas (Marsick and Watkins as cited in (Pennsylvania Department of Education, 2007). Learning communities are also groups of individuals who are bounded together by natural will and who are together bound to a set of shared ideas and ideals. This bounding and binding can transform them from a collection of 'I's' to a collective 'we' (Sergiovanni, 1996). The learning community is analogous to a great team that builds synergy from each other, able to form new assumptions while developing new skills and capabilities (Senge, 1994). Ultimately, the work of the learning community is a collaborative and intentional journey toward results (Wells & Keane, 2008).

Specifically, a *professional* learning community (PLC) is a unique *learning community*, and is a tailor-made entity with a sole purpose of improving professional development of teachers (R. DuFour, 2007). Teachers work together to learn from each other, study a topic related to their particular work and support each other as they change instructional practices and, ultimately make positive changes . One of the most important characteristics of PLCs, that set

them apart from other kinds of professional development, is that, in addition to the new learning that is generated, all participants *act* on that new knowledge (Huffman, 2001). In addition, six characteristics of schools that have developed the kind of culture that supports sustained educational change have been cited in the literature and five of those six characteristics directly relate to teachers working together in meaningful ways to improve instruction— professional learning communities (DuFour & R. Eaker, 1999). PLCs, therefore, are highly effective in improving teachers' professional knowledge and possess many of the qualities of effective PD noted above (Bullough, 2007; Cowley & Meehan, 2001; Danielson, 1996; Darling-Hammond & et al., 1992; Diaz-Maggioli, 2004; R. DuFour & R. Eaker, 1999; Fullan, 1998; Hipp & Huffman, 2002).

Throughout the literature, important positive consequences have been associated with teachers' participation in professional learning communities. In addition to a collegial and collaborative climate fostered amongst the staff, teachers set higher expectations for students, students tend to work collaboratively, the quality of pedagogy is improved and student achievement is improved (Louis & Marks, 1998). Sparks (2005) further suggests that "well implemented professional learning communities are a powerful means of seamlessly blending teaching and professional learning in ways that produce complex, intelligent behavior in all teachers" (p. 156). Three main characteristics of effective PLCs have emerged from the literature, they are: a focus on learning, a culture of collaboration and a focus on results (DuFour, DuFour, Eaker, & Many, 2006)

As cited earlier in this review of the literature, the engagement of teachers in PLCs generates strong and valuable positive consequences (Bullough, 2007; Cowley & Meehan, 2001; Danielson, 1996; Darling-Hammond & et al., 1992; Diaz-Maggioli, 2004; R. DuFour & R.

Eaker, 1999; Fullan, 1998; Fullan & Hargreaves, 1996; Guskey & Sparks, 2002; Hipp & Huffman, 2002; Resnick & Hall, 1998; Schmoker, 2006; Weiss & Pasley, 2006). However strong these results appear, the *act* of developing PLCs in educational settings faces many challenges and barriers, but teachers must put these theories into practice to affect positive changes in student achievement (Barth et al., 2005; Fullan & Hargreaves, 1996). For some, this is a significant change in the *way they do business*. The notion of educators becoming communities of learners is a major change in the culture of teaching (Joyce & Showers, 1995). It is a unique paradigm shift, but change is imperative in the current environment. To comply with NCLB, educators are forced to reexamine their roles as well as the purpose of education. Their primary focus must be on what teachers know and are able to do to improve student achievement (Pollock, 2007). Schmoker (2004) argues that the kind of true collaboration that results in professional learning communities "…could represent the most dramatic shift in the history of educational practice" (p.431).

The scope of change required to make professional learning communities a regular practice is great, and the magnitude of change required to implement these may be viewed differently by each stakeholder (Marzano, Waters, & McNulty, 2005; Waters, Marzano, & McNulty, 2003). But, whether the required change is voluntary or imposed can significantly add to its success or failure (Fullan, 2001). Effective leadership, then, will be the key to the success of professional learning communities as it has the single greatest impact on positive, systemic and sustainable change (Callan, Mitchell, Clayton, & Smith, 2007; Cohen & Ball, 1999; R. F. Elmore & Burney, 2000; Fullan, 2001; Lambert, 1998, 2003; Marzano, Waters, & McNulty, 2005; Reeves, 2006; Schmoker, 2006; Schwahn & Spady, 2002; P. Senge, 2000; Wald & Castleberry, 2000; Wallace, Engel, & Mooney, 1997). Accordingly, the research has shown a

causal link between high-quality teachers and student achievement, between effective professional development and high-quality teachers and between professional learning communities and effective professional development. As a result, making such a change is imperative (Richardson, 2000; Sparks & Hirsh, 2000).

2.7 THE NATURE OF LESSON STUDY AND ITS RELATIONSHIP TO MATHEMATICS INSTRUCTION FROM A CULTURAL PERSPECTIVE

The kinds of professional development in which teachers engage on a global scale differ in quality and effectiveness. Throughout the literature, few forms of professional development in the U. S. have been directly linked to marked improvement in student achievement—specifically mathematics (Fullan, 2001). In reviewing much of the research on professional development and student achievement, *Lesson study* has emerged as one kind of professional development that has produced results in Japanese schools and is emerging as a practice with promise for success in U.S. schools (Chokshi & Fernandez, 2005; C. Fernandez, 2005; Honigsfeld & Cohan, 2006; Hurd & Licciardo-Musso, 2005; Kolenda, 2007; Lewis, 2000; Masami & Reza, 2005; Matoba & Mohammed Sarkar Arani, 2006; Weeks & Stepanek, 2001). In addition, when looking at the elements of this practice, they embody many characteristics that have been linked to effective professional development, i.e. teacher collaboration, student centered, research-based, grounded in best instructional practices, has practical application in the classroom, and embraces adult learning theories (Lewis, Perry, Hurd, & O'Connell, 2006; Stepanek, 2001). Fundamentally, Lesson study is a problem-solving process where small incremental improvements to teaching occur over a long period of time (Stigler & Hiebert, 1999).

Lesson study, or *jugyou kenkyuu*, is a core professional development practice that has been used successfully in Japan for many years (M. Fernandez, 2005; Hiebert & Stigler, 2000; Lewis, 2000; Masami & Reza, 2005; Stigler & Hiebert, 1999). An interest in this practice was sparked in the U.S. after the publication of *The Teaching Gap* (Stigler & Heibert, 1999). These authors reported the findings of the Third International Mathematics and Science Study (TIMSS) noting the success of Japanese students in math (Lewis, 2002). differences in how teachers in the United States and Japan teach math were identified, as well as important differences in lesson construction and teachers' attitudes toward this process (C. Fernandez & Cannon, 2005). One conclusion drawn from TIMSS was that Japanese teachers' participation in Lesson study served to build professional knowledge and math content knowledge, resulting in improved student achievement (Stigler & Hiebert, 1999). Japanese teachers agreed with this conclusion identifying their participation in Lesson study as having a strong influence over their teaching noting that they improved their ability to "see children" (Lewis, 2000, 2002). U.S. teachers' participation was strongly urged (Stigler & Hiebert, 1999).

Lesson study's success in Japan is due, in part, to the teaching culture that exists there (C. Fernandez & Cannon, 2005; Lewis, 2002; Stigler & Hiebert, 1999). In Japan, the teaching culture generally supports the acquisition of the knowledge of both content and pedagogy in collaborative ways (Bass, Usiskin & Burrill, 2002). Lesson study incorporates collaboration amongst teachers, planning lessons for his or her classroom, observation of students, reflecting and discussing teaching, and excellent questioning skills. Lesson study is viewed as a cycle with only one or two lessons a year examined through this process and consists of a three-way interaction between teachers, students and the intended content to be taught (Hiebert & Stigler, 2000; Lewis, Perry, & Murata, 2003). It begins when teachers identify a gap in student

performance and/or achievement and progresses through a seven-stage cycle according to Stigler and Hiebert (1999). The cycle includes:

Step 1: Defining the Problem

Step 2: Planning the Lesson

Steps 3 and 4: Teaching and Evaluating the Lesson

Step 4: Reflecting on its Effects

Step 5: Revising the Lesson

Step 6: Teaching the Revised Lesson

Step 7: Evaluating and Reflecting Again (Stigler & Hiebert, 1999; Taylor, Anderson, Meyer, Wagner, & West, 2005)

The initial phase of this cycle, identifying a goal, is important and lays the groundwork for the focus of the study. This phase also illustrates unique cultural differences between Japanese educators and U.S. educators (Lewis, 2002). Japanese teachers see teaching from a more holistic perspective than U.S. teachers, and select a broad goal, such as "for our instruction to be such that students learn eagerly" (Lewis, 2002, p. 4). U.S. teachers traditionally focus on measureable academic outcomes and rarely share a common goal beyond a grade level or school (C. Fernandez, Cannon, & Chokshi, 2003; Lewis, 2002; Stigler & Hiebert, 1999). When questioned about important teaching goals, 61 percent of U.S. teachers identified *skills* as what they wanted students to learn, while 73 percent of Japanese teachers noted that *learning new ways of thinking* was their goal (Stigler & Hiebert, 1999). Additionally, it is not uncommon for Japanese teachers to adopt a Lesson study goal that comes from the National Ministry of Education, connecting their work to national endeavors (Stigler & Hiebert, 1999). This

connection between Japanese teachers and national educational policy makers is unique to Japan and a cultural difference between them and U.S. educators (Stigler & Hiebert, 1999).

During another important part of the Lesson study cycle, teachers meet weekly for several hours to plan, implement, analyze and revise lessons over a long period of time (Hiebert & Stigler, 2000). Again, this dedication of many hours to the research and planning components of a lesson is culturally different from U.S. teachers' planning and preparation for a lesson. While Japanese teachers tend to be *process* oriented, U.S. teachers are more *product* oriented (Weeks, 2001). Therefore, it is rare in the United States to find teachers who devote weeks, months or even years to the process of refining a lesson (Stepanek, 2001). U.S. teachers will claim lack of time as the obstacle preventing them from doing this, although both U.S. and Japanese teachers spend about the same amount of time teaching (Lewis, 2002; Masami & Reza, 2005; Stepanek, 2001; Stigler & Hiebert, 1999; Watanabe, 2002). Lastly, during this research and planning cycle, Japanese teachers invite outside experts, or *knowledgeable others*, to assist with the research and to offer valuable insight and feedback—a practice that is not seen in U.S. schools (Watanabe, 2002; Weeks, 2001).

Another unique cultural difference between U.S. teachers and Japanese teachers is the kinds and quality of teacher collaboration that exists. Japanese teachers view student achievement as a collective effort while U.S. teachers tend to view their classrooms and their work as private, isolated efforts (Fullan & Hargreaves, 1996; Lewis, 2002). Collaboration is at the core of every phase of the Lesson study cycle—but, especially during the teaching and lesson revision steps. During these steps, a single teacher volunteers to teach the collaboratively crafted lesson while colleagues observe. Once observed, the teachers collaborate again, analyzing student work, student responses and student understanding. The purpose of this phase is to

generate and share new knowledge—much is learned from both the lesson's successes and failures (Hiebert & Stigler, 2000; Stigler & Hiebert, 1999). Lastly steps six and seven involve revisions and a re-teaching of the lesson by an additional teacher, culminating in additional reflection, debriefing, revisions and ultimately publication of the lesson (Weeks & Stepanek, 2001). This revision and reflection process while common in Japanese schools and important for the success Lesson study, is rare in U.S. schools (Lewis, 2002). Moreover, self-critical reflection is noted as a very important practice for Japanese teachers and there is a noticeable difference in the role that external evaluations play in this culture (Lewis, 2002; Stigler & Hiebert, 1999). Unlike the U.S. teaching culture, the Japanese teaching culture supports and values identifying individual's shortcomings, and criticism is a natural step towards developing teacher competency (Lewis, 2002).

Overall, the purpose of Lesson study is not to produce the *perfect lesson,* but to produce new knowledge about content and pedagogy (Cohen & Ball, 1999). Teachers are able to gain new knowledge of, or change their understanding about, the concept being taught; teachers are able to make clearer connections between the standard being taught and classroom instruction; and teachers are able to clarify or change their thinking about student thinking (Lewis, Perry, & Murata, 2006). Additional benefits have been cited throughout the literature. Matoba and Arani (2006) note that: (p. 118)

> Teachers learn on the job
>
> Teachers are learners in their classrooms and in their schools, and they are capable of making decisions about how they should improve themselves
>
> Teachers learn from going through a process of assessing, planning, teaching, observing, journaling, reflecting, and feedback on decision-making in practice

Teachers learn through cooperation in review database of each student in school, planning lessons, participation and observation in others' classrooms, and through daily discussion and communication about teaching improvements

Teachers learn from observing themselves, review of ethnography and journal field notes, engaging in practice, and through participation in self-directed projects

Teachers learn through reflection, evaluation

Teacher-learning has been attributed to Lesson study, and this quality illuminates another cultural difference. U.S. teachers engage in professional development to learn something new, while Japanese teachers view themselves as professionals who possess an important responsibility to the teaching profession (Stigler & Hiebert, 1999). One of the roles of Lesson study is to add to the knowledge base of teaching and learning, and Japanese teachers see this as an important part of their job—a way to build professional authority (Stepanek, 2001; Stigler & Hiebert, 1999). Lesson study, then, is a highly collaborative and iterative process whose success in Japan can be attributed to a culture that supports the notion that student achievement is a collective effort (Lewis, 2002).

Weeks and Stepanek (2001) suggest that "exploring unfamiliar territory is an apt metaphor for embarking on Lesson study in this country" (p. 1). The literature on Lesson study enumerates many cultural differences between U.S. teaching and Japanese teaching and some of these differences appear to be formidable barriers to its implementation in the U.S. (C. Fernandez, Cannon, & Chokshi, 2003; Lewis, 2002; Masami & Reza, 2005; Stepanek, 2001; Stigler & Hiebert, 1999) However, the support for implementation is broad, and early results of the impact of Lesson study on student achievement and improved teaching practice across the country seems positive (C. Fernandez, Cannon, & Chokshi, 2003; Hurd & Licciardo-Musso, 2005; Kolenda, 2007; Lewis, 2002; Lewis, Perry, & Murata, 2006; Marble, 2006; Masami &

Reza, 2005; Matoba & Mohammed Sarkar Arani, 2006; Puchner & Taylor, 2006; Taylor, Anderson, Meyer, Wagner, & West, 2005; Watanabe, 2002; Weeks, 2001; Weeks & Stepanek, 2001). An early example of Lesson study being practiced in the U.S. is in Paterson Public School Number Two in Paterson, NJ. Working alongside two researchers from Teachers College at Columbia University, Makota Yoshida and Clea Fernandez, this practice was developed (Lewis, 2002). Additionally, other pioneers in Lesson study in the U.S. include schools in Bellevue, WA, Nashville, TN, Oakland, CA, and Delaware all reporting positive results (Boss, 2001; Masami & Reza, 2005). According to Choksi & Fernandez (2004) at least 28 states that include 90 districts, 230 schools and more than 1200 teachers participate in Lesson study (Masami & Reza, 2005). There is agreement across the literature that participation in this long term professional development practice offers great promise to teachers, students and to the teaching profession (Masami & Reza, 2005).

Lesson study has been a resounding success in Japan and there is great hope for its success in U.S. schools. However, given the cultural nature of teaching, questions about how to best implement Lesson study in the U.S. still remain (Chokshi & Fernandez, 2004; C. Fernandez & Cannon, 2005; C. Fernandez, Cannon, & Chokshi, 2003; Lewis, 2002; Masami & Reza, 2005; Stepanek, 2001; Stigler & Hiebert, 1999). There is agreement across the literature about the cultural nature of Lesson study but some disagreement about whether or not it should be replicated and implemented in the U.S. identically to its implementation in Japan (Lewis, 2002; Masami & Reza, 2005; Stepanek, 2001; Stepanek, Leong, & Barton, 2008; Stigler & Hiebert, 1999; Watanabe, 2002).

Despite the disagreement, there are several propositions about Lesson study implementation across the literature. It is suggested that these propositions will enhance the

likelihood of successful implementation of Lesson study in the U.S. Stigler & Hiebert (1999) outline six important principles for Lesson study ensuring that it creates gradual and measureable improvements to teaching (p. 131). They are:

Principle #1: Expect improvement to be continual, gradual, and incremental

Principle #2: Maintain a constant focus on student learning goals

Principle #3: Focus on teaching, not teachers

Principle #4: Make improvements in context

Principle #5 Make improvements in the work of teachers

Principle #6: Build a system that can learn from its own experience

Stigler and Hiebert (2004) suggest that adherence to these six principles will lay the groundwork for positive results from participation in Lesson study. Lewis (2002) identifies four features of Lesson study that she deems universal (p. 4). They are:

1) A shared long-term goal
2) Important lesson content
3) Careful study of students
4) Live observation of lessons

Lewis (2002) notes that these are universal practices that exist in Japan and features of Lesson study that are essential to its success. She suggests, however, that they would *look* different in the U.S. Watanabe (2002) agrees that there are important components of Lesson study that, when used, will assist with a successful implementation, including (p. 38):

1) Develop a shared professional culture
2) Develop the habit of writing an instruction plan for others
3) Anticipate students' thinking

4) Learn to observe

5) Give teachers a central role

Throughout the literature, there is agreement that implementing Lesson study will be most successful when key principles or universal practices are used. Disagreement about whether or not to adhere strictly to the Japanese model does exist as well. Most research suggests, though, that a balance between these essential elements and the cultural nature of teaching in the U.S. be reached (Stepanek, 2001). Additionally, the literature suggests that this careful balance *can* be reached (Lewis, 2002; Stepanek, 2001; Stigler & Hiebert, 1999; Watanabe, 2002).

The role that district leaders play in the implementation and evolution of Lesson study in Japan and, subsequently, the U.S. differs across the literature. In Japan, teachers possess the primary responsibility for improving their own teaching and believe this is done so in the classroom with support, but little involvement, from principals (Stigler & Hiebert, 1999). In the U.S., professional development practices differ widely in all aspects of it—where, when, how, why and how much (Darling-Hammond & Ball, 1998; Fullan, 2001; Guskey, 2000; Sparks, 2002). It is suggested throughout the literature that district support, both by the principal and at the superintendent's level, will be necessary for its success in the U.S. (Lewis, 2002; Masami & Reza, 2005; Stepanek, 2001; Stigler & Hiebert, 1999). Implementation of Lesson study requires a change in culture and, therefore, consensus for support must be built first, and foremost, by the superintendent with public support from the school board (Stigler & Hiebert, 1999). Although this initiative is teacher-led, the support of the principal will be essential to its success (Lewis, 2002). Moreover, the sustainability of Lesson study in any school building will be greatly improved when supported by an administrator who understands and values participation in Lesson study (Stepanek, Leong, & Barton, 2008). Additionally, administrators can assist with the

change in culture necessary for this initiative by helping to develop the kind of building culture that supports collaboration, teacher-learning, reflection, and a rigorous curriculum (Lewis, 2002; Stepanek, 2001; Stepanek, Leong, & Barton, 2008; Stigler & Hiebert, 1999). Through their participation in the Lesson study process, principals can create the kind of environment in which teachers can successfully engage in this process, and assist in eliminating the cultural barriers that may get in their way.

2.8 SUMMARY OF REVIEW OF LITERATURE

In conducting a review of the literature related to the kinds of professional development that have a positive impact on teacher quality, what emerges is a seven step, iterative model that has been very successful in Japan. The research overwhelming suggests that professional development which embodies specific qualities including, but not limited to: collaboration, a content-focus, job-embeddedness, active learning and reflection can provide a means for improving teacher quality and, ultimately, student learning. Moreover, it can assist teachers in improving their practice in meaningful ways that can be sustained over time. The promise of the development of better teachers of math through participation in Lesson study is a powerful motivator for engaging in Lesson study in the U.S. When teachers develop the skills to understand how students think about mathematics, understand what evidence of authentic student learning looks like, and when teachers collaborate in ways that change their practice, the benefits of Lesson study can be realized (C. Fernandez & Cannon, 2005; C. Fernandez, Cannon, & Chokshi, 2003; Lewis, 2000; Masami & Reza, 2005; Stepanek, 2001; Stigler & Hiebert, 1999; Watanabe, 2002; Weeks, 2001; Weeks & Stepanek, 2001). Through the careful implementation

of the universal principles of Lesson study in ways that acknowledge the cultural nature of teaching in the U.S., Lesson study may assume an important place in effective professional development (Lewis, 2000, 2002; Stepanek, Leong, & Barton, 2008; Stigler & Hiebert, 1999).

3.0 METHODOLOGY

3.1 INTRODUCTION

The purpose of this study was to examine teachers' perceptions of the impact that participation in Lesson study had on their math content knowledge and pedagogical content knowledge. The study examined the relationship between the characteristics of Lesson study as engaged in by the study participants and the research-based characteristics of effective professional development. This study also examined the perceived challenges and enabling factors that elementary math teachers noted relative to their participation in this professional development endeavor. In particular the study aimed to examine teachers' perceptions of the effect that Lesson study participation had on their ability to identify preconceptions and misconceptions students bring to their mathematics classrooms. This study also aimed to examine study participants' perceptions of the overall impact that Lesson study engagement had on their ability to prepare for and teach elementary mathematics.

The research population for this study engaged in some form of Lesson study as part of their ongoing professional development. Lesson study, first developed in Japan, has shown great promise in improving the quality of teaching mathematics. However, Lesson study has been practiced by teachers across the U.S. with mixed results. Many claim that it has assisted them in developing their practice in ways that generate higher achieving students, while others cite

challenges, such as the time investment, as barriers to continuing this practice (Chokshi & Fernandez, 2004). Most, however, acknowledge that they believe that they have a deeper understanding of mathematics, how children learn math, and how to more effectively teach math as a result of their participation in this endeavor (Fernandez & Robinson, 2006).

The premise of this study was that teachers, who engaged in Lesson study, participated in a form of professional development that is highly effective in improving mathematical content knowledge and pedagogical content knowledge, but unique to the U.S. teaching culture. It was further hypothesized that transplanting a professional development model from one country to another would pose challenges and barriers. However, an equally important premise of the study was that study participants would perceive themselves as gaining positive results relative to their ability to plan for and teach mathematics because of their Lesson study participation. And, the resulting positive views of their self-efficacy as a teacher of math would assist them in persevering with Lesson study, despite the unique challenges and potential barriers (Bandura, 1986). Ultimately, this study aimed to examine those challenges and barriers, and the important role that teacher self-efficacy has on helping them sustain participation in an effective professional development endeavor. Although this study did not observe teachers in their classrooms, it was hypothesized that teachers' ability to reflect on and identify their own learning of content and pedagogical-content skills was important prerequisites for actual application in their classrooms. Similarly, it was hypothesized that because these teachers were self-reporting accountings of behaviors rather than judgments about the quality of their teaching, the reliability and validity of this perception data would be high (Mullens, 1995).

This study used a survey instrument and a semi-structured interview of voluntary participants in southwestern Pennsylvania elementary schools. The survey was used to determine

teachers' perceptions of the effect that their Lesson study participation had on their mathematical content knowledge and on their pedagogical content knowledge. Data from the survey was analyzed quantitatively using SPSS[1] to determine the extent to which any perceived changes had occurred, and what patterns and themes emerged. Particular responses from the participants were used to illustrate specific examples, the extent of perceived change, and/or the nature of the responses. Interview transcripts were analyzed qualitatively to determine patterns in responses, perceived changes and emergent themes.

This chapter is devoted to the methodology of the study including the context in which it was conducted, the population and sampling, the data collection methods and sources and how the data were coded and analyzed. A conceptual design forms the framework for the study and is included here. Also described is the rationale and design of the survey instrument and interview questions, and a data collection methods and evidence chart that assisted with study design, data collection and subsequent data analysis.

3.2 CONTEXT OF THE STUDY

Elementary teachers of math who joined their colleagues in engaging in Lesson study provided the context for this study. The participants' Lesson study engagement was unique to their school or building as is its design. The number of group members, frequency of meetings, math content identified and implementation of the iterative Lesson study cycle was also unique to each group and, therefore, to each study participant.

[1] Statistical Package for Social Sciences for statistical analysis.

As mentioned in previous sections, the research population for this study was elementary teachers of mathematics in southwestern Pennsylvania who self-reported that they participated in Lesson study. These 'self-reports' were garnered through idiosyncratic personal encounters, and were also found in the Math/Science Collaborative Journal published by the Math/Science Collaborative[2] of Southwestern Pennsylvania (MSC). Ultimately, the research population included 154 participants from five counties in PA. Additionally, the majority of the research population attended workshops and conferences sponsored by the Math/Science Collaborative that focused on developing their understanding of Lesson study.

The MSC reported that Lesson study trainings in the forms of workshops and conferences were offered to teachers across southwestern PA over a four year period and served to introduce teachers to the Lesson study process. These teachers were then given opportunities to introduce Lesson study to others in their own school districts. The MSC also reported that there was a growth in the awareness of the value of Lesson study. While not every teacher in this study attended the Lesson study professional development opportunities offered by the MSC, it is noteworthy that all members of the research population either attended at least one workshop or conference provided by the MSC, or at least one member of their Lesson study team did.

Teachers who participate in Lesson study enjoy many of the characteristics of effective professional development as outlined earlier in this document. Therefore, the researcher provided a conceptual design as the foundation for the study and included the following characteristics (Yin, 2003): a) teachers develop an awareness that a reformation of their mathematics instruction is necessary for improved student achievement; b) teachers elect to participate in Lesson study as

[2] Math/Science Collaborative, founded in 1994, reports that it was "convened to develop a plan to guide regional action in math and science education, to coordinate efforts between schools, corporations, universities and non-profits, and to focus resources on strengthening math and science education".

it has many research-based elements of effective professional development (Darling-Hammond & et al., 1992; DuFour & Eaker, 1999; Elmore & Burney, 2000; C. Fernandez, Cannon, & Chokshi, 2003; Guskey & Sparks, 2002; Lewis, 2000; Sparks, 2002; Stepanek, 2001; Stigler & Hiebert, 1999); c) teachers perceive changes in their content and pedagogical-content knowledge; d) teachers encounter challenges and enabling factors that affect their ability to sustain participation in Lesson study; (Bass, Usiskin, & Burrill, 2002; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Cohen & Ball, 1999; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; M. L. Fernandez, 2008; LeFevre & Bisanz, 1987; Ma, 1999; National Council for Accreditation of Teacher Education, 2006; Phillips, 2007; Schoenfeld, 2007); and, e) teachers sustain their participation in effective professional development via Lesson study, if supported, and teachers change their practice to improve their teaching of mathematics (Carpenter, Fennema, & Franke, 1996; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Chokshi & Fernandez, 2005; Danielson, 1996; Darling-Hammond & et al., 1992; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Guskey & Sparks, 2002; Hiebert & Stigler, 2000; Lewis, Perry, & Murata, 2003; Stigler & Hiebert, 1999).

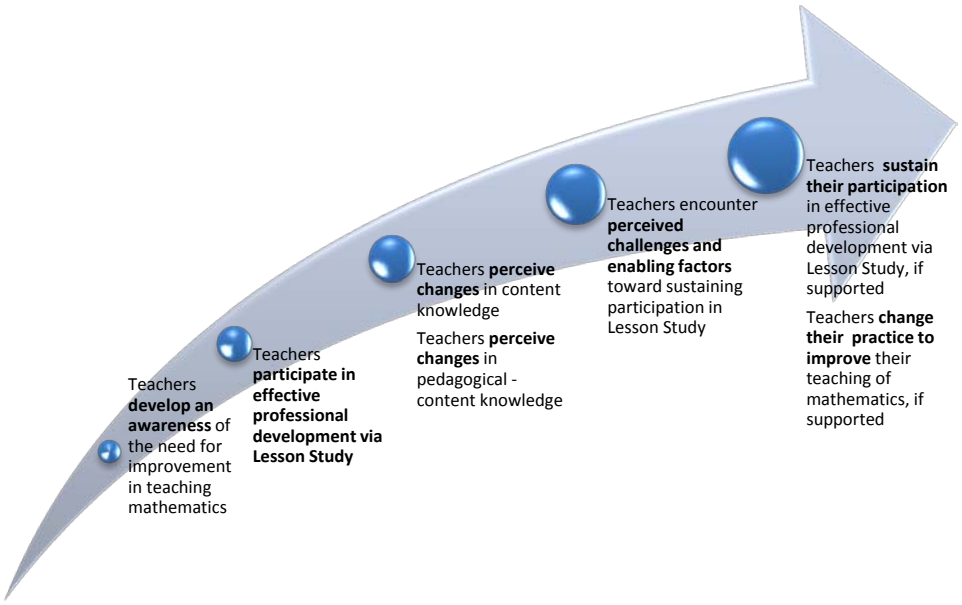

Figure 1. Conceptual design

What is most important to note here, is that this study was situated within a larger context outlined in this conceptual design. While research strongly suggests that effective professional development, among which Lesson study is a part, has a positive impact on improving teacher effectiveness, this study was limited to teachers' perceptions of this hypothesis. Therefore, while this study examined Lesson study and its role in affecting teaching, it did so strictly from a quantitative and qualitative position illuminating what teachers perceive these changes to be. This research study does not claim to examine any changes in teacher practice.

There is a call throughout the current literature for educational research that purposefully examines the effects that professional development has on student achievement. However, teachers' perceptions of the effectiveness of professional development are also an important source of information for educators and policymakers (Mullens, 1995). Given the autonomous nature of teaching in the U.S. and the lack of coherence in the requirements for ongoing professional development, teachers' perceptions of the PD in which they choose to engage are, again, important. The need for effective professional development is cited throughout the

literature. If teachers are given the freedom to choose the PD endeavors in which they will engage, then their perceptions of the PD become the gatekeepers to engagement in effective professional development opportunities such as Lesson study. If teachers perceive their engagement in Lesson study as a means to increase their effectiveness as a math teacher, it was hypothesized that they are much more likely to continue their participation in this effective PD endeavor.

3.3 RESEARCH QUESTIONS

1. To what extent are the characteristics of Lesson study implementation in this study, consistent with research-based definitions of quality professional development?
2. What are teachers' perceptions of their participation in Lesson study and its impact on their content knowledge of elementary mathematics?
3. What are teachers' perceptions of their participation in Lesson study and its impact on their pedagogical-content knowledge of elementary mathematics?
4. What are teachers' perceptions of the challenges and/or enabling factors for sustaining participation in Lesson study?

3.4 RESEARCH POPULATION

3.4.1 Survey Population

This study included a survey instrument and interviews of survey participants. The research population for the survey included 154 elementary teachers who reported that they participated in Lesson study (Rice & Rose, 2009). These teachers were employed in schools throughout southwestern Pennsylvania where some configuration of grades kindergarten through sixth grade were taught. Research subjects were selected due to their current or past participation in Lesson study as a means to examine their perceptions of any effects their participation had on their mathematical content knowledge or their pedagogical-content knowledge. The initial survey population of 154 teachers was ultimately reduced throughout the administration of the survey for several reasons that are explained in the following paragraphs. The final survey population was 129 teachers, of which 64.3% (n=83) took the survey. Additionally, only two of the seventy three questions on the survey were mandatory to answer. And, those questions aimed to ensure that the survey population only included elementary teachers of math who participated in Lesson study. All other survey questions were designed to give the respondents the option of whether or not to answer a question. Therefore, the number of respondents who answered each question changed throughout the survey. This accounts for the change in *n* from question to question.

3.4.2 Interview Population

The researcher proposed to interview approximately 20% of the survey respondents to gain a representative sample of the survey population. As a means to achieve this, four questions were included in the survey to ascertain necessary demographic information about the survey respondents so that they could be contacted for interviews. Of those who completed the survey, 53.8% (n=35) answered the demographic questions including their names and contact information. The interview population was then drawn from this group of survey respondents using a convenience sampling method. All 35 survey respondents were contacted via email and invited to participate in an interview. Of those contacted, 28.5% (n=10) agreed to be interviewed. Ultimately, eight (8) teachers completed the interview representing 22.8% of the potential interview population.

3.5 DATA COLLECTION METHODS

3.5.1 Introduction

This study of teachers' perceptions of the impact that Lesson study participation had on them was conducted in two parts; a survey instrument and follow-up interviews. The survey was administered on-line to teachers who have participated in Lesson study (Math & Science Collaborative Journal, 2009). This survey was divided into four parts; one section for each question, and was aligned to the Data Collections Method and Evidence Chart (Figure 3). The survey construction and the chart are both explained in more detail in the next section. Upon

completion of the survey, study participants were selected for an in-depth interview and a convenience sampling method was used for this (Patton, 1990).

3.5.2 Data Collection Procedures via Survey

The researcher began by administering a seventy-three (73) question survey on-line via SurveyMonkey[3]. The survey was sent through email with a unique link directing study participants to the SurveyMonkey website and the survey. This survey was confidential and anonymity of all respondents was password protected on the computer. All other identifying information was secured in a locked file.

On the first day of survey administration, 154 elementary teachers were invited to complete the survey. Included in the first page of the survey was a description of the study and an explanation of the participants' rights (Appendix A). A daily record of the number of respondents was kept. Figure 2, a record of the survey administration, includes the number of participants who responded each day of the survey administration, the number of participants who completed the survey and the number of survey invitations that did not reach their intended participants. Also included in Figure 2 is when additional email reminders were sent from SurveyMonkey, and to what number of participants. A total of four email reminders were sent at seven day intervals to those potential study participants who did not respond to previous invitations to participate.

In an effort to include all potential study participants, i.e. any elementary teacher from southwestern Pennsylvania who participated in Lesson study, a follow-up email was sent to all

[3] SurveyMonkey is a company that enables users to create their own Web-based surveys

survey respondents. The respondents were invited to identify all members of their own Lesson study group. This was done in an effort to reach any teacher who was not reported in the Math & Science Collaborative Journal which was used to identify the original research population. Figure 2 includes the number of follow-up emails that were sent to the survey respondents asking for information about their Lesson study team members, the day they were sent, and the outcome of the follow-up emails. Subsequent to the email, a survey invitation was then sent to those teachers who were newly identified by their colleagues.

Survey administration day	# of Invitations /re-invitations sent	# of teachers who took the survey	# of teachers identified by their colleagues and invited to participate after the survey began	# of Bounce-backs[4]	# of teachers who opted out	# of Respondents who emailed researcher to be removed from participant list
1	154	12		4		
2		5				
3		3				
4		1				
5		0				
6		0				
7		0				
8	129	13		3		
9		4	3			1
10		1				1
11		3				
12		3				
13		0				
14		0				
15	100	1	2	6		2
16		7				2
17		0				
18		2	4			1
19		2				
20		0				1
21		1				
22	76	4				
23		0				
24		0				
25		0				
26	68	3				2
27		1				
28		0				
29		1				
TOTALS		83	12	20		10

Figure 2. Record of survey administration

[4] Bounce backs are invitations that were returned to either SurveyMonkey or the researcher's email address as undeliverable.

It is also noteworthy that, in response to the 154 original survey invitations that were distributed, 20 potential members of the research population sent emails to the researcher noting their ineligibility to complete the study because they did not fit the study criteria; they were not elementary math teachers and/or a Lesson study participant. Additionally, 9 potential study participants opted out using that feature of SurveyMonkey.

Ultimately, 129 surveys were administered and 64.3% (n=83) participants started the survey. Of those who started the survey, 78.3% (n=65) completed the survey.

3.5.3 Survey Development

The first part of this study included a survey instrument that was used to gather data about teacher's perceptions of the impact that participation in Lesson study had on their professional development as a teacher of elementary mathematics. This on-line 73-question survey was divided into four parts. The first part sought to gather teachers' perceptions about how consistent Lesson study characteristics were to research-based definitions of effective professional development. The second section sought to examine teachers' perceptions of the impact that Lesson study participation had on their math content knowledge, and the third section gathered data about the teachers' perceptions of the impact that Lesson study participation had on their pedagogical content knowledge. The fourth, and last, section of the survey sought to gather data about the challenges that the study participants faced when participating in Lesson study, and also gathered data about factors that enabled the participants to feel that Lesson study engagement was a successful professional development endeavor.

When gathering data about how consistent the characteristics of Lesson study are to the research-based definition of effective professional development, the survey questions focused on

six main characteristics as summarized in Chapter 2 (Carpenter, Fennema, & Franke, 1996; Darling-Hammond & et al., 1992; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Elmore & Burney, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Sparks, 2002; Sparks, 2002; Sparks & Hirsh, 2000; Weiss & Pasley, 2006). These qualities of effective professional development are:

It is collaborative; there is collective participation

It is content-focused

It is reform-oriented

It is extended in duration

It is coherent

It involves active learning

Survey questions in the first section also sought to gather data related to the Lesson study experiences that participants had. Specifically, data was collected relative to the Lesson study cycle as outlined in the review of literature in Chapter 2. As practiced in Japan, Lesson study is an iterative process that includes the follow steps (Lewis, 2000; Stepanek, 2001; Stigler & Hiebert, 1999; Taylor, Anderson, Meyer, Wagner, & West, 2005):

Step 1: Defining the Problem

Step 2: Planning the Lesson

Steps 3 and 4: Teaching and Evaluating the Lesson

Step 4: Reflecting on its Effects

Step 5: Revising the Lesson

Step 6: Teaching the Revised Lesson

Step 7: Evaluating and Reflecting Again

In the second section of the survey instrument, the data that was gathered examined teachers' perspectives on the impact that their participation in Lesson study had on their mathematical content knowledge. Specifically, as described in Chapter 2, questions sought to examine the following (Carpenter, Fennema, & Franke, 1996; Darling-Hammond & et al., 1992; Desimone, Smith, & Ueno, 2006; Garet, Porter, Desimone, Birman, & Yoon, 2001):

Understanding how children learn mathematics

Understanding the core mathematical concepts students need to learn

Understanding the connections between and across math concepts

Understanding the cognitive demands of mathematical concepts

Teaching mathematical concepts rather than discrete skills

Effectively planning for instruction

Overall mathematical knowledge

The third section of the survey instrument gathered data about teachers' perspectives on the impact that Lesson study participation had on their pedagogical content knowledge.

The last section of the survey was devoted to gathering data on teachers' perspectives on the challenges to participating in Lesson study and on those factors that enabled them to feel that Lesson study was an effective professional development endeavor. The survey questions in this section were developed as a result of a review of the current literature as presented in Chapter 2. Several challenges and enabling factors emerged (C. Fernandez, Cannon, & Chokshi, 2003; Lewis, 2002; Stepanek, 2001; Watanabe, 2002). They are:

Creating an over-arching goal on which to base the lesson

The size/make up of the group

The amount of time needed to devote

Scheduling meeting time

Understanding the process

Completing each of the steps in the process

The amount/kind of administrative support provided

Additionally, the literature cites barriers to Lesson study participation due to its cultural roots in Japan and its unique difference from U.S. professional development (Lewis, 2002; Masami & Reza, 2005; Stigler & Hiebert, 1999; Watanabe, 2002; Weeks & Stepanek, 2001). Therefore, data was collected in the form of open-ended responses in this last section of the survey to gain a deeper understanding of the nature of the responses.

The Data Collection Methods and Evidence Chart presented in Figure 3 ultimately served as a guide during survey development as it shows the connection between what evidence serves as data for each research question.

Data Collection Methods and Evidence			
Data to be Gathered		Evidence	Methods
Background information about participants		Name Age Gender Years of teaching experience Teaching certification/s School and District	-Survey
Study Question 1 **1.Qualities of Professional development**	a. Content-focused	1.Teachers are engaged in activities that are focused on improving students' math content knowledge	-Survey -Interviews
	b. Reform activity	1.Teachers participate in a collaborative study group 2.Teachers use more technology 3.Teachers use inquiry-based teaching 4.Teachers use differentiated instruction 5.Teachers pose problems that have more than one solution or the solution is not immediately obvious 6.Teachers use multiple and different forms of assessment	
	c. Long in duration	1.Teachers participate for a length of time	
	d. Collective participation	1.Teachers participate with colleagues from the same school and/or grade level	
	e. Active learning	1.Teachers are actively engaged in meaningful discussions 2.Teachers are actively engaged in analysis of teaching and learning	
	f. Coherence	1.Teachers' perceived growth is consistent with personal goals 2.Teachers' perceived growth is consistent with district and state goals and standards 3.Teachers shared their new knowledge with others; teachers, principal, parents	
Study Question 2 **2. Content Knowledge**	1.Teachers perceive a change in their overall subject knowledge 2.Teachers perceive a change in their understanding of more challenging math concepts 3.Teachers perceive a change in their ability to see the mathematical connections between math concepts 4.Teachers perceive a change in their understanding of the cognitive demands of math concepts 5.Teachers perceive a change in their preparedness to teach math 6.Teachers perceive a change in their understanding of the core math knowledge, or key concepts, my students must know 7.Teachers feel more prepared to teach concepts rather than computational skills 8.Teachers feel more prepared to plan for instruction effectively		-Survey -Interviews

Study Question 3 **3. Pedagogical-content knowledge**	1.Teachers perceive a change in their understanding of how children learn math 2.Teachers perceive a change in their understanding of how students think about mathematics 3.Teachers perceive a change in their preparedness to develop students' conceptual understanding of mathematics 4.Teachers perceive a change in their use of high level math tasks for all students 5.Teachers perceive a change in their use of questions that have open-ended responses for all students 6.Teachers perceive a change in their acceptance of the use of alternate strategies and/or explanations from students 7.Teachers perceive a change in the kinds of alternate strategies and explanations they provide to struggling students 8.Teachers feel more prepared to identify student misunderstandings of math concepts 9.Teachers feel more prepared to identify student preconceptions of math concepts 10.Teachers feel more prepared to pose real-world problems to all students 11.Teachers feel more prepared to provide opportunities for students to investigate to solve problems 12.Teachers feel more prepared to discuss alternative mathematical hypotheses 13.Teachers feel more prepared to elicit student reflection	-Survey -Interviews
Study Question 4 **4. Challenges and/or Enabling factors for Lesson study as a sustainable practice**	1.Teachers perceive it to be challenging to generate a common goal overarching goal on which to base the lessons 2.Teachers perceive the size or make up of the Lesson study group to be a barrier for success 3.Teachers perceive the time commitment as a challenge 4.Teachers perceive scheduling time together as a challenge 5.Teachers perceive a lack of a thorough understanding of Lesson study as a barrier for success 6.Teachers perceive a lack of administrative support as a barrier for success 7.Teachers feel that participation in Lesson study does not directly affect student achievement 8.Teachers feel uncomfortable planning lessons with others 9.Teachers feel uncomfortable being observed while teaching the Lesson study lesson 10.Teachers feel uncomfortable discussing the observed Lesson study lesson 11.Teachers feel that participation in Lesson study provides opportunities for ongoing professional development 12.Teachers feel that the lessons learned through their participation in Lesson study can be applied to other lessons and subjects 13.Teachers feel that participation in Lesson study provides an opportunity to gather evidence of student learning 14.Teachers feel that they are more effective as a teacher	-Survey -Interviews

Figure 3. Data Collection Methods and Evidence Chart

3.5.4 Data Collection Procedures via Interviews

Data for the study was collected via survey instrument and interview transcripts. As mentioned in an earlier section, interview participants resulted from a convenience sampling of survey respondents. Of those who completed the survey, 53.8% (n=35) answered the demographic questions so that they could be contacted. The researcher sent each potential interview participant an email (n=35). See Appendix B. This email served as an invitation to participate in a 30-45 minute interview conducted in the participant's preferred method; face-to-face or by phone and 22.8% (n=8) were interviewed. After agreeing to be interviewed, the participants were sent an email requesting a time, location and date of their choice for the interview. Of those who agreed to be interviewed; 50% (n=4) were conducted face-to-face, and 50% (n=4) were conducted via phone. Prior to the beginning of each interview, participants were given a copy of their rights for review and signature (See Appendix B). These documents remain confidential and are kept locked in a file. Also, prior to each interview, the researcher gained verbal permission to audiotape the interview from each participant.

Each interview began with an introduction of the researcher and a brief summary of the study being conducted including the research questions. Data was then collected in the form of interview responses via a semi-structured interview, and it was audio-taped. At the conclusion of each interview, it was transcribed by a paid transcriber. Each interview participant was sent a copy of the interview transcript for review, additions, deletions and/or corrections. The interview transcripts are kept in a locked file and any, and all, identifying information is kept in a separate location so that confidentiality and anonymity is maintained.

3.6 ANALYSIS

Two types of analyses were conducted on the survey and interview transcripts to explore the four research questions. Data from the survey were analyzed quantitatively using SPSS[5] to determine the extent to which any perceived changes had occurred, and if they were notable. Descriptive statistics were conducted to gather data. These included frequencies and percentages. The data were further disaggregated by various factors and descriptive statistics were again used to identify the extent, if any, of perceived changes.

Particular responses from the participants that were embedded in the survey and interview transcripts were initially coded using a unique data set developed by the researcher. These data were used to illustrate specific examples, the extent of perceived change, and/or the nature of the responses. Interview transcripts were analyzed qualitatively to determine patterns in responses, perceived changes and emergent themes. The coding was developed based on the Data Collection and Methods Chart (Figure 3) and each statement made by the survey respondents or interview participants was assigned a code. This coding method was developed by the researcher and piloted on five teachers who participated in Lesson study but were not part of this study. Each pilot participant was interviewed and the transcripts were analyzed and coded. Once coded, the pilot participants were asked to review the coding and note their level of agreement to the coding of the researcher. One suggested change resulted from the piloting of the

[5] Statistical Package for Social Sciences for statistical analysis.

coding method—that is, responses could answer more than one research question and should be coded in multiple ways when possible.

After all of the interview transcripts were coded, similar data sets were examined for patterns and emerging themes. Additionally, all interview participants were offered an opportunity to review their coded interview transcript for accuracy.

Specifically, a content analysis was conducted on the interview transcripts by first reading through the document and color coding the responses based on which research question was answered (Patton, 1990). In the event that a response answered more than one question, the response was recorded multiple times. An Excel spreadsheet was used to organize this data. Once all of the responses from all of the interviewees were analyzed and organized by research question, the researcher coded each response based on how closely it related to the evidence reported in the Data Collections Methods and Evidence Chart (Figure 3). Each research question was numbered, each descriptor for question 1 was lettered, and each item in the 'Evidence' column was numbered. For example, the response below was coded as 1.b.3.

> I never used inquiry-based [instruction] through math. I had always done it through science and so I feel like it was a whole new ballgame for me—using inquiry-based [instruction]. I pretty much start every lesson off in math with a question and then give students an opportunity to investigate.

It was coded as such because it answers research question #1, it refers to a reform-based activity (b), and it refers to "teachers use of inquiry-based instruction" (3) listed on the Data Collections Methods and Evidence Chart. The following response was coded as both 1.a.1 and 2.1 as it answers questions #1 and #2 and refers to content knowledge:

> I don't know if my content knowledge has changed, I guess the way I go about the content might be different. You know, it was

> still teaching pennies to a five year old, but the way I go about the content is different.

Further examples of the coding method used to explicate patterns and themes in the interview transcripts are included in Appendix E.

3.7 SUMMARY OF METHODOLOGY

This study sought to gather data to understand teachers' perspectives related to their participation in Lesson study and its impact on their mathematical knowledge and their pedagogical-content knowledge. The researcher employed a mixed methods approach using a survey and follow-up, semi-structured interview. A 64.3% (n=83) response rate was achieved on the survey, and a 22.8% (n=8) response rate was achieved for the interview.

SurveyMonkey, a web-based survey tool, was used to collect the survey data which was then uploaded to SPSS for statistical analysis. A unique set of codes was developed by the researcher to identify patterns and emerging themes throughout the interview transcripts.

4.0 RESULTS

4.1 DEMOGRAPHICS

This chapter presents the results of an analysis of survey responses and interview transcripts. The analysis identified emergent themes and responses related to the research questions presented in earlier chapters. A further comparative analysis was generated to examine patterns in responses. Ultimately, the comparative analysis provides the basis for implications for both Lesson study participation in the future and for further study of this phenomenon. This chapter is divided into five different sections: the first section is devoted to demographics, and each of the subsequent four sections is devoted to the findings related to each research question.

4.1.1 Demographics of the Survey Population

This section describes the characteristics of the survey population. As described in earlier chapters, all survey participants were self-reported elementary school (kindergarten through sixth grade) teachers who taught mathematics in the southwestern region of Pennsylvania. The survey population included 129 elementary mathematics teachers from across the southwestern region of Pennsylvania including nine counties. Embedded in the survey were demographic questions

about participants' school districts and school, gender, most current teaching assignment, number of years of teaching and teaching certifications held.

A summary of the results shows that of those who responded to the questions about demographics, participants reported working in 17 *school districts* and 24 *different schools*. Additionally, of those who responded, 88.4% (n=38) were *female* and 11.6% (n=5) were *male*. Survey respondents were also asked to identify their current teaching assignment. It is notable that 40% (n=31) were *intermediate grade teachers (4th through 6th)* and 7.7% (n=6) were self-reported as *Math Specialists/Math Coaches*. Also noteworthy is that 12.8% (n=10) reported that they *did not teach elementary school* after beginning the survey. These participants did not complete any more of the survey.

Survey participants were asked to report the length of time they had been teaching as of the time of the survey. Of those who responded, the majority of respondents (69%; n=29) had been teaching for *15 or less years* with the greatest percentage of study participants (31%; n=13) reporting that they had been teaching for *11-15 years*. Also, 38% (n=16) had been teaching for *10 or less years* at the time of the survey, and 31% (n=13) had been teaching for *more than 15 years*; Table 1 depicts these results.

Table 1. Numbers of years participants have been teaching

Number of years teaching	% (n)
0-5	19.0 (8)
6-10	19.0 (8)
11-15	31.0 (13)
16-20	11.9 (5)
21-25	4.8 (2)
26-30	9.5 (4)
30+	4.8 (2)
Total	100.0 (42)

Participants were asked to identify their current teaching certifications. In the state of Pennsylvania, public school teachers must have earned either Temporary Professional Employee status, and hold an Instructional I Certificate, or have earned Professional Employee status and possess an Instructional II Certificate to teach. In addition, teachers may possess teaching certificates in subject areas; for example: mathematics, reading, or science. Of those who responded to this question, the largest percentage of participants (79.1%; n= 34) reported holding an *Instructional II Certificate*.

4.1.2 Demographics of the Interview Population

This section describes the characteristics of the interview population. As described in earlier chapters, all interview participants completed the study survey and acknowledged their

willingness to participate in an interview through their survey responses. Ultimately, thirty-five (35) survey respondents completed the survey demographic questions expressing a willingness to be interviewed. All thirty-five (35) were contacted via email and invited to participate in an interview. Of those contacted, 28.5% (n=10) agreed to be interviewed. This interview population (n=10) represents 15.3% of those who completed the survey. Of those ten (10) teachers who agreed to be interviewed, eight (8) teachers completed the interview and two (2) withdrew.

All eight (8) members of the interview population were self-reported elementary school (kindergarten through sixth grade) teachers who taught mathematics in the southwestern region of Pennsylvania and 100% (n=8) were female. Table 2 shows their demographic information.

Table 2. Demographic information of interview population

Name *(pseudonym)*	Gender	No. of years teaching	No. of years participating in Lesson study	Teaching Certifications
Dean, Lisa	F	0-5	1	Instructional II
Hart, Paula	F	16-20	3	Instructional II
Johns, Kim	F	11-15	2	Instructional II
Lark, Tara	F	0-5	1	Instructional I
Mains, April	F	11-15	3	Instructional II
Marks, Laurie	F	21-25	5	Instructional II
Sands, Karen	F	6-10	2	Instructional II
Young, Mary	F	11-15	2	Instructional II

4.2 FINDINGS RELEVANT TO RESEARCH QUESTION #1

Research Question #1: *To what extent are the characteristics of Lesson study implementation in this study, consistent with research-based definitions of quality professional development?*

The data related to this question were drawn from both survey results and interview transcripts. The findings are reported in six main areas related to the six research-based qualities of professional development as presented in a review of the literature. Chapter 2 presented a summary of the current literature regarding professional development and it was concluded that six characteristics emerge throughout many research-based definitions of quality professional development (Carpenter, Fennema, & Franke, 1996; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Elmore & Burney, 2000; Garet, Porter, Desimone, Birman, & Yoon,

2001; Guskey & Sparks, 2002; Sparks, 2002; Sparks & Hirsh, 2000; Weiss & Pasley, 2006). These qualities indicate that professional development is effective when it is:

Collaborative; there is collective participation

Content-focused

Reform-oriented

Extended in duration

Coherent

Involves active learning

The data related to research question #1 and the six qualities of effective professional development reported below were drawn from a 73 question survey and from interviews of eight elementary math teachers who engaged in Lesson study.

4.2.1 Lesson Study as a Collaborative Endeavor

Participants were asked to respond to questions about how frequently they engaged in particular behaviors during their engagement in Lesson study. The behaviors they were asked to respond to are typically associated with effective professional development (Desimone, Porter, Garet, Yoon, & Birman, 2002; Lewis, Perry, & Hurd, 2004; Sparks & Hirsh, 2000; Stigler & Hiebert, 1999). Specifically, they were asked to think about how much they collaborated with colleagues during their engagement in Lesson study. When asked how much they collaborated with colleagues from the same school or grade while engaging in Lesson study, the data indicate that a large percentage, 71.4% (n=35), responded *very much*, and 22.4% (n=11) responded *somewhat*. Also indicated is that only 6.1% (n=3) responded that they collaborated *very little* or *not at all*.

In addition to the survey responses strongly supporting *collaboration among colleagues*, interview participants seemed to perceive collaboration as a very important by-product of Lesson study engagement, as well. Karen reported,

> [One of the greatest benefits has been] working together as colleagues and just being able to talk to each other and bounce ideas off one another and share our successes and our difficulties and just helping each other as teachers become better. Because before we did Lesson study there wasn't any time, besides the in-services, that teacher's really got to sit down and talk and share with each other.

Laurie concurred and explained,

> ….looking at it in detail, the concepts, and how they should be taught and being able to work together as colleagues with all of our different expertise areas and seeing the different strategies we could use to teach the concepts. That's been very helpful, just being able to collaborate with each other. And again, like I said, pull all of our expertise together to make the lesson as perfect as it could be.

Karen specifically identified the challenges that come with the culture of teaching in the U.S. and the effect that Lesson study participation had on changing that for her. She explained,

> I really enjoyed Lesson study. And, I enjoyed the thinking behind it—just talking to colleagues—the communication behind it. Because, teaching is lonely. You go into your own classroom, you close the door, and that's it for six to eight hours. And, then you come out. And, you never get to see someone else teach, or someone else reflect on it. Because everyone has their own styles, it was nice to see, 'Am I doing this right?' or 'How would they do it?' Just validation that you are on the right page and you are doing the right thing. So, it was meaningful to me as a teacher.

Collaboration involves many components. In addition to planning collaboratively with colleagues, study participants were asked how often they shared their math knowledge with their

colleagues. Specifically, they were asked how often they shared their math knowledge before participating in Lesson study, and then how often they believed they shared their math knowledge after engaging in Lesson study. Of those who responded, 46.9% (n=23) reported that they shared their math knowledge with colleagues *often* or *very often* before engaging in Lesson study. Additionally, the data indicate that 38.8% (n=19) more of the respondents reported that they shared their knowledge *often* or *very often*—85.7% (n=42) after participating in Lesson study. A complete set of responses is shown in Table 3.

Table 3. Perceptions of frequency of shared learning with colleagues

Frequency	Before	After	Change
Very often	20.4 (10)	34.7 (17)	+14.3 (+7)
Often	26.5 (13)	51.0 (25)	+24.5 (+12)
Sometimes	40.8 (20)	12.2 (6)	-28.6 (-14)
Rarely	10.2 (5)	2.0 (1)	-8.2 (-4)
Never	2.0 (1)	0	-2.0 (-1)
Total	100.0 (49)	100.0 (49)	

4.2.2 Lesson Study as a Content-focused Endeavor

Carpenter, Fennema and Franke (1996) argue that teachers' knowledge of mathematics and the development of the knowledge base related to that are important characteristics of effective professional development. Professional development that focuses on both subject matter knowledge and knowledge of how students think and learn about mathematics are more likely to benefit students (Kennedy, 1999).

Study participants were asked how focused they were on improving student's mathematical content knowledge while engaging in Lesson study and 100% (n=49) of those who responded said *very much* or *somewhat* with 87.8% (n=43) reporting *very much* and 12.2% (n=6) reporting *somewhat*.

Lesson study is a professional development endeavor that encourages the analysis of instruction and reflection (Lewis, 2000; Stigler & Hiebert, 1999). It requires that teachers collaboratively analyze the results of their instruction and use that analysis to inform future practice. To seek out participants' perceptions of the role that Lesson study played in developing their skills related to analysis and reflection, participants were asked how much they felt that they analyzed their own mathematics instruction during the time they engaged in Lesson study. The largest percentage, 95.9% (n=47), responded *very much* or *somewhat* and 4.1% (n=2) responded *very little*. All participants who responded to this question felt that *some* of their time in Lesson study was devoted to actively analyzing math instruction.

4.2.3 Lesson Study as a Reform-oriented Endeavor

An important quality of effective professional development is that it is reform-oriented (Desimone, Porter, Garet, Yoon, & Birman, 2002). Reform-oriented PD is classified as activities like: teacher study groups, teacher collaborative, networks or committees (Desimone, Porter, Garet, Yoon, & Birman, 2002). Reform-oriented PD has also been characterized as collaborative activities that include technology, that develop the skills of inquiry-based teaching and/or differentiated instruction, that foster the use of multiple forms of assessment and/or assist in

teachers' developing their ability to pose open-ended questions (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989).

The next set of survey and interview questions sought to explore teachers' perceptions of any changes that occurred in the frequency of their use of reform-oriented skills or techniques. Specifically, respondents were asked to think about particular instructional methods they employed before engaging in Lesson study, then think about those same practices after having engaged in Lesson study. The instructional methods about which they answered questions are also typically aligned with effective mathematics teaching (Desimone, Smith, Baker, & Ueno, 2005).

When study participants were asked to consider how often they used inquiry-based instruction before and after participating in Lesson study, 50% (n=24) responded *often* or *very often* before engaging in Lesson study, and 85% (n=41) reported *very often* or *often* after participating in Lesson study indicating that 30.4% (n=17) more teachers reported that the use of inquiry based instruction after participating in Lesson study. Before participating in Lesson study, 35.4% (n=17) of the respondents said they believe that they *sometimes* used inquiry based instruction, and 14.6% (n=7) said they *rarely* or *never* used it. After engaging in Lesson study, 14.6% (n=7) of those who responded said they use inquiry-based instruction *sometimes*. Therefore, the data indicate that 14.5% (n=7) less teachers reported using inquiry-based instruction *rarely* or *never* after participating in Lesson study. All participants (100%) reported that they felt that they used inquiry-based instruction at least *sometimes*, after having engaged in Lesson study. These data are shown in Table 4.

The interview transcripts indicate that these data are similar to the survey data. Several respondents commented on an increase in the frequency of their use of inquiry-based instruction. Paula explained,

> I never used inquiry-based [instruction] through math. I had always done it through science and so I feel like it was a whole new ballgame for me—using inquiry-based [instruction]. I pretty much start every lesson off in math with a question and then give students an opportunity to investigate.

Karen also agreed, stating,

> I'm doing more now because Lesson study seems to encourage the students to think more on their own and come up with ways to solve a problem instead of us doing direct instruction.

Table 4. Perceptions of frequency of use of inquiry-based instruction

Frequency	Before	After	Change
Very often	20.8 (10)	45.8 (22)	+20.0 (+12)
Often	29.2 (14)	39.6 (19)	+10.4 (+5)
Sometimes	35.4 (17)	14.6 (7)	-20.8 (-10)
Rarely	12.5 (6)	0	-12.5 (-6)
Never	2.1 (1)	0	-2.1 (-1)
Total	100.0 (48)	100.0 (48)	

Another pedagogical method often associated with reform-oriented teaching is the inclusion of technology (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). When asked how often they used technology in their classrooms before they participated in Lesson study, then how often they used it after participating in Lesson study, 31.3% (n=15) of the participants

responded *often* or *very often* before engaging in Lesson study, and 41.7% (n=20) responded *often* or *very often* after engaging in Lesson study. These data indicate only a small change in participants' perception of the effect Lesson study participation had on their use of technology. Similarly, 45.8% (n=22) of the respondents said they used technology *sometimes* before they did Lesson study, and 43.8% (n=21) said they used technology *sometimes* after participating in Lesson study. Of those who responded, 23% (n=11) reported that they believed that they *rarely* or *never* used technology in their classroom before engaging in Lesson study, and 14.5% (n=7) felt that they *rarely* or *never* used technology in their classrooms after engaging in Lesson study. These data indicated very little change. Table 5 includes a complete set of responses.

Interview transcripts indicate a close similarity to the survey data. None of the interview participants indicated any change in their perceptions of the frequency of their technology use as a result of Lesson study participation. Of those who answered the question, they most frequently cited an absence of technology in their particular lesson plan as the reason.

Table 5. Perceptions of frequency of use of technology

Frequency	Before	After	Change
Very often	6.3 (3)	10.4 (5)	+4.1 (+2)
Often	25.0 (12)	31.3 (15)	+6.3 (+3)
Sometimes	45.8 (22)	43.8 (21)	-2.0 (-1)
Rarely	18.8 (9)	12.5 (6)	-6.3 (-3)
Never	4.2 (2)	2.1 (1)	-2.1 (-1)
Total	100.0 (48)	100.0 (48)	

Differentiated instruction is a reform-oriented pedagogical method that is frequently associated with highly effective teaching, specifically mathematics instruction (Desimone, Porter, Garet, Yoon, & Birman, 2002). Study participants were asked to think about how often they used this instructional method in their classrooms before participating in Lesson study and then again after participating in Lesson study. Of those who responded, 57.1% (n=27) believed that they used differentiated instruction *often* or *very often* before they participated in Lesson study and 87.7% (n=43) believed they used differentiated instruction *often* or *very often* in their classrooms after engaging in Lesson study. These data indicate that 32.6% (n=16) more teachers reported an increase in their use of differentiated instruction *very often* or *often* after engaging in Lesson study. A complete set of responses is shown in Table 6.

While interview transcripts did not reveal a change in respondents' perceptions of a change in the frequency of use of differentiated instruction, respondents did note a change in *how* they believed they used differentiated instruction after participating in Lesson study. Paula explained,

> Originally when I did differentiated instruction I would take a test, or pre-assessment, and take the results of pre-assessment and divide the kids based upon the results. And, I put all the kids that did really well in assessment in one group and the kids who weren't doing so well in a different group. And, I would have different activities available to two or three different groups at the same time. I don't do that anymore. I feel like I group the kids and I can advance them in a different manner just by asking them certain questions or asking them to do an activity in just a different way. So, everybody's doing the same activity, but through different questioning techniques I could get them to do something a little more difficult or more challenging.

Table 6. Perceptions of frequency of use of differentiated instruction

Frequency	Before	After	Change
Very often	28.6 (14)	46.9 (23)	+18.3 (+9)
Often	26.5 (13)	40.8 (20)	+14.3 (+7)
Sometimes	36.7 (18)	10.2 (5)	-26.5 (-13)
Rarely	8.2 (4)	2.0 (1)	-6.2 (-3)
Never	0	0	0
Total	100.0 (49)	100.0 (49)	

Ongoing assessment of student learning in both formative and summative ways provides important information to teachers (Tananis, 2008). Professional development that provides opportunities for teachers to learn about formative assessment is cited as reform-oriented (citation). Formative assessment provides information during the *formation* of skills and knowledge; during *learning* (Tananis, 2008). This unique set of information can be used to plan effectively for instruction; it allows us to gather data for *diagnosis and remedy*—so that teachers can impact the learning cycle in effective ways (Tananis, 2008). Some examples include: quizzes, unit tests, projects, and journals, written pieces for feedback, progressive labs, and dialogue in class. Survey respondents were asked to think about how frequently they used multiple forms of assessments in their classrooms before engaging in Lesson study, and then again after participating in Lesson study. Of those who responded, 35.9% (n=28) reported that they used multiple forms of assessment *often* or *very often* before engaging in Lesson study. After engaging in Lesson study, 58.3% (n=41) reported that they believed that they used multiple forms of assessments in their classrooms *often* or very *often*. These data indicate that 27.1%

(n=13) more teachers reported an increase in the frequency of use of assessments as a result of Lesson study participation. Table 7 shows a complete set of responses.

Table 7. Perceptions of frequency of use of assessments

Frequency	Before	After	Change
Very often	25.0 (12)	47.9 (23)	+22.9 (+11)
Often	33.3 (16)	37.5 (18)	+4.2 (+2)
Sometimes	35.4 (17)	14.6 (7)	-20.8 (-10)
Rarely	6.3 (3)	0	-6.3 (-3)
Never	0	0	0
Total	100.0 (48)	100.0 (48)	

Another suggested reform-oriented method of mathematics teaching was is an increase in the use of questions that require knowledge construction and problem-solving, i.e. open-ended questions (National Council of Teachers of Mathematics, 2000). Therefore, study participants were asked to report how often they felt that they posed open-ended mathematical questions to their students before engaging in Lesson study, and then after participating in Lesson study. Of those who responded, 59.1% (n=29) reported that they believed that they posed open-ended questions to their students *often* or *very often* before doing Lesson study. After participating in Lesson study, 95.8% (n=46) of the respondents reported that they felt that they posed open-ended questions to their students *often* or *very often* indicating an increase of 36.7% (n=17) more teachers posing open-ended questions. Table 8 depicts all of the responses.

Interview transcripts suggest that two participants identified specific changes in their use of open-ended responses as a direct result of Lesson study participation. Laura explained,

> Yes, I use them more now. Thinking about the tasks that you do, I've understood the value of problems where there are multiple ways to get an answer, or multiple answers. But Lesson study has made me consider those more when planning. I think I've always accepted many of them, but when I plan now, it makes me anticipate which ones [solutions] they're going to come up with. Paula also perceived an increase in her use of open-ended questions, explaining, "I just know I use a lot more of them and I require a lot more explanation on how they got their answers.

Table 8. Comparison of perceptions of frequency of use of open-ended math questions

Frequency	Before	After	% of Change
Very often	36.7 (18)	62.5 (30)	25.8 (+12)
Often	22.4 (11)	33.3 (16)	10.9 (+5)
Sometimes	30.6(15)	4.2 (2)	-26.4 (-13)
Rarely	10.2 (5)	0	-10.2 (-5)
Never	0	0	0
Total	100.0 (49)	100.0 (48)	

4.2.4 Disaggregated Data related to Reform-oriented Teaching

The data reported above related to reform-oriented teaching were further analyzed to look for patterns and/emerging themes. Therefore, these data were disaggregated by the number of years of Lesson study participation to examine what, if any, this had on teachers' perceptions of how Lesson study impacted their use of reform-oriented teaching skills. This was achieved by comparing how often teachers reported using reform-oriented skills before participating in Lesson study, and then, again, after participating in Lesson study. These data were divided into

three categories[6]: teachers who participated in Lesson study for less than one year, teachers who participated for one to three years, and teachers who participated in Lesson study for four or more years. Table 9 shows the results of teachers' perceptions of the impact that Lesson study participation had on their use of reform-oriented teaching after less than one year of participation. Table 10 shows the results of teachers' perceptions of the impact that Lesson study participation had on their use of reform-oriented teaching after participating for one to three years, and Table 11 shows the results of teachers' perceptions of the impact that Lesson study participation had on their use of reform-oriented teaching after participating for four or more years. These data indicate, overall, that regardless of how long teachers participated in Lesson study, they reported an increase in how often they used each of the reform-oriented teaching skills noted here.

[6] Teachers reported the length of time they participated in Lesson study in ranges rather than years. These ranges formed the categories for disaggregation.

Table 9. Perceptions of the impact that Lesson study had on their use of reform-oriented teaching skills after participating for less than one year

Before participating in Lesson study, I used	Very often	Often	Sometimes	Rarely	Never
inquiry-based lessons	31.3 (5)	31.3 (5)	31.3 (5)	0	6.3 (1)
technology	0	18.8 (3)	56.3 (9)	18.8(3)	6.3 (1)
differentiated instruction	37.5 (6)	12.5 (2)	37.5 (6)	12.5 (2)	0
different forms of assessments	25.0 (4)	43.8 (7)	31.3 (5)	0	0
open-ended questions	37.5 (6)	43.8 (7)	18.8 (3)	0	0

After participating in Lesson study, I used	Very often	Often	Sometimes	Rarely	Never
inquiry-based lessons	43.8 (7)	50.0 (8)	6.3 (1)	0	0
technology	6.3 (1)	25.0 (4)	50.0 (8)	12.5 (2)	6.3 (1)
differentiated instruction	43.8 (7)	25.0 (4)	25.0 (4)	6.3 (1)	0
different forms of assessments	50.0 (8)	31.3 (5)	18.8 (3)	0	0
open-ended questions	75.0 (12)	25.0 (4)	0	0	0

Table 10. Perceptions of the impact that Lesson study had on their use of reform-oriented teaching skills after participating for one to three years

Before participating in Lesson study, I used	Very often	Often	Sometimes	Rarely	Never
inquiry-based lessons	17.9 (5)	32.1 (9)	32.1 (9)	17.9 (5)	0
technology	10.7 (3)	25.0 (7)	39.3 (11)	21.4 (6)	3.6 (1)
differentiated instruction	27.6 (8)	37.9 (11)	31.0 (9)	3.4 (1)	0
different forms of assessments	28.6 (8)	28.6 (8)	32.1 (9)	10.7 (3)	0
open-ended questions	37.9 (11)	13.8 (4)	34.5 (10)	13.8 (4)	0

After participating in Lesson study, I used	Very often	Often	Sometimes	Rarely	Never
inquiry-based lessons	46.4 (13)	35.7 (10)	17.9 (5)	0	0
technology	14.3 (4)	28.6 (8)	42.9 (12)	14.3 (4)	0
to effectively plan for math instruction	51.7 (15)	48.3 (14)	0	0	0
different forms of assessments	46.4 (13)	46.4 (13)	7.1 (2)	0	0
open-ended questions	57.1 (16)	35.7 (10)	7.1 (2)	0	0

Table 11. Perceptions of the impact that Lesson study had on their use of reform-oriented teaching skills after participating for four or more years

Before participating in Lesson study, I used	Very often	Often	Sometimes	Rarely	Never
inquiry-based lessons	0	0	75.0 (3)	25.0 (1)	0
technology	0	50.0 (2)	50.0 (2)	0	0
differentiated instruction	0	0	75.0 (3)	25.0 (1)	0
different forms of assessments	0	25.0 (1)	75.0 (3)	0	0
open-ended questions	25.0 (1)	0	50.0 (2)	25.0 (1)	0

After participating in Lesson study, I used	Very often	Often	Sometimes	Rarely	Never
inquiry-based lessons	50.0 (2)	25.0 (1)	25.0 (1)	0	0
technology	0	75.0 (3)	25.0 (1)	0	0
differentiated instruction	25.0 (1)	50.0 (2)	25.0 (1)	0	0
different forms of assessments	50.0 (2)	0	50.0 (2)	0	0
open-ended questions	50.0 (2)	50.0 (2)	0	0	0

These data were further analyzed to compare how long teachers participated in Lesson study and how frequently they reported using these reform-oriented skills *very often* before engaging in Lesson study, and then, again, after participating in Lesson study. These data are reported in Table 12. The most increases reported were in the use of inquiry-based instruction and differentiated instruction, by teachers who participated in Lesson study for four or more years—50.0% (n=2) more teachers reported that they used each of these *very often* in their classroom after participating in Lesson study. These same teachers reported no change in their use of technology *very often* after Lesson study participation. Of teachers who participated in Lesson study for less than one year, 37.5% (n=6) more reported using open-ended questions *very*

often and 25.0% (n=4) more reported using different forms of assessments *very often*. This same population reported that only 6.3% (n=1) more reported using technology *very often* as a result of Lesson study participation. Of those teachers who engaged in Lesson study for one to three years, 28.5% (8) more reported that they used inquiry-based instruction *very often*, and 24.1% (n=7) more reported using differentiated instruction *very often*. This same population reported that only 3.6% (n=1) more used technology *very often* after participating in Lesson study. Overall, there is a positive relationship between the number of years a teacher engaged in Lesson study and an increase in their reporting that they used reform-oriented teaching practices *very often* in their classrooms.

Table 12. Percentage of change in teacher responses of 'very often' after Lesson study participation when considering reform-oriented teaching

Responses	Teachers who participated in Lesson study > 1 yr.			Teachers who participated in Lesson study 1-3 yrs.			Teachers who participated in Lesson study 4+ years		
	Before	After	*% of change*	Before	After	*% of change*	Before	After	*% of change*
inquiry-based lessons	31.3 (5)	43.8 (7)	*+12.5 (2)*	17.9 (5)	46.4 (13)	*+28.5 (8)*	0	50.0 (2)	*+50.0 (2)*
technology	0	6.3 (1)	*+6.3 (1)*	10.7 (3)	14.3 (4)	*+3.6 (1)*	0	0	*0*
differentiated instruction	37.5 (6)	43.8 (7)	*+6.3 (1)*	27.6 (8)	51.7 (15)	*+24.1 (7)*	0	25.0 (1)	*+25.0 (1)*
different forms of assessments	25.0 (4)	50.0 (8)	*+25.0 (4)*	28.6 (8)	46.4 (13)	*+17.8 (5)*	0	50.0 (2)	*+50.0 (2)*
open-ended questions	37.5 (6)	75.0 (12)	*+37.5 (6)*	37.9 (11)	57.1 (16)	*+19.2 (5)*	25.0 (1)	50.0 (2)	*+25.0 (1)*

4.2.5 Lesson Study as an Enduring Endeavor

After a review of current literature as presented in Chapter 2, it has been suggested that the length of time devoted to a particular professional development is directly related to its effectiveness in improving teachers' knowledge of teaching and learning in meaningful ways (Elmore & Burney, 2000; Guskey & Sparks, 2002; Hiebert, 1999; Sparks & Hirsh, 2000). Lesson study, as it is practiced in Japan, is a professional development practice that is cyclical in nature and is, therefore, conducted over long periods of time. Engagement in this process requires that teachers devote time to collaborative planning with colleagues, research into best instructional practices, in-depth planning of a learning event, deliberation and reflection of learning events, revisions of learning events and a renewal of this process (Stepanek, 2001; Stigler & Hiebert, 1999; Watanabe, 2002). It is expected to be ongoing and enduring in nature.

A survey instrument and interview transcripts were used to gather data related to what degree the study participants were engaged in an enduring professional development endeavor in the form of Lesson study. When asked how long they have participated in Lesson study, more than half of respondents 57.9% (n=33) participated in Lesson study for 1-3 years. Additionally, 35.1% (n=20) participated in Lesson study for less than one year and 7.0% (n=4) participated in Lesson study for 4-6 years. No one reported that they have participated in Lesson study for more than six years.

Interview participants were asked to describe how often they met in a Lesson study group. All respondents reported that they met repeatedly over the course of a school semester at a minimum, and over multiple years, at a maximum. Additionally, some respondents reported

that they met at regular intervals, while other respondents reported meeting irregularly for different reasons. For example, Mary noted,

> We probably met every couple of weeks, or every other week. The beginning of this school year we met every other week or every two weeks, something like that. And then as the year went on we met less and less because there were so many things going on. And then we decided, 'Oh, we need to get in gear and get this done.' And then we started to meet more often, like once a week, until we got it done.

Karen explained the value of engaging in Lesson study for extended periods of time saying,

> You can't sit down at one thirty-minute faculty meeting and say, 'We're going to do Lesson study. Let's do it on this lesson out of the textbook and just do it.' You need more planning. You need a little more creativity than that. You need to talk about the questioning strategies. You need to anticipate what they're going to do. And, really plan it out the right way. You can't hurry through it.

In addition to responding to questions related to how long participants engaged in Lesson study, participants were also asked if they plan to continue. It was reported in Chapter Two that teachers must overcome cultural barriers to participate in Lesson study as it requires teachers to engage in practices not typically associated with the kinds of professional development offered to U.S. teachers (Chokshi & Fernandez, 2004; Lewis, 2002; Lewis, Perry, Hurd, & O'Connell, 2006). One of the characteristics of Lesson study and other forms of effective professional development is the length of time in which participants are engaged. Lesson study is an on-going and cyclical activity (Lewis, 2000; Stigler & Hiebert, 1999). Traditional professional

development in a U.S. setting is characterized by workshops, conferences and courses (Fullan & Hargreaves, 1996; Guskey, 2000).

Therefore, it is important to understand whether or not teachers will continue engagement in spite of, or as a result of, these challenges and enabling factors. When asked if they plan to continue Lesson study participation, 66.0% (n=31) responded *yes*, and 34% (n=16) responded *no*.

The survey data were further analyzed to look for patterns or emerging themes related to the responses above. Therefore, data were analyzed to examine the relationship between how strongly a subject agreed that Lesson study helped them become a better teacher, and whether or not they planned to continue to participate in Lesson study. The survey data indicate that 100% (n=21) of the teachers who *strongly agreed* that Lesson study helped them become a better math teacher plan to continue participating in Lesson study. Survey data also indicate that 39.1% (n=9) of those who agreed that Lesson study helped them become a better math teacher plan to continue participating in Lesson study.

Survey data were also analyzed to examine the relationship between how strongly a subject agreed that Lesson study was an effective way to continue professional development and if they plan to continue participating in Lesson study. These data indicate that 92.3% (n=44) of those who *strongly agreed* that Lesson study was an effective way to continue professional development plan to continue. Of those who *agreed* that Lesson study was an effective way to continue professional development, only 35.0 % (n=7) plan to continue.

Additional patterns and emerging themes related to sustaining participation in Lesson study were also examined by further analyzing the survey data. The relationship between how long a study participant engaged in Lesson study and what effect, if any, that had on a

participant's plan to continue was examined. Survey data indicate that the longer a teacher engaged in Lesson study, the more likely they were to plan to continue. Of those teachers who participated in Lesson study for less than one year, 53.3% (n=8) reported that they plan to continue. Survey data also indicate that 71.4% (n=20) of teachers who participated in Lesson study for one to three years plan to continue, and 75.0% (n=3) of teachers who participated in Lesson study for four or more years also plan to continue. Table 13 depicts these results.

Table 13. Relationship between the number of years a teacher engaged in Lesson study and whether they plan to continue, in percentages

Responses	Teachers who participated in Lesson study > 1 yr.	Teachers who participated in Lesson study 1-3 yrs.	Teachers who participated in Lesson study 4+ years
Yes	53.3 (8)	71.4 (20)	75.0 (3)
No	46.7 (7)	28.6 (8)	25.0 (1)
Total	100.0 (15)	100.0 (28)	100.0 (4)

Survey data were analyzed to examine the relationship between how long study participants taught, and whether they plan to continue participating in Lesson study. A current review of the literature as presented in Chapter Two revealed that barriers to on-going participation in Lesson study exist as a result of the unique cultural differences between Japanese teachers and U.S. teachers, and it was hypothesized that more experienced teachers would be less likely to sustain participation in Lesson study due to their lengthy enculturation in U.S. traditions in education. Therefore, it is important to know if the length of time an individual teacher has taught has an effect of whether or not they will sustain their participation in Lesson study. The survey data indicate that 87.5% (n=7) of teachers who taught 0-5 years plan to continue their

participation in Lesson study; 62.5% (n=5) of teachers who taught 6-10 years plan to continue participating in Lesson study; 66.7% (n=12) of teachers who taught 11-20 year plan to continue to participate; and, 75.0% (n=6) of teachers who taught 21 or more years plan to continue. Therefore, these data indicate that the majority of participants plan to continue to participate in Lesson study and the less time an individual has been teaching, the more likely he or she is to continue participating in Lesson study. The responses are shown in Table 14.

Table 14. Relationship between the number of years a teacher taught and whether they plan to continue participating in Lesson study

Response	0-5 years teaching experience	6-10 years teaching experience	11-20 years teaching experience	21+ years teaching experience
Yes	87.5 (7)	62.5 (5)	66.7 (12)	75.0 (6)
No	12.5 (1)	37.5 (3)	33.3 (6)	25.0 (2)
Total	100.0 (8)	100.0 (8)	100.0 (18)	100.0 (8)

4.2.6 Lesson Study as a Coherent Endeavor

A review of literature regarding past practices in professional development suggests that teachers enjoyed a very high level of autonomy in the decision making regarding their professional development (Hatch & Shulman, 2005). Therefore, U.S. teachers have often been free to choose how professional development time and money was spent. This practice has also been deemed ineffective in producing results that positively impact teacher learning and student achievement. In the past, there was no requirement that engagement in professional development assist teachers, schools and/or districts in moving toward specific goals or objectives (Guskey, 2000;

Hatch & Shulman, 2005). Today, the literature suggests that professional development has been deemed effective when it is a collective, or coherent, exercise where colleagues possess shared beliefs and cultural norms that support both the professional development and the goals of the school, district and/or state (Fullan & Hargreaves, 1996). Of equal importance is that effective professional development is aligned with curricular standards at local, state and national levels (Hill, 2002).

Lesson study is a professional development endeavor that requires teachers to identify a gap in student performance and/or achievement and then collaboratively set a learning goal to close that gap (Stigler & Hiebert, 1999). Additionally, it is not uncommon for Japanese teachers to adopt a Lesson study goal that comes from the National Ministry of Education, connecting their work to national endeavors (Stigler & Hiebert, 1999). This unique level of coherence adds to the overall effectiveness of Lesson study as a professional development endeavor.

To answer questions about whether or not study participants engaged in Lesson study in ways that were coherent, data were collected from interview transcripts. There were few occasions where interview participants reported specifically that Lesson study participation was aligned with their personal, school, district or state goals. When asked what effect, if any, Lesson study participation had on their progress toward any personal, school, district or state goals, very few participants spoke explicitly about shared goals. Mary did report that,

> [In our district, there is] the big push towards having the kids investigate, and ask the right questions. Instead of using the typical using the right algorithm…. I guess Lesson study would be a very good way to do that.

When asked to describe the Lesson study process in which they engaged, several respondents reported that they discussed and agreed upon a goal for their lesson creation. Mary

also reported that their Lesson study lesson was developed with an *overall theme*. This participant stated, “The overall theme was how to become independent learners through problem-solving activities”.

Laura suggested that a shared learning goal was *not* the foundation of the lesson noting,

> We were a cross-grade level team so we wanted to do something that would be appropriate for all three grade levels. Geometry was something that we taught early in the year. We were beginning our Lesson study in August, so it was designed around what was going to be convenient at the time, rather than what we felt was a need for our students, since it was our first time doing Lesson study. So we decided to do a lesson on triangles because third grade does triangles, fourth grade does triangles, fifth grade does triangles, and we thought that we could adapt it easily from third to fourth to fifth grade.

Overall, interview respondents did not report with any notable importance that they perceived their participation in Lesson study to be consistent with their personal, school, district or state standards or goals.

4.2.7 Lesson Study and Active Learning

Active engagement in one’s own learning is a characteristic of both Lesson study and effective professional development (DuFour & Eaker, 1999; Huffman, 2001; Stigler & Hiebert, 1999). Teachers who work together to improve their content and pedagogical-content knowledge, and then act on that new knowledge experience valuable and positive results in their classrooms (Danielson, 1996; Linda Darling-Hammond, 1992; Louis & Marks, 1998). The iterative cycle of Lesson study also requires that teachers actively engage in several processes throughout the cycle including setting a goal for improved student performance, collaboratively planning a

lesson that is research-based, teaching a lesson, actively reflecting on and debriefing after the lesson is taught, and modifying and/or revising the lesson. To gather data to measure teachers' perceptions of how actively they participated in their own learning, they were asked several survey and interview questions. Specifically, they were asked how actively they participated in meaningful discussions about mathematics with colleagues and were also asked to describe the Lesson study process in which they participated.

Survey data indicated that 68.8% (n=33) responded that they actively participate in meaningful discussions with their colleagues *very much*, 27.1% (n=13) responded *somewhat* and 4.2% (n=2) responded *very little*. These data indicate that a large percentage of respondents, 95.9% (n=46) perceived themselves as actively participating in meaningful discussions about mathematics *very much* or *somewhat* while participating in Lesson study.

Interview transcripts indicate that participants perceived themselves as participating in meaningful discussions about mathematics during their Lesson study participation. One interview participant gave specific examples of a particular discussion held with her Lesson study Team.

> We came back together [and] we talked about what we observed amongst those particular students—what things stood out that were strengths, what things stood out that were needs. And, then after talking with our colleagues about it, they were able to give more insight into the class we were observing and gave more insight about those students. And then, along with talking about individual students, we talked about how the lesson could be improved……. what things could be done differently to get more students on board with understanding the concept.

When asked how actively they analyzed the impact that their own instruction had on student learning, 61.2% (n=30) responded *very much*, 36.7% (n=18) responded *somewhat* and

4.1% (n=1) responded *very little*. These data indicate that all participants who responded felt that they actively analyzed the impact that their instruction had on their students to some degree.

A review of the interview transcripts indicate results similar to the survey data—the majority of respondents described Lesson study experiences that included an analysis of the impact their instruction had on student learning. When asked *if* and *how* she analyzed the impact her instruction had on student learning, Paula responded,

> I think I'm cognizant now of the kids who are really strong math students in my class. I have become more aware of how I can try to get them to think more differently to get them to the next level. So, I know I have a handful of kids who are really, really bright math students. And I'm always trying to think, 'Well what can I get them to do next that will challenge them?' And I don't think I did that before. I might have said, 'Here's a group of enrichment sheets. And let's work on these.' But now I can really talk to them more and gauge their thinking.

Laura, during her interview, also gave a specific example of how her participation in Lesson study required her to analyze her instruction and, ultimately, change it. She explained,

> Division is probably the one that I notice the most—that students come to me having an idea about division. But their idea about division is not necessarily conceptual, and they are a little frustrated about using manipulatives. And, I always had this idea that if they came to me having a procedural understanding of division that I need to go back to square one with them and say, 'OK, let's back up all the way to the beginning'. And, it was frustrating for them, and it was frustrating for me, because they just wanted to jump to what they already knew. So it has changed my thinking in that way because now it's more of a meet them where they are kind of thing. [I] present a task where the procedure is not really going to get the answer for them. So they're going to have to have an understanding of what division is before they can attack the problem. The procedure is not going to do them any good explaining an answer or… you know what I mean? So, in that way, I think it [Lesson study participation] changed the way I teach… I need to meet them more of where they are than where I want to be.

Interview participants reported being actively engaged in several other practices during their Lesson study engagement, and described these as *important* and *meaningful*. These other practices that were reported have also been cited as part of the iterative cycle of Lesson study (Stigler & Hiebert, 1999). They are: setting an over-arching goal, researching a lesson, and debriefing after the lesson.

One component of the Lesson study cycle that is commonly used in Japan is goal setting (Lewis, 2000; Stepanek, 2001; Stigler & Hiebert, 1999). Interview transcripts indicate that two participants reported identifying a goal as part of their Lesson study participation and two participants reported not setting a goal at all. One respondent, Chris, explained that her team identified a topic, rather than a goal stating,

> The second time we met I asked them in between those times to think about what type of topic, what kind of questions do you want to have answered or addressed. I know when we did it in the professional development we were supposed to have a, I don't know what to call it, a category and then a specific topic within that category. So, I asked them to try and think of those two things. When we met again they decided that they wanted to do measurement as their general topic and then specifically measuring to the nearest inch. I'm not sure that we really interpreted, or they really interpreted…when we met again, it wasn't exactly what I had wanted. I had wanted more of a general type of, do you want better questioning strategies from your students.

These data indicate differences in the goal-setting process and in respondents reported understanding of this step in the cycle.

Interview transcripts also included three descriptions of researching for a Lesson study lesson. Lisa described the experience of researching for the lesson by saying,

> The research we were doing was more like looking for best practices or different types of problem-solving or things like that. And, quality examples that the kids would be able to use and that

> we would maybe be able to get the results that we were looking for. It took us a little while to find some examples where they lent themselves to multiple problem-solving strategies and being able to see the way the kids were thinking.

Both Paula and Mary described their experience with the research component differently. Paula stated,

> The research involved finding articles that were pertinent to what we wanted to implement our lesson on. So the one I'm doing here right now involves measurement. So, we used the resources that were available to us and we found all sorts of different articles related to measurement.

Mary described her research as,

> With the problem that we chose, we did some research on different problem solving strategies. And, we also researched different types of words problems that we might want to use.

These data indicate a difference in respondents reporting of how this step in the Lesson study cycle was understood and implemented.

De-briefing after the lesson was another component of Lesson study that was reported by interview participants when asked to describe their active engagement in the process. Paula described her group's experiences as,

> The debriefing process involved us sitting in a group and just analyzing what we thought worked, what we thought didn't work, and what we thought we could do better.

Laura described a different experience, explaining,

> We actually had someone from the MSP[7] come and do the role of the facilitator. So it was more formal and there were more people

[7] MSP is the Math/Science Partnership of Southwestern Pennsylvania

> involved because more people were involved in the planning of it. It was for a sixth grade classroom, but we had high school and middle school and elementary school teachers involved in that one.

And, Mary described her debriefing experience, saying,

> We found that the answers we thought we would get, we did get. We talked about what things we would have liked to see differently. For example, the students, they all used the same problem solving strategy. And I had, being that I was the teacher, I had to prompt them to what other strategies could you use to help you solve the problem. ….. So we had talked about what we would get, we all saw the same thing, and thought that maybe next time, we would do a better job encouraging them to use different strategies in the very beginning as opposed to halfway through the lesson. And, then we also thought about having the students work independently on trying to answer it first, and then go back and have them talk as a group to see how each individual student did it differently. I think we would have gotten a wider variety of problem solving strategies if we would have had them do it independently. That's about all that we discussed.

These data indicate that respondents reported similar experiences during the debriefing process when they included it as part of the Lesson study cycle.

4.2.8 Overall Perceptions of the Effectiveness of Lesson Study Engagement as a Professional Development Endeavor

As mentioned in previous paragraphs, Lesson study embodies the characteristics most closely linked to effective professional development, and Japanese and American teachers have enjoyed much success through their engagement in it (Chokshi & Fernandez, 2005; C. Fernandez, Cannon, & Chokshi, 2003; Maria Fernandez, 2005; Lewis, 2000; Lewis, Perry, Hurd, & O'Connell, 2006; Masami & Reza, 2005; Rice & Rose, 2009; Stepanek, 2001; Stigler & Hiebert, 1999; Watanabe, 2002; Weeks & Stepanek, 2001). This study sought to examine the relationship between the characteristics of effective professional development and the characteristics of the experiences of study participants as they engaged in Lesson study in their individual schools and school districts. Those data were discussed in previous paragraphs. To gain a perspective on teachers' overall perceptions of the effectiveness of Lesson study engagement as a professional development endeavor, study participants were asked to identify rate their agreement of the following statement: *Lesson study is an effective way to continue my professional development*. The survey data indicate that 97.9% (n=46) either *strongly agreed* or *agreed*—that is 55.3% (n=26) and 42.6% (n=20) respectively with this statement and 2.1% (n=1) disagreed.

Survey data were further analyzed to identify any patterns in responses or emerging themes. Therefore, survey data were examined to look for a relationship between how long a teacher participated in Lesson study and the extent to which they agreed that it was an effective way to continue their professional development. These data indicate that those teachers who participated in Lesson study the longest agreed more strongly that it was an effective way to

continue their professional growth. Of those participants who participated in Lesson study for four or more years, 75.0% (n=3) *strongly agreed* that it was effective. Of those teachers who participated in Lesson study for one to three years, 57.1% (n=16) *strongly agreed* that Lesson study was an effective way to continue professional development, and 46.7% (n=7) of those teachers who participated in Lesson study for less than one year *strongly agreed* that it was an effective way to continue professional development. These responses are shown in Table 15.

Table 15. Relationship between the number of years a teacher engaged in Lesson study and how strongly they agree that Lesson study is an effective way to continue their professional development

Responses	> 1 yr. Lesson study participation	1-3 yrs. Lesson study participation	4+ years Lesson study participation
Strongly agree	46.7 (7)	57.1 (16)	75.0 (3)
Agree	53.3 (8)	39.3 (11)	25.0 (1)
Disagree	0	3.6 (1)	0
Strongly disagree	0	0	0
Total	100.0 (15)	100.0 (28)	100.0 (4)

4.3 FINDINGS RELEVANT TO RESEARCH QUESTION #2

Research Question #2: *What are teachers' perceptions of their participation in Lesson study and its impact on their content knowledge of elementary mathematics?*

Effective professional development, as mentioned in earlier chapters, is focused on developing teachers' knowledge of the subject or subjects they must teach and how to teach them

(Linda Darling-Hammond & Ball, 1998; Linda Darling-Hammond & Cobb, 1995; Elmore & Burney, 2000; Fullan, 2001; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000). Furthermore, professional development (PD) that is highly effective helps teachers become deeply immersed in the content (Sparks & Hirsh, 2000). And, the content, or core tasks of teaching, when mastered, provide teachers with the necessary skills to make important decisions about their students' progress (Linda Darling-Hammond & Ball, 1998). Carpenter, Fennema and Franke (1996) argue that teachers' knowledge of mathematics and the development of the knowledge base related to that are important characteristics of effective PD. Lastly, Ma (1999) stresses that teachers must possess a profound understanding of fundamental mathematics (p. 123) as a corollary to effective teaching.

Learning and understanding mathematics is a core feature of Lesson study engagement. Lesson study, as documented in the literature, requires that participants collaboratively plan a lesson that is built upon research they conduct (Stigler & Hiebert, 1999). This research into the subject matter provides opportunities for teachers to deepen their understanding of it. When asked, Japanese teachers indicated that Lesson study participation increased their subject-matter knowledge (Lewis, Perry, & Murata, 2003). Overall, the purpose of Lesson study is to produce new knowledge about content and pedagogy (Cohen & Ball, 1999). This study sought to examine and come to understand the role that Lesson study participation had on teachers' perception of changes in their knowledge of mathematics.

The data related to research question #2 were drawn from both survey results and interview transcripts. Participants were asked about their perspectives on the effects that their Lesson study participation had on their mathematical content knowledge. Based on a current review of the literature, six characteristics of mathematical content knowledge emerged.

Therefore, study participants were asked to specifically consider how frequently they spent time focusing on these characteristics of mathematical content knowledge before engaging in Lesson study and then to reflect on their perceptions of what effect, if any, Lesson study participation had on these. The six research-based characteristics and/or skills typically associated with mathematical content knowledge are (citation):

Understanding the core mathematical concepts students need to learn

Understanding the connections between and across math concepts

Understanding the cognitive demands of mathematical concepts

Teaching mathematical concepts rather than discrete skills

Effectively planning for instruction

Overall mathematical knowledge

4.3.1 Content-Focus

When teachers deepen their core subject knowledge they are much more likely to understand how children learn math, ultimately improving their own teaching (Gearhart & Saxe, 2004). While increasing their content knowledge, teachers increase their ability to *know what students know*. Chapter 2 presented a comprehensive review of the literature on the importance of a teacher's ongoing improvement in content knowledge and the role that effective professional development plays in that pursuit. A summary of that literature suggests that teaching is a very complex undertaking, and all teachers need to clearly understand what mathematics students must know and be able to do (Ma, 1999; National Council of Teachers of Mathematics, 2000; Stigler & Hiebert, 1999). Teachers must be responsive to the needs and abilities of their students

and understand a broad base of content and teaching pedagogy (National Council of Teachers of Mathematics, 2000).

This study posed questions in the forms of survey instrument and interview to gather data related to teachers' perspective on the impact that Lesson study had on a change in their math content knowledge. Participants were asked how much time they were focused on mathematical content during the times they were engaged in Lesson study. The survey data indicated that, of those who responded, 100% (n=49) reported that they were focused on math content *very much* or *somewhat*.

4.3.2 Understanding the Core Mathematical Concepts Their Students Need to Learn

Understanding the core mathematical concepts students need to master is vital to effective teaching. Liping Ma (1999) argues that teachers must possess a strong knowledge of the "Basic Ideas—an awareness of the simple but powerful basic concepts and principles of mathematics" (p. 122). Therefore, participants were asked how often they felt as if they understood the core mathematics their students needed to learn before participating in Lesson study, and then after participating in Lesson study. The survey data indicated that 70.8% (34) of the respondents believed that they *very often* or *often* understood the core mathematics before engaging in Lesson study. After participating in Lesson study, 100% (n=48) felt that they understood the core mathematics that their students needed to know *very often* or *often*. An increase of 54.2% (n=26) more teachers perceived an understanding of the core math *very often* or *often* is indicated by the data. A complete set of responses is shown in Table 16.

Interview transcripts offer some insight into respondents' perceptions of *if* and *how* their understanding of the core concepts has changed. Laura reported that she believed that her math content knowledge increased and described an example of that change in her content knowledge, saying,

> I think so. I never knew about the sides of the triangle, that two [can't] be less than the third one. I didn't know that before we started. In my own content knowledge, I think that's one thing I learned.

Paula also described her perceptions of how her understanding has changed, offering,

> I've always been a really good math student myself. And I've always felt like I've understood the math. I could get it through procedure. But I don't think I've always taught why something was done the way it was to really get the nuts and bolts of the concepts—the *meatiness* of it. And, I think through Lesson study I've been able to get a better grasp of math—why it works. And, showing visuals on how it should work. And, showing multiple ways on why something is done. I think I've become better about the math content.

Lisa described the changes in her understanding of the core concepts as,

> With Lesson study I'm realizing that obviously we are all learners and we need to continue to make ourselves better. And I'm learning that there's a lot that I can still learn. …. we struggle quite a bit with the concepts that we have to teach, versus being able to teach the kids in a mastery-type situation. I'm learning more and more that, though…..there's still quite a bit that I can learn and Lesson study is a great way.

Of the eight interviewees, two respondents disagreed. One kindergarten teacher disagreed, stating,

> I don't know if my content knowledge has changed. I guess the way I go about the content might be different. You know, it was

> still teaching pennies to a five year old. But, the way I go about teaching the content is different.

Another teacher, Tara, explained why she didn't feel that her understanding of the core math content had changed, stating,

> See, that's where I thought I'd know more about it, and I don't know if we did enough research on the actual math part. I think we thought we knew more than we did. Because we chose problem solving and we already knew, I mean, we thought we knew all the ways the students were going to get to the problem. Whether it was……repeated addition, just using a regular algorithm, or drawing a picture—they basically did all of the ways that we had thought, so I don't know if my actual math knowledge has increased at all from this.

Table 16. Perception of the frequency with which teachers understood the core math concepts

Frequency	Before	After	% of Change
Very often	37.5 (18)	79.2 (38)	+41.7 (+20)
Often	33.3 (16)	20.8 (10)	-12.5 (-6)
Sometimes	27.1 (13)	0	-27.1 (-13)
Rarely	2.1 (1)	0	-2.1 (-1)
Never	0	0	0
Total	100.0 (48)	100.0 (48)	

4.3.3 Understanding the Connections Between Math Concepts

Connectedness, or making connections among mathematical concepts and procedures, from simple and superficial to complicated and underlying, and identifying the connections among different operations is a prerequisite for effective teaching of mathematics (Ma, 1999).

Participants were asked how often they felt that they understood the connections between mathematical concepts before participating in Lesson study, and then again after participating in Lesson study. Of those who responded, 25% (n=12) reported that they understood the connections between math concepts *very often*; 33.4% (n=16) reported *rarely* or *sometimes.* After engaging in Lesson study, 66.7% (n=32) of the respondents reported understanding the mathematical connections between math concepts *very often*. Therefore, the data indicate a number of respondents who perceive themselves as understanding the connections between math concepts *very often*—that is an increase of 41.7% (n=10) more teachers perceived an increase after engaging in Lesson study. Also, it is notable that after participating in Lesson study the data indicate that 29.2% (n=14) less respondents perceived that they *rarely* or *never* understand the connections between math concepts. Table 17 shows the complete set of survey data.

Table 17. Perceptions of the frequency with which teachers understood the connections between math concepts

Frequency	Before	After	% of Change
Very often	25.0 (12)	66.7 (32)	+41.7 (+10)
Often	41.7 (20)	29.2 (14)	-12.5 (-6)
Sometimes	29.2 (14)	4.2 (2)	-25.0 (-12)
Rarely	4.2 (2)	0	-4.2 (-2)
Never	0	0	0
Total	100.0 (48)	100.0 (48)	

4.3.4 Understanding the Cognitive Demands of Mathematical Concepts

The kinds of tasks in which students engage impacts the mathematics they learn. When students only work on low-level tasks, the learning that occurs tends to be procedural in nature. Students who solve cognitively demanding tasks are more likely to develop a conceptual understanding (Stein, Grover, & Henningsen, 1996; Stein & Lane, 1996). Therefore, it is imperative that teachers know and understand the cognitive demands of the mathematical concepts in which their students are engaged. Furthermore, professional development that provides opportunities for teachers to strengthen their understanding of the cognitive demands of mathematical concepts is an effective endeavor. A review of the current literature of Lesson study suggests that engagement in this practice provides opportunities for teachers to examine the cognitive demands of the math concepts. As such, participants in this study were asked about their perceptions about how frequently this occurred for them. Specifically, they were asked how frequently they felt that they understood the cognitive demands of the mathematical concepts their students needed to learn before engaging in Lesson study, and then after practicing Lesson study. The participants who responded reported that 22.9% (n=11) felt that they understood the cognitive demands of the math concepts *very often* before engaging in Lesson study, and 52.1% (n=25) felt that they understood the cognitive demands *very often* after having participating in Lesson study. These data indicate that 29.2% (n=19) more teachers felt that they understood the cognitive demands of math *very often* after Lesson study. Before participating in Lesson study, 10.4% (n=5) reported that they *rarely* or *never* understood the cognitive demands of the math concepts. None of those who responded reported that they felt that way after participating in

Lesson study indicating a 10.4% (n=5) decrease in the number of teachers. Table 18 shows the responses.

Interview participants were asked to describe how Lesson study affected their understanding of the cognitive demands of math. One respondent explained how she used what she learned through Lesson study in her classroom, stating,

> I look at math differently than I did before. I have them talk through it more. And I ask them a lot, explain your thinking. Tell me what you're thinking. Why did you do that? Not just, what is four plus two? But, why do you know it's this? Or, how did you get to that answer? Tell me your thinking. Show me what you were doing when you were doing it. And it gets kids thinking about their thinking—the higher level metacognitive thinking skills that they might not be doing. They say, well I know two plus two is four. But when you say, how do you know that, sometimes they can tell you it's four, but they can't tell you why it's four. So it's getting down to all of those strategies of how they get to it.

Table 18. Perceptions of the frequency with which teachers understood the cognitive demands of math concepts

Frequency	Before	After	% of Change
Very often	22.9 (11)	52.1 (25)	+29.2 (+14)
Often	31.3 (15)	41.7 (20)	+10.4 (+5)
Sometimes	35.4 (17)	6.3 (3)	-29.1 (-14)
Rarely	8.3 (4)	0	-8.3 (-4)
Never	2.1 (1)	0	-2.1 (-1)
Total	100.0 (48)	100.0 (48)	

4.3.5 Prepared to Teach Math Concepts

Research, as presented in Chapter 2, has outlined the need for an improvement in the way U.S. teachers teach mathematics. It has been suggested that this improvement include a change in the level of content in which students are engaged—U.S. mathematical concepts are presented to students later than our internationally successful counterparts (Stigler & Hiebert, 1999). A review of the literature has also suggested that the pattern of mathematics instruction implemented in U.S. schools did not add to the depth of students' understanding. Instruction was described as "overly broad and thin" (Pianta, Belsky, Houts, & Morrison, 2007). Additionally, teachers were ill-equipped to deliver the kinds of instruction that support conceptualization, higher order thinking and problem-solving (Weiss & Pasley, 2006).

Lesson study, as research suggests, affords teachers the opportunity to gain new knowledge of, or change their understanding about, math concepts being taught; teachers are able to make clearer connections between the standard being taught and classroom instruction; and teachers are able to clarify or change their thinking about student thinking (Lewis, Perry, & Murata, 2006).

This study collected data in the form of survey instrument and interview transcripts to identify teachers' perceptions of the impact that Lesson study had on how prepared they were to teach math conceptually. Of those who responded to this question about how prepared they felt to teach math concepts rather than skills, they reported that, before engaging in Lesson study, 60.7% (n=29) felt prepared *often* or *very often*. 95.7% (n=45) reported that they felt prepared to teach math concepts rather than skills *often* or *very often* after engaging in Lesson study

indicating that 34% (n=16) more teachers perceived an increase. Table 19 shows all of the results.

Interview transcripts indicate similar findings—most respondents reported feeling more prepared to teach math concepts rather than skills after participating in Lesson study. Mary explained her thinking,

> Yes, definitely. It makes you look at the concepts. It makes you look at the overall picture, not just the individual skills that you have to keep teaching or you have to get done—but that broader content. You don't so much have to isolate each individual skill when you teach the concept.

When asked to describe *how* she felt she taught concepts rather than skills, Mary offered,

> After, [Lesson study participation] there was a big push towards having the kids investigate—so I had to ask the right questions. Instead of teaching the typical right algorithm and saying, this is the way you have to answer the question. Having the students be able to say this is the way to solve it on its own and pushing towards that. I guess the Lesson study was a very good way to do that. I think the biggest part is that the kids independently thinking and trying to solve the problems. And, not just trying to follow one certain way. They're able to investigate and able to see the different ways but still come up with the same answer. And, sharing those different strategies and different ways with the class—then, those kids that aren't getting it could possibly understand it from another student.

Karen explained her perceptions of the role that Lesson study played in helping her to learn to teach concepts rather than skills, saying,

> I started looking at it in detail, the concepts, and how they should be taught and being able to work together as colleagues with all of our different expertise areas and seeing the different strategies we could use to teach the concepts. That's been very helpful.

Table 19. Perceptions of how prepared teachers felt to teach math concepts rather than skills

Frequency	Before	After	% of Change
Very often	29.8 (14)	63.8 (30)	+34.0 (+16)
Often	31.9 (15)	31.9 (15)	0
Sometimes	36.2 (17)	4.3 (2)	-31.9 (-15)
Rarely	2.1 (1)	0	-2.1 (-1)
Never	0	0	0
Total	100.0 (47)	100.0 (47)	

4.3.6 Prepared to Plan for Instruction

In addition to being asked how prepared they felt to teach concepts rather than skills, study participants were asked how prepared they felt to plan for instruction before they engaged in Lesson study and then again after. Survey data indicated that 29.8% (n=14) felt prepared to plan for instruction *very often* before they participated in Lesson study. And, of those who responded, 70.2% (n=33) reported that they felt prepared to plan for instruction after participating in Lesson study. These data indicate a 40.4% (n=19) increase in the number of respondents reporting that they feel prepared to plan for instruction *very often* as a result of their Lesson study participation. Table 20 shows these results.

Interview transcripts also indicate that the majority of participants perceived a change in how prepared they felt to plan for instruction. Several respondents described a heightened awareness of needing to think more deeply about their planning. Laura described this saying,

> Actually, it [Lesson study participation] makes me consider what I don't know. I think you feel less competent when you do it,

> because I think like, oh, man. Ok. I didn't think of that before. And I never considered that before when I planned a lesson. So when you're cruising along and you're thinking you're at a good place in your career, and you're at a good place in you're planning and thinking, here comes Lesson study to smack you in the head and say, well, perhaps you should think a little more deeply about that—what you say and what you do. I think what it's done, is it's made me think more in my planning about what the students are going to do rather than what I'm going to do.

Lisa also described a new awareness of the importance of planning as a result of Lesson study participation, explaining,

> I used to think I was incredibly prepared, and I do still think I know the concepts well, but it kind of shook me up a little bit. It shook up my understanding of things and it's certainly given me a new goal for the summer and as I'm continuing, of just being more prepared and being able to learn more about the way the kids are thinking. And, to learn more about best practices in math and things like that. Just to feel very confident in teaching math and I still do. I'm not going to say it totally shattered my abilities to teach it. But it's certainly showed me that there's a lot more I have to learn. And I learned that in a good way….. I was more inspired to learn even more to become more prepared.

Paula stressed the importance of planning carefully, saying,

> I'm much more prepared at planning because of Lesson study. I'm just finding out it takes a lot more planning. You can't just come into the classroom and expect to get something done. You really have to think ahead of time, prepare ahead of time. So it's time consuming.

Table 20. Perceptions of how prepared teachers felt to plan for math instruction

Frequency	Before	After	% of Change
Very often	29.8 (14)	70.2 (33)	+40.4 (+19)
Often	48.9 (23)	29.8 (14)	-19.1 (-11)
Sometimes	21.3 (10)	0	-21.3 (-10)
Rarely	0	0	0
Never	0	0	0
Total	100 (47)	100 (47)	

4.3.7 Overall Math Content Knowledge

Data were collected from interview transcripts to identify teachers' perspectives on the impact that Lesson study participation had on their overall math content knowledge, and the perspectives differed widely. One respondent noted the difference between knowing math and teaching math, stating:

> I've always been a really good math student myself. And I've always felt like I've understood the math. I could get it through procedure. But I don't think I've always taught why something was done the way it was to really get the nuts and bolts of the concepts--the *meatiness* of it. And, I think through Lesson study I've been able to get a better grasp of math; why it works, showing visuals on how it should work, and showing multiple ways on why something is done. I think I've become better, absolutely, about the content.

One respondent provided a specific math example, saying:

> I never knew about the sides of the triangle, that two [can't] be less than the third one. I didn't know that before we started. In my own

> content knowledge, I think that's what I learned through Lesson study.

Karen disagreed, offering

> I don't know if my content knowledge has changed, I guess the way I go about the content might be different. You know, it was still teaching pennies to a five year old, but the way I go about the content is different.

4.3.8 Disaggregated Data Related to Teachers' Perceptions of Their Math Content Knowledge

Survey data related to teachers' perceptions of the impact that Lesson study participation had on their mathematical content knowledge were disaggregated in an effort to uncover any patterns or emerging themes. These survey data were disaggregated by the number of years teachers participated in Lesson study, and were, therefore, divided into three categories: teachers who participated in Lesson study for less than one year, teachers who participated for one to three years, and teachers who participated in Lesson study for four or more years. Teachers were asked to respond to questions that measured their perceptions of how often they understood or felt prepared to use skills related to math content knowledge in their classrooms before Lesson study engagement, and then, again, after (Linda Darling-Hammond & Ball, 1998; Linda Darling-Hammond & Cobb, 1995; Elmore & Burney, 2000; Fullan, 2001; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000). These disaggregated data are reported in Tables 21, 22 and 23 and indicate that teachers perceived themselves as understanding or feeling prepared to use each of the skills and/or competencies more often after engaging in Lesson study, regardless of how long they had participated. There is an increase in teachers reporting that they understood

or felt prepared to use these skills *very often* after participating Lesson study. It is notable that, amongst teachers who participated in Lesson study for less than one year, or for one to three years, the highest percentage—80.0% (n=12) and 82.8% (n=24) respectively reported understanding the core mathematical concepts my students are expected to learn *very often* after engaging in Lesson study.

Table 21. Perceptions of the impact that Lesson study participation had on their math-content knowledge after participating for less than one year

Before participating in Lesson study, I	Very often	Often	Sometimes	Rarely	Never
understood the core mathematical concepts my students are expected to learn	46.7 (7)	33.3 (5)	20.0 (3)	0	0
understood the connections between mathematical concepts	33.3 (5)	40.0 (6)	26.7 (4)	0	0
understood the cognitive demands of mathematical concepts	33.3 (5)	26.7 (4)	40.0 (6)	0	0
felt prepared to teach mathematical concepts rather than mathematical procedures	46.7 (7)	13.3 (2)	33.3 (5)	6.7 (1)	0
felt prepared to effectively plan for math instruction	40.0 (6)	40.0 (6)	20.0 (3)	0	0

After participating in Lesson study, I	Very often	Often	Sometimes	Rarely	Never
understood the core mathematical concepts my students are expected to learn	80.0 (12)	20.0 (3)	0	0	0
understood the connections between mathematical concepts	73.3 (11)	26.7 (4)	0	0	0
understood the cognitive demands of mathematical concepts	60.0 (9)	40.0 (6)	0	0	0
felt prepared to teach mathematical concepts rather than mathematical procedures	80.0 (12)	20.0 (3)	0	0	0
felt prepared to effectively plan for math instruction	66.7 (10)	33.3 (5)	0	0	0

Table 22. Perceptions of the impact that Lesson study participation had on their math-content knowledge after participating for one to three years

Before participating in Lesson study, I	Very often	Often	Sometimes	Rarely	Never
understood the core mathematical concepts my students are expected to learn	37.9 (11)	31.0 (9)	31.0 (9)	0	0
understood the connections between mathematical concepts	24.1 (7)	37.9 (11)	31.0 (9)	6.9 (2)	0
understood the cognitive demands of mathematical concepts	17.2 (5)	31.0 (9)	34.5 (10)	13.8 (4)	3.4 (1)
felt prepared to teach mathematical concepts rather than mathematical procedures	17.9 (5)	42.9 (12)	39.3 (11)	0	0
felt prepared to effectively plan for math instruction	28.6 (8)	50.0 (14)	21.4 (6)	0	0

After participating in Lesson study, I	Very often	Often	Sometimes	Rarely	Never
understood the core mathematical concepts my students are expected to learn	82.8 (24)	17.2 (5)	0	0	0
understood the connections between mathematical concepts	62.1 (18)	31.0 (9)	6.9 (2)	0	0
understood the cognitive demands of mathematical concepts	44.8 (13)	44.8 (13)	10.3 (3)	0	0
felt prepared to teach mathematical concepts rather than mathematical procedures	53.6 (15)	39.3 (11)	7.1 (2)	0	0
felt prepared to effectively plan for math instruction	75.0 (21)	25.0 (7)	0	0	0

Table 23. Perceptions of the impact that Lesson study participation had on their math-content knowledge after participating for four or more years

Before participating in Lesson study, I	Very often	Often	Sometimes	Rarely	Never
understood the core mathematical concepts my students are expected to learn	0	2	1	1	0
understood the connections between mathematical concepts	0	3	1	0	0
understood the cognitive demands of mathematical concepts	25.0 (1)	50.0 (2)	25.0 (1)	0	0
felt prepared to teach mathematical concepts rather than mathematical procedures	50.0 (2)	25.0 (1)	25.0 (1)	0	0
felt prepared to effectively plan for math instruction	0	75.0 (3)	25.0 (1)	0	0

After participating in Lesson study, I	Very often	Often	Sometimes	Rarely	Never
understood the core mathematical concepts my students are expected to learn	50.0 (2)	50.0 (2)	0	0	0
understood the connections between mathematical concepts	75.0 (3)	25.0 (1)	0	0	0
understood the cognitive demands of mathematical concepts	75.0 (3)	25.0 (1)	0	0	0
felt prepared to teach mathematical concepts rather than mathematical procedures	75.0 (3)	25.0 (1)	0	0	0
felt prepared to effectively plan for math instruction	50.0 (2)	50.0 (2)	0	0	0

In the section above, data were analyzed to determine the impact that Lesson study participation had on teachers' perceptions of their math content knowledge disaggregated by the number of years of Lesson study participation. This was measured by teacher reports of how often they understood or felt prepared to use the related skills and/or competencies in their classrooms before participation in Lesson study, and then after. Table 24 shows a comparison of the percentage of teachers who reported that they understood or felt prepared to use these skills *very often* before Lesson study and then again after participating in Lesson study. These data were disaggregated by the number of years of Lesson study participation. Several areas of notable findings are reported. Teachers who participated in Lesson study for less than one year reported that 40.0% (n=6) more teachers reported understanding the connections between mathematical concepts *very often* after participating in Lesson study. Of those teachers who participated in Lesson study for one to three years, 46.4% (n=13) more reported that they feel prepared to plan effectively for mathematics instruction *very often* after engaging in Lesson study. Of this same group 44.9% (n=13) more reported that they understand the core mathematical concepts students are expected to learn *very often* after Lesson study participation. Of those who participated in Lesson study for four or more years, 75.0% (n=3) more reported understanding the connections between mathematical concepts *very often* after engaging in Lesson study. As mentioned above, an increase in the percentage of teachers who *very often* understand or feel prepared to use each of the skills and competencies presented in this study related to math content knowledge was indicated by these data.

Table 24. Perceptions of the use of math content related skills' very often' disaggregated by number of years of Lesson study participation

Responses	Teachers who participated in Lesson study > 1 yr.			Teachers who participated in Lesson study 1-3 yrs.			Teachers who participated in Lesson study 4+ years		
	Before	After	*% of change*	Before	After	*% of change*	Before	After	*% of change*
Understood the core mathematical concepts my students are expected to learn	46.7 (7)	80.0 (12)	*+33.3 (5)*	37.9 (11)	82.8 (24)	*+44.9 (13)*	0	50.0 (2)	*+50.0 (2)*
Understood the connections between mathematical concepts	33.3 (5)	73.3 (11)	*+40.0 (6)*	24.1 (7)	62.1 (18)	*+38.0 (11)*	0	75.0 (3)	*+75.0 (3)*
Understood the cognitive demands of mathematical concepts	33.3 (5)	60.0 (9)	*+26.7 (4)*	17.2 (5)	44.8 (13)	*+27.6 (8)*	25.0 (1)	75.0 (3)	*+50.0 (2)*
Felt prepared to teach mathematical concepts rather than mathematical procedures	46.7 (7)	80.0 (12)	*+33.3 (5)*	17.9 (5)	53.6 (15)	*+35.7 (10)*	50.0 (2)	75.0 (3)	*+25.0 (1)*
Felt prepared to effectively plan for math instruction	40.0 (6)	66.7 (10)	*+26.7 (4)*	28.6 (8)	75.0 (21)	*+46.4 (13)*	0	50.0 (2)	*+50.0 (2)*

4.4 FINDINGS RELEVANT TO RESEARCH QUESTION #3

Research Question #3: *What are teachers' perceptions of their participation in Lesson study and its impact on their pedagogical-content knowledge of elementary mathematics?*

The data related to this question were drawn from both survey results and interview transcripts. The findings are reported in nine key areas. The nine key areas emerged as a result of a current review of literature as presented in Chapter 2. Specifically, data were gathered to measure teachers' perceptions of the impact that Lesson study participation had on their pedagogical-content knowledge.

Shulman proposed the idea of "subject matter knowledge *for teaching"*, or pedagogical-content knowledge: "I include . . . the ways of representing and formulating the subject that make it comprehensible to others . . . [and] an understanding of what makes the learning of specific topics easy or difficult, of the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning.. . ." (1986, p. 9). Pedagogical-content knowledge differs from both content knowledge and pedagogical knowledge in important ways. It is a unique combination of both that embodies both the 'what' and the 'how' of a particular discipline.

Chapter 2 presented a review of the literature related to the knowledge and skills that effective math teachers possess. Specifically, Chapter 2 described the role that pedagogical-content knowledge plays in the effectiveness of the teacher. And, a summary of this same literature generated a list of qualities and/or skills that are often linked to a teacher's pedagogical-content knowledge of mathematics (Desimone, Porter, Garet, Yoon, & Birman, 2002).

They are:

Understanding how children learn math

Understanding how students think about mathematics

Preparedness to develop students' conceptual understanding of mathematics

Use of high level math tasks for all students

Use of questions that have open-ended responses for all students

Acceptance of the use of alternate strategies and/or explanations from students

Identifying student misunderstandings of math concepts

Identifying student preconceptions of math concepts

Posing real-world problems to all students

Providing opportunities for students to investigate to solve problems

Discussing alternative mathematical hypotheses

4.4.1 Understanding How Children Learn Mathematics

A review of the current literature on qualities of effective math teachers suggests the importance of understanding both the mathematical content, and how students learn that content. Teaching is a very complex undertaking, and all teachers need to clearly understand what mathematics students must know and be able to do (Ma, 1999; National Council of Teachers of Mathematics, 2000; Stigler & Hiebert, 1999). Excellent teachers are concerned with knowing what students understand and how they learn, so they can help students integrate new ideas and transform prior conceptions (Shulman, 1987 as cited in (Thousand, Villa, & Nevin, 2004).

Over the past decade, research has emerged that provides insight into high-quality professional development (Desimone, Smith, & Ueno, 2006). This research suggests that professional development will be successful in changing teacher practice in important and positive ways when it focuses on a teacher's content knowledge, and on an understanding of how children learn that content (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Researchers argue that Lesson study fulfills these characteristics (Chokshi & Fernandez, 2005; C. Fernandez, 2005; Hiebert et al., 2003).

To that end, participants were asked how often they felt that they understood how children learn math both before participating in Lesson study and then after engaging in Lesson study. Of those who responded, 14.6% (n=7) reported feeling as if they understood how children

learned math *very often* before they did Lesson study. Conversely, 54.2% (n=26) of those same respondents reported that they felt that they understood how children learn math *very often* after participating in Lesson study indicating that 39.6% (n=19) more teachers perceived an increase. Table 25 shows the complete set of results.

Interview transcripts suggest similar results. Participants explained that now they "consider the bigger picture more—I consider where they've come from and where they're going and what my little moment means in their progression towards that". Karen offered,

> Like I said, they might know two plus two is four just because they've memorized it, but that doesn't mean they know that they're joining two groups together. Or when they subtract, they're taking things away.

She also added,

> I think my first few years of teaching, I thought, they have to be quiet, they have to be in a seat, they have to just be doing this and kind of go about it. But, now I use a lot more with math of, Ok, we're going to put out ten counters. We're going to turn of them six over. We're going to use inchworms to measure—and it's a lot more hands-on; a lot more of the investigations type math where they really have to do it on their own. We're measuring with inchworms. We're weighing things. We are using connecting blocks to add things. It's a lot more hands on. They're actually doing it and they're actually seeing it, it helps them. It changes math for them. And they can understand it. It's just more concrete and more meaningful to the students.

Lisa explained that through Lesson study she learned things about how her students learn math that surprised her. She explained,

> Based on the Lesson study that we did, we learned very quickly that these kids are… we had a hard time getting them to try some other strategies. They are very comfortable with one or two strategies. And, we found that the strategies that they're comfortable with are a lot of times are the same problem solving strategies that are used across the board regardless of a teachers' understanding of the math. The kids were very, very reluctant to kind of put themselves out on a limb a little bit and say, hey,

> there's two or three ways I could do this, but I'm going to take a risk in trying it this way. They are so conditioned to do repeated addition for a multiplication problem and that's all that we saw. And when we asked them to try and come up with another way to solve that problem, they struggled.

Interview transcripts also indicated that participants perceived themselves as having used their new understanding of how children learn math in their classrooms. Laura explained,

> It [Lesson study] forces you to look for evidence of what they understand in you're doing. That it's one thing to stand up and ask questions and go around and see what they're doing, but it's another thing to base the next step in your lesson on what you see…….you're considering what they're doing and what that means according to what they understand. I'm considering what they show—and what they say and how that represents what they know.

Paula also explained how she feels she uses her understanding of how students learn math in her classroom,

> With Lesson study, I became aware, as I increasingly walked around the classroom, listening, for evidence of student-learning. I really started to pay attention to what the kids were saying to each other. Just by what I could hear, I would figure out where somebody was not understanding a concept, or where one student would be grasping a concept easily.

Table 25. Perceptions of how often teachers understood how children learn math

Frequency	Before	After	% of Change
Very often	14.6 (7)	54.2 (26)	+39.6 (+19)
Often	43.8 (21)	43.8 (21)	0
Sometimes	33.3 (16)	2.1 (1)	-31.2 (-16)
Rarely	8.3 (4)	0	-8.3 (-4)
Never	0	0	0
Total	100.0 (48)	100.0 (48)	

4.4.2 Understanding How Students Think Mathematically

A knowledge of students' thinking is an essential element for an improvement in teaching (Carpenter, Fennema, & Franke, 1996). Professional development that affords teachers the opportunity to expand their understanding of how their students think mathematically has been deemed effective. Through Lesson study, according to a current review of literature, teachers are able to gain new knowledge of, or change their understanding about, the concept being taught; teachers are able to make clearer connections between the standard being taught and classroom instruction; and teachers are able to clarify or change their thinking about student thinking (Lewis, Perry, & Murata, 2006). Professional development that focuses on developing skills to better understand students' thinking provides important opportunities for teachers to improve their practice (Carpenter, Fennema, & Franke, 1996; Desimone, 2009).

Study participants were asked how often they felt that they understood how children think mathematically both before engaging in Lesson study and then after participating in Lesson

study. Of those who responded, 21.3% (n=10) reported understanding how children think mathematically *very often* and 29.9% (n=14) reported understanding how children think mathematically *often* before engaging in Lesson study. Conversely, 50% (n=24) felt that they understood how children think mathematically *very often* and 41.7% (n=20) reported *often* after engaging in Lesson study indicating that 40.6% (n=20) more teachers perceived an increase. A complete set of findings is shown in Table 26.

Interview transcripts uncovered participants' perspective on how Lesson study affected their understanding of how children think mathematically. Tara noted her surprise during the teaching of the math lesson created by her Lesson study team.

> I think it's interesting to see, we had thought by putting them in groups that we had chosen—we chose them with the low-mid and then mid-high and we thought we were going to see a difference in how they were going to do this. I was surprised to see that most of them had decided to do it the same way. I thought that, and I've never taught third grade, I thought for sure that some of them were going to go straight to the math. You know, the 5x7=35 or the division of it, and they didn't. So I guess I was surprised that a lot of them think more alike than I would have thought and I was hoping to see more differences and I didn't. So, I was just surprised to see that they were doing it more similar, which to me would show that that's the way they were taught. And that also means that we probably aren't working their brains as much as we should be. I mean trying to get them to try different things in the previous grades or what not I guess.

Several respondents acknowledged that they had learned more about how children think mathematically and described their explicit pursuit of this in their lessons. Katie explains,

> I certainly ask a whole lot more questions to get at their thinking than I ever did. It is definitely a practice that has developed through the last four years. And Lesson study also is a part of that, because anticipating their strategies then I ask better questions so I can lead them, if they don't even know where to start… So I guess Lesson study built on the emphasis of teaching through

> questioning—so, yeah, maybe Lesson study adds that little extra piece of OK so I'm anticipating their approaches, I've thought about what they could do. So if they don't know how to get started I have somewhere to guide them.

Lastly, Paula acknowledges how much she has learned about the value of understanding how children think mathematically and explains the strategies she now uses in her classroom to uncover it.

> I just find that I tap into their minds a lot more. I want to tap into what they're thinking and I want them to explain out loud what they're thinking and why they're thinking the way they do. It's because, sometimes I can't even understand what they're trying to get across. And, so I really like hearing their thought processes—like what's going on in their brain. I find that sometimes they don't think the way I think. And, there's multiple strategies out there and it's interesting that everybody has something different to share.

Mary also spoke about the importance of knowing how students think mathematically, stating,

> It was interesting to see the students, how they think. There are many times they're sitting there and they look like they're working really hard. And [you think] 'What's going on in your mind? What's going on in there? And, getting them to talk about it is sometimes very difficult. Especially your brighter student. They know the answer—they write it down. But, when you go back [and ask], 'How'd you get that?' They don't know how. They just know the answer. So, those students that just know it, when they're asked to explain, they really have a difficult time. But then you have those kids who really have to put a lot of thought process into it, but they're understanding what they're doing. It was kind of interesting to get at their thinking.

April also described her how Lesson study participation changed her perceptions about the value of understanding how children think mathematically, explaining,

> Like I said before, it's so important to know what kids are thinking. It seems like they come up with ideas and solve problems that myself as a teacher and a learner never thought of. So they are very creative in how they solve problems. And if they don't know how to do it the way you taught it, they may come up with their own way that works that you would have never thought of to teach to them in that way. So they're coming up with those ways and sharing those ways with their fellow students and then those students are understanding the concept more because it's down at their level more than at the teacher-student level.

Table 26. Perceptions of how often teachers understood how children think mathematically

Frequency	Before	After	% of Change
Very often	21.3 (10)	50.0 (24)	+28.7 (+14)
Often	29.8 (14)	41.7 (20)	+11.9 (+6)
Sometimes	40.4 (19)	8.3 (4)	-32.1 (-15)
Rarely	8.5 (4)	0	-8.5 (-4)
Never	0	0	0
Total	100.0 (47)	100.0 (48)	

4.4.3 Prepared to Develop Students' Conceptual Nnderstanding

Students will undoubtedly face new kinds of problems in the future so it becomes imperative that the kinds of math learning provided to them enable them to understand math in new ways (National Council of Teachers of Mathematics, 2000). A conceptual understanding is called for—more attention must be paid to number concepts. Additionally, students need to learn to make connections and do so by developing conjectures, evaluating the thinking of themselves and others, and by developing reasoning skills (C. Fernandez & Cannon, 2005; Hiebert et al.,

2003; Hiebert & Stigler, 2000; LeFevre & Bisanz, 1987; Ma, 1999; National Council of Teachers of Mathematics, 2000; Stigler & Hiebert, 1999)

Survey participants were asked to identify how prepared they felt to develop their students' conceptual understanding of mathematics both before they engaged in Lesson study and then again after engaging in Lesson study. Of those who responded, 61.7% (n=29) noted that they felt prepared to develop a conceptual understanding *very often* or *often* before engaging in Lesson study. After participating in Lesson study, 97.8% (n=46) of the survey respondents reported that they felt prepared to develop their students' conceptual understanding of mathematics *very often* or *often* indicating that 36.2% (n=17) more teachers perceived an increase in feeling prepared to develop their students' conceptual understanding of math. A complete set of responses is shown in Table 27.

Table 27. Perceptions of how often teachers felt prepared to develop their students' conceptual understanding of math

Frequency	Before	After	% of Change
Very often	29.8 (14)	63.8 (30)	+34.0 (+16)
Often	31.9 (15)	34.0 (16)	+2.1 (+1)
Sometimes	31.9 (15)	2.1 (1)	-29.8 (-14)
Rarely	6.4 (3)	0	-6.4 (-3)
Never	0	0	0
Total	100.0 (47)	100.0 (47)	

4.4.4 Use of Best Practices

Chapter 2 presented a review of literature related to the Third International Math and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), and the subsequent call for a reform in the teaching of mathematics in the U.S. by several national organizations, and by leading educators and researchers (Desimone, Smith, Baker, & Ueno, 2005; Gonzales et al., 2001; Hiebert, 1999; Hiebert et al., 2003; Hiebert & Stigler, 2000; Mariann Lemke et al., 2001; M. Lemke et al., 2004; Lewis, 2000; Ma, 1999; National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008; Schmidt, 2002; Stigler & Hiebert, 1999). This call for a reformation of the teaching of mathematics in U.S. classrooms suggested that several changes were imperative in order for American students to improve their mathematics performance on international measures. This call for reform was built on the fundamental premise which required that all students should be able to understand and use math in everyday life and in the workplace (National Council of Teachers of Mathematics, 2000). Therefore, it was strongly recommended that teachers change their practice to ensure that students be provided with:

Accommodations and necessary supports to meet high expectations

Opportunities to learn important mathematics

Opportunities to solve more sophisticated problems

Opportunities to develop new understandings and construct their knowledge of important ideas, through collaboration, discussion, problem-solving, construction of arguments and real-world experiences (National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008)

In an effort to seek out teachers' perceptions of the role that Lesson study played in reforming their practice in these important ways, several survey and interview questions were posed to study participants. The following paragraphs report the data collected related to these responses.

When asked how frequently they felt that they used high level math tasks before engaging in Lesson study and, then again, after engaging in Lesson study, 16.7% (n=8) reported that they felt they used them *very often,* and 31.3% (n=15) reported that they used them *often* before they participated in Lesson study. Of those who responded, 53.1% (n=26) felt that their teaching had changed and, therefore, reported that they felt that they presented high level math tasks to all of their students *very often* with 36.7 (n=18) reporting that they used high level math tasks *often*. These data indicate an overall increase of 41.8% (n=21) of participants who perceive that they use high level math tasks *often* or *very often* as a result of engaging in Lesson study. Table 28 shows all of the results.

Table 28. Comparison of perceptions of how often teachers used high level math tasks in their classroom

Frequency	Before	After	% of Change
Very often	16.7 (8)	53.1 (26)	36.4 (+18)
Often	31.3 (15)	36.7 (18)	5.4 (+3)
Sometimes	35.4 (17)	10.2 (5)	-25.2 (-12)
Rarely	16.7 (8)	0	-16.7 (-8)
Never	0	0	0
Total	100.0 (48)	100.0 (49)	

4.4.5 Use of Open-ended Mathematical Questions

Another suggested reform of mathematics teaching was a call for an increase in the use of questions that require knowledge construction and problem-solving (National Council of Teachers of Mathematics, 2000). Therefore, study participants were asked to report how often they felt that they posed open-ended mathematical questions to their students before engaging in Lesson study, and then after participating in Lesson study. Of those who responded, 59.1% (n=29) reported that they believed that they posed open-ended questions to their students *often* or *very often* before doing Lesson study. After participating in Lesson study, 95.8% (n=46) of the respondents reported that they felt that they posed open-ended questions to their students *often* or *very often* indicating that 36.7% (n=17) more teachers felt that they posed open-ended questions *often* or *very often*. Table 29 depicts all of the responses.

Interview transcripts suggest that two participants identified specific changes in their use of open-ended responses as a direct result of Lesson study participation. Laura explained,

> Yes, I use them more now. Thinking about the tasks that you do, I've understood the value of problems where there are multiple ways to get an answer, or multiple answers. But Lesson study has made me consider those more when planning. I think I've always accepted many of them, but when I plan now, it makes me anticipate which ones [solutions] they're going to come up with.

Paula also perceived an increase in her use of open-ended questions, explaining,

> I just know I use a lot more of them and I require a lot more explanation on how they got their answers.

Table 29. Comparison of perceptions of how often teachers posed open-ended math questions to their students

Frequency	Before	After	% of Change
Very often	36.7 (18)	62.5 (30)	25.8 (+12)
Often	22.4 (11)	33.3 (16)	10.9 (+5)
Sometimes	30.6(15)	4.2 (2)	-26.4 (-13)
Rarely	10.2 (5)	0	-10.2 (-5)
Never	0	0	0
Total	100.0 (49)	100.0 (48)	

4.4.6 Use of Alternate Teaching Strategies and/or Explanations

As mentioned earlier, NCTM's call for a reformation of the teaching of mathematics in U.S. schools was built upon the fundamental premise that all students should be able to understand and use math in everyday life and in the workplace (National Council of Teachers of Mathematics, 2000). As such, all students need to have access to an excellent math program that is responsive to their needs, including prior knowledge, personal interests and strengths—and the support to use these skills to make connections (Ma, 1999; National Council of Teachers of Mathematics, 2000; Stigler & Hiebert, 1999). Therefore, study participants were asked to report their perceptions of the role that Lesson study participation had on their use of alternate strategies and explanations with their students. Survey participants were asked how often they used alternate strategies and/or explanations with their struggling students before they participated in Lesson study and then after. Of those who responded, 27.1% (n=13) reported that

they felt they used them *very often* before participating in Lesson study. And, 56.3% (n=27) reported that they used alternate strategies and explanations with struggling students *very often* after they did Lesson study. These data indicate that 29.2% (n=14) more teachers believe that they use alternate teaching strategies and/or explanations *very often*. Table 30 shows all of the responses.

Table 30. Comparison of perceptions of how often teachers used alternate teaching strategies and/or explanations with their students

Frequency	Before	After	% of Change
Very often	27.1 (13)	56.3 (27)	29.2 (+14)
Often	35.4 (17)	41.7 (20)	6.3 (+3)
Sometimes	33.3 (16)	2.1 (1)	-31.2 (-15)
Rarely	2.1 (1)	0	-2.1 (-1)
Never	2.1 (1)	0	-2.1 (-1)
Total	100.0 (48)		

4.4.7 Use of real-world problems

The National Council of Teachers of Mathematics (NCTM) has called upon teachers to provide more opportunities for students to develop new understandings and construct their knowledge of important mathematical ideas, through collaboration, discussion, problem-solving, construction of arguments, and real-world experiences (National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008). Therefore, teachers are required to pose real-world problems to their students, facilitate discussion and collaboration, and develop their students'

ability to problem-solve through investigation. To seek out teachers' perceptions of the role that Lesson study played in assisting them in developing and/or strengthening their ability to use these skills, three questions were posed to them. When asked how often they posed real-world problems to their students before participating in Lesson study, 34.7% (n=17) respondents reported that they felt that they posed real-world problems *very often*, and 28.6% (n=14) reported *often*. After participating in Lesson study, 58.3% (n=28) of the survey respondents reported that they felt that they posed real-world problems to their students *very often*, and 35.4% (n=17) reported *often*. These data indicate that 30.4% (n=14) more teachers report that they use real-world problems *often* or *very often* in their math instruction. A complete set of responses is shown in Table 31.

Table 31. Comparison of perceptions of how often teachers posed real-world problems

Frequency	Before	After	% of Change
Very often	34.7 (17)	58.3 (28)	23.6 (+11)
Often	28.6 (14)	35.4 (17)	6.8 (+3)
Sometimes	28.6 (14)	4.2 (2)	-13.4 (-12)
Rarely	8.2 (4)	2.1 (1)	-6.1 (-3)
Never	0	0	0
Total	100.0 (49)	100.0 (48)	

4.4.8 Providing Opportunities to Investigate to Solve Problems

Survey participants were asked how often they felt that they provided opportunities to investigate to solve mathematical problems before they engaged in Lesson study and then again after participating in Lesson study. Of those who responded, 25.5% (n=12) reported that they did this *very often* before they engaged Lesson study. Additionally, 59.6% (n=28) reported that they felt that they provided opportunities for their students to investigate to solve mathematical problems *very often* after having participated in Lesson study indicating that 34.1% (n=16) more teachers provide these opportunities *very often*. Table 32 shows these results.

Table 32. Comparison of perceptions of how often teachers provided opportunities for students to investigate to solve problems

Frequency	Before	After	% of Change
Very often	25.5 (12)	59.6 (28)	+34.1 (+16)
Often	34.0 (16)	36.2 (17)	+2.2 (+1)
Sometimes	34.0 (16)	4.3 (2)	-29.7 (-14)
Rarely	6.4 (3)	0	-6.4 (-3)
Never	0	0	0
Total	100.0 (47)	100.0 (47)	

4.4.9 Discussing Alternate Hypotheses with Students

The last question in this section asked participants how often they felt that they provided their students with opportunities to discuss alternate mathematical hypotheses in their classrooms both before they engaged in Lesson study and then after. The survey data indicate that 23.4% (n=11) reported that they discussed alternate hypotheses with their students *very often* before they did Lesson study and 46.8% (n=22) reported *very often* after having participated in Lesson study. The data indicate a 23.4% (n=11) increase in the number of teachers who reported that they discussed alternate hypotheses *very often*. A complete set of survey responses is shown in Table 33.

Table 33. Comparison of perceptions of how often teachers provided opportunities for students to discuss alternate hypotheses

Frequency	Before	After	% of Change
Very often	23.4 (11)	46.8 (22)	+23.4 (+11)
Often	31.9 (15)	44.7 (21)	+12.8 (+6)
Sometimes	34.0 (16)	8.5 (4)	-25.5 (-12)
Rarely	10.6 (5)	0	-10.6 (-5)
Never	0	0	0
Total	100.0 (47)	100.0 (47)	

4.4.10 Identifying Student Preconceptions

Essential components of teachers' pedagogical-content knowledge are the skills to be able to discern and identify students' understanding of the core mathematical concepts presented to them (Carpenter, Fennema, & Franke, 1996; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Specifically, understanding the conceptions, preconceptions and misconceptions that students possess about specific content assists teachers in developing their own knowledge; a key component to effective instruction (Carpenter, Fennema, & Franke, 1996). And, a professional development endeavor, such as Lesson study, that focuses on developing skills to better understand students' thinking provides important opportunities for teachers to improve their practice (Carpenter, Fennema, & Franke, 1996; Desimone, 2009). In an effort to seek out study participants perspectives on the role that Lesson study played in their ability to identify their students' preconceptions and misconceptions of mathematical content, two questions were posed to them.

When asked how prepared they felt to identify student preconceptions of mathematical concepts, 14.9% (n=7) of those who responded reported that they felt prepared *very often* and 27.7% (n=13) reported that they felt prepared *often* before they practiced Lesson study. Of those who responded to the question as to how prepared they felt to identify student preconceptions after participating in Lesson study, 40.4% (n=19) reported *very often* and 51.1% (n=24) reported feeling prepared *often*. Therefore, these data indicate a 48.9% (n=23) increase in the number of respondents reporting that they felt prepared to identify student preconceptions of math after participating in Lesson study. Table 34 shows a complete set of results.

Interview participants were also asked how Lesson study participation affected their ability to identify student preconceptions of mathematical concepts in their classrooms and several reported feeling that it changed their ability somewhat. One respondent, Laura, used an example from her classroom to elaborate on the changes she felt. She noted,

> Division is probably the one that I notice the most—that students come to me having an idea about division. But, their idea about division is not necessarily conceptual, and they are a little frustrated about using manipulatives. And, I always had this idea that if they came to me having a procedural understanding of division that I need to go back to square one with them and say, 'OK, let's back up all the way to the beginning.' And it was frustrating for them, and it was frustrating for me, because they just wanted to jump to what they already knew. So it has changed my thinking in that way because now it's more of a meet them where they are kind of thing.

In her explanation, she also includes examples of how she uses this skill of identifying student preconceptions in her planning for instruction, explaining,

> So I present a task where the procedure is not really going to get the answer for them. They're going to have to have an understanding of what division is before they can attack the problem. The procedure is not going to do them any good explaining an answer or…. So in that way I think it's changed the way I teach. I need to meet them more of where they are than where I want to be.

Table 34. Comparison of perceptions of how prepared teachers felt to identify student preconceptions of mathematical concepts

Frequency	Before	After	% of Change
Very often	14.9 (7)	40.4 (19)	+25.5 (+12)
Often	27.7 (13)	51.1 (24)	+23.4 (+11)
Sometimes	46.8 (22)	8.5 (4)	-38.3 (-18)
Rarely	10.6 (5)	0	-10.6 (-5)
Never	0	0	0
Total	100.0 (47)	100.0 (47)	

4.4.11 Identifying Student Misconceptions

Study participants were also asked how prepared they felt to identify students' misconceptions of mathematical concepts before they engaged in Lesson study, and then again after participating in Lesson study. Of those who responded, 57.5% (n=27) reported that they felt prepared *often* or *very often* before they engaged in Lesson study. Of those who responded to the question asking how prepared they felt to identify student misconceptions after engaging in Lesson study, 97.9% (n=46) reported that they felt prepared *often* or *very often*. These data indicate a 40.4% (n=19) increase in the number of teachers reporting that they feel prepared to identify student misconceptions of math concepts *often* or *very often* as a result of Lesson study participation. Table 35 depicts total responses.

Interview transcripts indicate a notable change in how prepared teachers felt to identify student misconceptions as a result of Lesson study participation. Every interview participant

cited feeling more prepared. When asked to describe how Lesson study affected how prepared she felt to identify student misconceptions, April described how she uncovers them. She explained,

> [I feel] definitely better at identifying misconceptions because I'm clueing myself more into listening to their explanations of how they got an answer, or, the math talk between the students. I think Lesson study overall has made me more aware of listening to my students. Because it's not just what they write on paper, it's interviewing them, it's listening to their explanations about a problem, listening to how they're working in groups and discussing with each other.

Karen described how the Lesson study process enabled her to begin to learn about misconceptions, explaining,

> We met after school and just briefly went over it [the lesson]. Kindergarten teachers and principals had been in the room sitting at each of the tables [during the teaching of the lesson] so they were individually watching the students and seeing what they were doing. So they came back with a lot of things that I would have not have heard. They came back with misconceptions because they were able to sit there and hear them and bring them back to me and say, 'this child still was saying he had a dime, but it was the same color as a nickel'. So they were catching misconceptions that we could fix in future lessons.

Laura described what she learned about the importance of considering student misconceptions as a result of Lesson study participation, explaining,

> It forces you to look for evidence of what they understand in what you're doing. It's one thing to stand up and ask questions and go around and see what they're doing, but it's another thing to base the next step in your lesson on what you see. You don't have to stick to the plan. Just considering what they show, and what they say, and how that represents what they know—that you just consider that before you move on.

Tara described how her learning about student misconceptions during the Lesson study lesson changed. She said,

> Yes. I definitely think it's changed. When we were watching them [the students] in their groups is when we saw a lot of misconceptions. We saw students say that 3 divided by 7 was 35, and that 35x5 was 7. So, it was neat to see. As one teacher in a room, you probably wouldn't have caught all the little things that the students do and go through.

Table 35. Comparison of perceptions of how prepared teachers felt to identify student misconceptions of mathematical concepts

Frequency	Before	After	% of Change
Very often	14.9 (7)	55.3 (26)	+40.4 (+19)
Often	42.6 (20)	42.6 (20)	0
Sometimes	40.4 (19)	2.1 (1)	-38.3 (-18)
Rarely	2.1 (1)	0	-2.1 (-1)
Never	0	0	0
Total	100.0 (47)	100.0 (47)	

4.4.12 Pedagogical-content Knowledge Data Disaggregated by Number of Years of Lesson Study Participation

The next set of data was disaggregated to look for patterns and/or emerging themes related to teachers' perceptions of the impact that Lesson study participation had on their pedagogical knowledge and its relationship to the length of time they participated in Lesson study. Therefore the data were analyzed to compare how prepared teachers felt to engage in tasks typically associated with increased pedagogical knowledge (Campbell, 1963; Carpenter, Fennema, &

Franke, 1996; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Ma, 1999). Specifically, teacher were asked how prepared they felt to complete a set of tasks before engaging in Lesson study, and then again after participating in Lesson study. Furthermore, these comparisons were divided into three categories[8]: teachers who participated in Lesson study for less than one year, teachers who participated in Lesson study for one to three years, and teachers who participated in Lesson study for four or more years. Table 36 shows the responses from teachers who participated in Lesson study for less than one year, Table 37 shows the data from teachers who participated for one to three years and Table 38 shows the data from teachers who participated in Lesson study for four or more years.

[8] Study participants were asked to report how long they participated in Lesson study in ranges of time. As such, these ranges formed the framework for disaggregation.

Table 36. Comparison of teachers who participated in Lesson study for less than one year and their perceptions of the impact it had on their pedagogical knowledge

Before participating in Lesson study, I felt prepared	Very often	Often	Sometimes	Rarely	Never
to teach mathematics	60.0 (9)	26.7 (4)	13.3 (2)	0	0
to teach mathematical concepts rather than mathematical procedures	46.7 (7)	13.3 (2)	33.3 (5)	6.7 (1)	0
to effectively plan for math instruction	40.0 (6)	40.0 (6)	20.0 (3)	0	0
to develop my students' conceptual understanding of mathematics	53.3 (8)	13.3 (2)	33.3 (5)	0	0
to identify students' misunderstandings of mathematical concepts	20.0 (3)	33.3 (5)	46.7 (7)	0	0
to identify students' preconceptions of mathematical concepts	20.0 (3)	26.7 (4)	46.7 (7)	6.7 (1)	0
to provide opportunities for students to investigate to solve math problems	46.7 (7)	26.7 (4)	26.7 (4)	0	0
to discuss alternate mathematical hypotheses with my students	46.7 (7)	26.7 (4)	20.0 (3)	6.7 (1)	0
After participating in Lesson study, I felt prepared	**Very often**	**Often**	**Sometimes**	**Rarely**	**Never**
to teach mathematics	86.7 (13)	13.3 (2)	0	0	0
to teach mathematical concepts rather than mathematical procedures	80.0 (12)	20.0 (3)	0	0	0
to effectively plan for math instruction	66.7 (10)	33.3 (5)	0	0	0
to develop my students' conceptual understanding of mathematics	73.3 (11)	26.7 (4)	0	0	0
to identify students' misunderstandings of mathematical concepts	46.7 (7)	53.3 (8)	0	0	0
to identify students' preconceptions of mathematical concepts	40.0 (6)	60.0 (9)	0	0	0
to provide opportunities for students to investigate to solve math problems	73.3 (11)	26.7 (4)	0	0	0
to discuss alternate mathematical hypotheses with my students	66.7 (10)	26.7 (4)	6.7 (1)	0	0

Table 37. Comparison of teachers who participated in Lesson study for one to three years and their perceptions of the impact it had on their pedagogical knowledge

Before participating in Lesson study, I felt prepared	Very often	Often	Sometimes	Rarely	Never
to teach mathematics	32.1(9)	35.7 (10)	32.1 (9)	0	0
to teach mathematical concepts rather than mathematical procedures	17.9 (5)	42.9 (12)	39.3 (11)	0	0
to effectively plan for math instruction	28.6 (8)	50.0 (14)	21.4 (6)	0	0
to develop my students' conceptual understanding of mathematics	17.9 (5)	39.3 11)	32.1 (9)	10.7 (3)	0
to identify students' misunderstandings of mathematical concepts	14.3 (4)	46.4 (13)	35.7 (10)	3.6 (1)	0
to identify students' preconceptions of mathematical concepts	14.3 (4)	28.6 (8)	42.9 (12)	14.3 (4)	0
to provide opportunities for students to investigate to solve math problems	17.9 (5)	32.1 (9)	42.9 (12)	7.1 (2)	0
to discuss alternate mathematical hypotheses with my students	10.7 (3)	32.1 (9)	42.9 (12)	14.3 (4)	0
After participating in Lesson study, I felt prepared	**Very often**	**Often**	**Sometimes**	**Rarely**	**Never**
to teach mathematics	78.6 (22)	21.4 (6)	0	0	0
to teach mathematical concepts rather than mathematical procedures	53.6 (15)	39.3 (11)	7.1 (2)	0	0
to effectively plan for math instruction	75.0 (21)	25.0 (7)	0	0	0
to develop my students' conceptual understanding of mathematics	60.7 (17)	35.7 (10)	3.6 (1)	0	0
to identify students' misunderstandings of mathematical concepts	57.1 (16)	39.3 (11)	3.6 (1)	0	0
to identify students' preconceptions of mathematical concepts	39.3 (11)	46.4 (13)	14.3 (4)	0	0
to provide opportunities for students to investigate to solve math problems	57.1 (16)	35.7 (10)	7.1 (2)	0	0
to discuss alternate mathematical hypotheses with my students	35.7 (10)	53.6 (15)	10.7 (3)	0	0

Table 38. Comparison of teachers who participated in Lesson study for four years or more and their perceptions of the impact it had on their pedagogical knowledge

Before participating in Lesson study, I felt prepared	Very often	Often	Sometimes	Rarely	Never
to teach mathematics	0	75.0 (3)	25.0 (1)	0	0
to teach mathematical concepts rather than mathematical procedures	50.0 (2)	25.0 (1)	25.0 (1)	0	0
to effectively plan for math instruction	0	75.0 (3)	25.0 (1)	0	0
to develop my students' conceptual understanding of mathematics	25.0 (1)	50.0 (2)	25.0 (1)	0	0
to identify students' misunderstandings of mathematical concepts	0	50.0 (2)	50.0 (2)	0	0
to identify students' preconceptions of mathematical concepts	0	25.0 (1)	75.0 (3)	0	0
to provide opportunities for students to investigate to solve math problems	0	75.0 (3)	0	25.0 (1)	0
to discuss alternate mathematical hypotheses with my students	25.0 (1)	50.0 (2)	25.0 (1)	0	0
After participating in Lesson study, I felt prepared	**Very often**	**Often**	**Sometimes**	**Rarely**	**Never**
to teach mathematics	100.0 (4)	0	0	0	0
to teach mathematical concepts rather than mathematical procedures	75.0 (3)	25.0 (1)	0	0	0
to effectively plan for math instruction	50.0 (2)	50.0 (2)	0	0	0
to develop my students' conceptual understanding of mathematics	50.0 (2)	50.0 (2)	0	0	0
to identify students' misunderstandings of mathematical concepts	75.0 (3)	25.0 (1)	0	0	0
to identify students' preconceptions of mathematical concepts	50.0 (2)	50.0 (2)	0	0	0
to provide opportunities for students to investigate to solve math problems	25.0 (1)	75.0 (3)	0	0	0
to discuss alternate mathematical hypotheses with my students	50.0 (2)	50.0 (2)	0	0	0

A further analysis of the data was conducted to examine the frequency at which participants reported feeling prepared *very often* before Lesson study and then after Lesson study and these data were disaggregated by the length of time teachers had participated in Lesson

study. Table 39 shows the comparison of teachers who reported *very often* before Lesson study to teachers who reported *very often* after Lesson study, disaggregated by the number of years of Lesson study participation. These data indicate that all teachers perceived a positive impact from Lesson study in all tasks associated with pedagogical-content knowledge regardless of how long they participated in Lesson study. These data also indicate that the greatest gain reported was in how prepared teachers felt to teach math, and this was consistent regardless of how long teachers participated in Lesson study. These data also indicate that overall the greatest impact in how prepared teachers felt was experienced by teachers who participated in Lesson study for more than one year.

Table 39. Change in teacher responses of 'very often after Lesson study participation disaggregated by number of years of Lesson study participation

Response	**Teachers who participated in Lesson study > 1 yr.**			**Teachers who participated in Lesson study 1-3 yrs.**			**Teachers who participated in Lesson study 4+ years**		
Very often, I felt prepared:	Before	After	*% of change*	Before	After	*% of change*	Before	After	*% of change*
to teach mathematics	60.0 (9)	86.7 (13)	*+26.7 (4)*	32.1(9)	78.6 (22)	*+46.5 (13)*	0	100.0 (4)	*+100.0 (4)*
to teach mathematical concepts rather than mathematical procedures	46.7 (7)	80.0 (12)	*+33.3 (5)*	17.9 (5)	53.6 (15)	*+35.7 (10)*	50.0 (2)	75.0 (3)	*+25.0 (1)*
to effectively plan for math instruction	40.0 (6)	66.7 (10)	*+26.7 (4)*	28.6 (8)	75.0 (21)	*+46.4 (13)*	0	50.0 (2)	*+50.0 (2)*
to develop my students' conceptual understanding of mathematics	53.3 (8)	73.3 (11)	*+20.0 (3)*	17.9 (5)	60.7 (17)	*+42.8 (12)*	25.0 (1)	50.0 (2)	*+25.0 (1)*
to identify students' misunderstandings of mathematical concepts	20.0 (3)	46.7 (7)	*+26.7 (4)*	14.3 (4)	57.1 (16)	*+42.8 (12)*	0	75.0 (3)	*+75.0 (3)*
to identify students' preconceptions of mathematical concepts	20.0 (3)	40.0 (6)	*+20.0 (3)*	14.3 (4)	39.3 (11)	*+25.0 (7)*	0	50.0 (2)	*+50.0 (2)*
to provide opportunities for students to investigate to solve math problems	46.7 (7)	73.3 (11)	*+26.6 (4)*	17.9 (5)	57.1 (16)	*+39.2 (11)*	0	25.0 (1)	*+25.0 (1)*
to discuss alternate mathematical hypotheses with my students	46.7 (7)	66.7 (10)	*+20.0 (3)*	10.7 (3)	35.7 (10)	*+25.0 (7)*	25.0 (1)	50.0 (2)	*+25.0 (1)*

4.4.13 Overall Perceptions of the Impact that Lesson Study had on Teaching Math

Survey data were collected to identify participants overall perspective of the impact that Lesson study had on their improvement in the teaching of math. Specifically, they were asked to identify their level of agreement to the statement: *Lesson study helped me become a better math teacher*. The data indicate that overall 93.6% (n=44) either *strongly agree* or *agree* that Lesson study helped them to become a better math teacher and 6.4% (n=3) disagreed.

Survey data were further analyzed to identify patterns and emerging themes. Specifically, data were analyzed to examine the relationship between how long a participant engaged in Lesson study and the extent to which they agree that Lesson study helped them become a better math teacher. The data indicate that teachers who have participated in Lesson study longer more *strongly agree* that it has helped them become a better math teacher. Of those teachers who participated in Lesson study for less than one year, 26.7% (n=4) *strongly agreed* that it helped them become a better math teacher. Additionally, of those teachers who participated in Lesson study for 1-3 years, 53.6% (n=15) *strongly agreed* that it helped them become a better math teacher, and 50.0% (n=2) of teachers who participated in Lesson study for four or more years *strongly agreed*. These data are shown in Table 40.

Table 40. Relationship between the number of years of Lesson study participation and the extent to which teachers' agree that it helped them become a better math teacher, in percentages

Responses	> 1 yr. of Lesson study participation	1-3 yrs. of Lesson study participation	4+ years of Lesson study participation
Strongly agree	26.7 (4)	53.6 (15)	50.0 (2)
Agree	66.7 10)	39.3 (11)	50.0 (2)
Disagree	6.7 (1)	7.1 (2)	0
Strongly disagree	0	0	0
Total	100.0 (15)	100.0 (28)	100.0 (4)

The relationship between the *numbers of years* an individual taught, and the extent to which they *agree* that Lesson study helped them become a better math teacher was also examined. The data indicate similarities across all categories. Of the teachers who taught 0-5 years, 100.0% (n=8) *strongly agreed* or *agreed* that Lesson study helped them become a better math teacher. Similarly, 87.5% (n=7) of the teachers who taught 6-10 years *strongly agreed* or *agreed*; 88.8% (n=8) of teachers who taught 11-20 years *strongly agreed* or *agreed*; and, 100.0% (n=8) *strongly agreed* or *agreed* that Lesson study helped them become a better math teacher.

No differences are indicated in this data. Table 41 shows these data.

Table 41. Relationship between number of years teaching and the extent to which teachers agree that Lesson study helped them to become a better math teacher

Response	0-5 years teaching experience	6-10 years teaching experience	11-20 years teaching experience	21+ years teaching experience
Strongly agree	50.0 (4)	62.5 (5)	44.4(8)	50.0 (4)
Agree	50.0 (4)	25.0 (2)	44.4(8)	50.0 (4)
Disagree	0	12.5 (1)	11.2 (2)	0
Strongly disagree	0	0		0
Total	100.0 (8)	100.0 (8)	100.0 (18)	100.0 (8)

4.5 FINDINGS RELEVANT TO RESEARCH QUESTION #4

Research Question #4: *What are teachers' perceptions of the challenges and/or enabling factors for sustaining participation in Lesson study?*

This research study posed questions regarding the challenges of engaging in and sustaining participation in Lesson study and also, those factors that enabled participants to perceive the practice as successful. The data gathered to answer research question #4 were drawn from a survey instrument and interview transcripts. The findings are reported related to prior research-based hypotheses regarding the challenges and enabling factors necessary for successful implementation of Lesson study.

In Japan, one of the highest performing countries in math and science, teachers regularly participate in a form of professional development known as *Lesson study*, and this participation has often been cited as having an impact on the mathematics performance of their students

(Chokshi & Fernandez, 2004; Lewis, 2002; Stigler & Hiebert, 1999). Additionally, research also suggests that this professional development endeavor, regularly practiced in Japanese schools, poses some barriers due to its cultural nature. Cited in the literature, the most common barriers to implementing Lesson study across the U. S. include: lack of shared long-term goals across staffs, lack of curricular coherence, lack of U.S. teachers' strong content knowledge, teacher isolation, and the lack of shared planning time (Chokshi & Fernandez, 2004; Lewis, 2002; Stigler & Hiebert, 1999). Fernandez and Cannon (2005) argue that another important barrier to implementing Lesson study is grounded in U.S. teachers' views of teaching; their focus on teacher behaviors rather than student behavior (p. 482). Moreover, U.S. teachers' attitudes toward collaborative, in-depth planning of lessons and self-reflective teaching practices also differ from Japanese teachers in ways (C. Fernandez & Cannon, 2005).

4.5.1 Challenges and Enabling Factors

Chapter 2 presented a review of the current literature on Lesson study and six challenges and/or enabling factors for Lesson study participation emerged. They are:

Creating an over-arching goal on which to base the lesson

The size/make up of the group

The amount of time needed to devote

Scheduling meeting time

Understanding the process

Completing each of the steps in the process

The amount/kind of administrative support provided

Each of the six factors identified as either barriers or enabling factors that are typically associated with Lesson study participation were presented to study participants in the form of a survey instrument. They were asked to report their perceptions along a 5-point continuum of *major challenge that hindered success* to *factor enabling success*.

Of those who responded, 43.2% (n=19) reported that *scheduling time to meet* was a major challenge, while 31.8% (n= 14) identified the *amount of time needed to do Lesson study* was a major challenge. Conversely, 45.5% (n=20) of those who responded identified *the size and make-up of the group* as a major factor enabling their success. Also notable is that 34.9% (n= 15) said that *creating an overarching goal* was a major factor enabling success and 29.5% (n= 13) identified *administrative support* as a major enabling factor. Lastly, 20.5% (n=9) reported that their understanding of the Lesson study process enabled them to be successful. Overall, the survey data indicate that the *amount of time needed* for Lesson study and *scheduling meeting time* were the greatest challenges—75.0% (n=33) reported these as *major challenges that hindered success*. The data also indicated that the *size and make-up of the group, creating an overarching goal* and *the amount of administrative support* were the most factors enabling success. Table 42 shows these results.

Table 42. Challenges that hindered, and enabling factors that enhanced, the success of Lesson study participation

Responses	Creating an overarching goal	Size and make up of group	Amount of time needed	Scheduling meeting time	Understanding the Lesson study process	Completing the steps	Administrative support
1-Major challenge that hindered success	2.3 (1)	9.1 (4)	31.8 (14)	43.2 (19)	0	0	13.6 (6)
2	16.3 (7)	11.4 (4)	18.2 (8)	31.8 (14)	4.5 (2)	13.6 (6)	18.2 (8)
3	34.9 (15)	13.6 (6)	31.8 (14)	6.8 (3)	36.4 (16)	31.8 (14)	20.5 (9)
4	11.6 (5)	20.5 (9)	11.4 (5)	9.1 (4)	38.6 (17)	29.5 (13)	18.2 (8)
5-Major factor enabling success	34.9 (15)	45.5 (20)	6.8 (3)	9.1 (4)	20.5 (9)	25.0 (11)	29.5 (13)
Total	100 .0 (43)	100.0 (44)	100.0 44)	100.0 (44)	100.0 (44)	100.0 44)	100.0 (44)

Survey respondents were also given an opportunity to expand on their responses to the survey questions regarding the challenges and enabling factors related to Lesson study. When asked to identify *what other challenges faced while participating in Lesson study*, the most frequently cited challenge was *time*. Some participants specifically identified how time was an issue, stating:

> In the elementary setting, teachers have prep time at different times during the day and other responsibilities to get done during this time. This made it difficult to find time to consistently meet to correctly do a Lesson study. We tried meeting during our PLC [professional learning community] time, however, there were still times that we did not have consistent and efficient enough time to meet and prepare. Much of the Lesson study was done on our own time because we volunteered for it. I feel that it was a lot of work on the teachers outside of class.

Another respondent agreed, saying,

> Time was the biggest factor. We often don't have common planning time, or the common planning time that we do have is interrupted with meetings, conferences, etc. Planned lessons for others to observe were frequently canceled due to things beyond the teacher's control.

The lack of administrative support, or a lack of *continued* administrative support, was also frequently cited as a major challenge that hindered their success. One survey respondent summarized this, saying,

> TIME and administrative support are the two biggest factors that will influence the quality of Lesson study, and whether it occurs.

Another survey respondent agreed and added,

> In order to be successful you need 100% support from administrative staff.

Lastly, several respondents claimed that it was more than just a lack of administrative support.

This was summarized by one, who said,

> After our first experience with Lesson study, we had several administrative changes. Although my desire as a teacher was to continue doing Lesson study, we lost our administrative guidance.

While lack of administrative support and/or guidance was cited by many survey respondents as a major challenge, many respondents also perceived the support of their administrator as a major factor enabling their success. This is captured in the following five remarks from survey respondents:

> Our principal was very supportive.

> The knowledge, experience & facilitation skills of the leader [and] being given the time and support from administration to participate.

> When we did our Lesson study, it was easy to schedule observations because of the support of our administration.

> Administrators were interested in Lesson study and its benefits to promote student growth and assisted with scheduling substitutes for common planning time.

> We had a great team; excellent administrative leadership.

Overall, the most frequently cited major factor enabling success as perceived by the survey respondents was collaboration with peers. Respondents noted that their colleagues were "knowledgeable", "supportive" and "enthusiastic" about the Lesson study process.

One survey participant summarized the perceptions of many, reporting,

> The members of the group worked extremely well together and we were able to make progress at each meeting. Each member also brought to the table a very different perspective of teaching mathematics depending on the level he or she teaches. It made for a more dynamic and well-rounded lesson in the end.

Lastly, one respondent noted the unique importance of collaboration,

> My team is a group of educators with the same beliefs and goal …..this solid team work leads to success in Lesson study.

Interview participants also reported that collaboration was a factor that enabled their success. Laurie stated,

> I would say that Lesson study has made me think about teaching math as not an isolated event. That in terms of planning there's collaboration to do before you plan. There are people to talk to before you plan. Third grade teachers, what did you do here? Fifth grade teachers, what do they need to know? Other fourth grade teachers, when your students do this what do they think about it?...And even without other people in the classroom, imagining that they're there and thinking about what they're seeing—trying to be their eyes while I'm teaching. What would they see if they were in here? And, how do I use that midstream in a lesson to deepen their understanding—or where to go from there.

Interview transcripts indicated that the most frequently cited challenges to Lesson study participation were the *amount of time* one needed to devote to this practice, and the *lack of administrative support*. Conversely, interview transcripts also indicated that the most frequently cited factors enabling success were administrative support and the opportunity to collaborate with colleagues. When asked to describe any challenges encountered when participating in Lesson study, the majority of respondents mentioned that the amount of time that was needed to

engage in Lesson study was challenging. Tara summarized what most participants said, explaining,

> Oh, I honestly think the one greatest challenge for us was time and trying to meet and get everyone together. We have a lot of meetings and we tried to work it on school time and I think if we wanted to do this right we would probably have to come in early or stay after school because trying to work it out during the school day wasn't working out so well.

Mary added,

> Everyone's schedule—coordinating it together to meet, to plan, and to develop the lesson. I think, when it's one grade level all working together to plan something, you have that common time. Where, when it's across the grade levels and the specialists and support staff, that made it a little more difficult -- all getting together to meet.

Lisa also reported *time* as a major challenge, stating,

> So I think time is the biggest issue. Time to collaborate is a big issue. Because as much as Lesson study is going to help me on a personal level, if I'm looking at those best practices that we used, being able to talk with a group of people was so much more enlightening and it's something that I would love to continue to do, but again the biggest challenge is going to be getting the time with colleagues to be able to sit down and have meaningful discussions that are going to accomplish quite a bit in the little bit of time that we had.

Interview transcripts also indicate that every respondent reported that their building administrator had an effect on Lesson study participation—half of the respondents identified administrative support as a major challenge and half identified it as an enabling factor. All respondents reported that administrative support was an important prerequisite for successful implementation of Lesson study. This was explained by several respondents in different ways.

Laura reported having two different experiences due to a change in building administrators and explained that for part of her experience with Lesson study, lack of administrative support was a major challenge for her group.

She explained,

> Not having somebody take the reins and be in charge of the Lesson study in our district was the greatest challenge. I believe that there's interest there--and I don't want to say that we don't have administrative support—we don't have an administrative leader who will take it as their project and encourage the participation to do it. When we did our first lesson, the three people in our group were all willing to meet beyond the school day. And that's great. But when you have other people believe in Lesson study and also believe that their day ends when the contract says it does—without administrative support, I think it's difficult to sustain any interest in the Lesson study process.

Laura also described an earlier experience with Lesson study with a different administrator,

> Well the first time it was with the building principal. He believed in it. He was the driving force behind it. He made the time for the workshop; got everyone involved, gave us the time to meet. And then by the time school was ready, we were all ready to do it. Everybody was excited about doing it. By the time I did the second one, it was because I was interested in doing it because of the learning that I had.

April also reported that lack of administrative support was a major challenge, saying,

> Getting our principals to give us enough professional development days where we're able to work together was a challenge. I think something I would like to see more is the administration involved more. They haven't stopped into any of our meetings, they haven't come into our classrooms when we're doing Lesson study, and they're definitely welcome to do that, and they've been invited to do that. I just think they have so much on their plate, which I understand.…. I wish that our Lesson study could be more of a priority.

Several other respondents reported that administrative support was a factor that enabled their success. Paula reported,

> I'd have to say that our administrator has been excellent with us in terms of doing Lesson study. I mean, he's on the ball with this and I think to our benefit we all have a common planning time. That's ultimately been good for us. I think if you're in a situation where you're with a group of teachers that work different grade levels and have different planning times that's more of a challenge. But we worked on the same planning time. Our principal has said he would get us substitutes as we need them. He doesn't have a problem with that. We're getting Act 48 hours for our meeting times so we had the support of our administrators. And that's always helpful.

In addition to the data analysis discussed in previous paragraphs, the survey data were further analyzed to look for patterns and/or emerging themes. Therefore, survey data related to participants' perspectives on the challenges and enabling factors encountered during Lesson study participation were disaggregated by how many years teachers engaged in Lesson study, and by how many years teachers taught.

Table 43 shows the most commonly reported challenges[9] to Lesson study disaggregated by the number of years teachers participated in Lesson study. These data indicate that factors related to *time* were the greatest challenges to all participants regardless of how many years they engaged in Lesson study. Of those teachers who participated in Lesson study for less than one year 80.0% (n=12) reported that *scheduling time to meet* was the greatest challenge—this was the highest percentage reported overall. Teachers who participated in Lesson study for 1-3 years and for 4 or more years also reported that *scheduling time to meet* as the greatest challenge. It is

[9] These data were collected on a 5-point scale: 1=Major challenge and 5=Major factor enabling success. This disaggregation includes all data reported as a '1' or a '2'.

also important to note that *the amount of administrative support received* was reported as a great challenge. Additionally, it is noted that the less time a teacher participated in Lesson study, the more likely they were to report this as a major challenge. It is also notable, as seen in the data that the more years a teacher participated in Lesson study the less likely they were to identify the characteristics of Lesson study as *major challenges*. Table 43 shows these results.

Table 43. Self-reported major challenges encountered when participating in Lesson study disaggregated by number of years of Lesson study participation

Most commonly reported challenges	1 year or less	1-3 years	4 or more years
Developing a common overarching goal on which to base the research lesson/s	21.4 (3)	20.0 (5)	0
The size/make up of the Lesson study Group	20.0 (3)	20.0 (5)	25.0 (1)
The amount of time I had to devote to Lesson study	66.7 (10)	48.0 (12)	0
Scheduling time to meet as a group	80.0 (12)	72.0 (18)	75.0 (3)
My understanding of the Lesson study process	0	8.0 (2)	0
The steps in the Lesson study process	13.3 (2)	16.0 (4)	0
The amount of administrative support we received	40.0 (6)	28.0 (7)	25.0 (1)

Survey data related to the reported factors that enabled success[10] were also disaggregated by the number of years of Lesson study participation. These data indicate that a factor that enabled success was *the size/make up of the Lesson study group* as reported in all three categories and therefore not related to the numbers of years of Lesson study participation. Other factors also reported as enabling success regardless of the number of years of Lesson study

[10] These data were collected on a 5-point scale: 1=Major challenge and 5=Major factor enabling success. This disaggregation includes all data reported as a '4' or a '5'.

participation are those factors related to the *Lesson study process* and the *amount of administrative support received.* Also notable is that the greater the number of years a teacher participated in Lesson study, the more likely they were to report the characteristics of Lesson study as *enabling factors*. Table 44 shows these results.

Table 44. Self-reported factors enabling success when participating in Lesson study disaggregated by number of years of Lesson study participation

Most commonly reported factors enabling success	1 year or less	1-3 years	4+ years
Developing a common overarching goal on which to base the research lesson/s	35.7 (5)	52.0 (13)	50.0 (2)
The size/make up of the Lesson study Group	60.0 (9)	68.0 (17)	75.0 (3)
The amount of time I had to devote to Lesson study	20.0 (4)	16.0 (4)	25.0 (1)
Scheduling time to meet as a group	6.7 (1)	24.0 (6)	25.0 (1)
My understanding of the Lesson study process	46.7 (7)	60.0 (16)	100.0 (4)
The steps in the Lesson study process	40.0 (6)	56.0 (14)	100.0 (4)
The amount of administrative support we received	40.0 (6)	52.0 (13)	50.0 (2)

When disaggregated by the number of years teaching[11], the data indicate that the major challenges reported in each category were the same as those when disaggregated by number of years of Lesson study participation—factors related to time. In each of the four categories in Table 59 *scheduling time to meet* and the *amount of time needed to devote to Lesson study* were reported as major challenges by the highest percentage of the population regardless of the number of years they had been teaching. Also, *the amount of administrative support received*

[11] The survey asked teachers to report their teaching experience by selecting a range of years. These ranges form the basis for these reporting categories.

was reported as a major challenge in three of the four groups—participants teaching 6-10 years did *not* report this as a major challenge.

Table 45. Self-reported major challenges encountered when participating in Lesson study disaggregated by teaching experience

Most commonly reported challenges	0-5 years	6-10 years	11-20 years	21+ years
Developing a common overarching goal on which to base the research lesson/s	25.0 (2)	12.5 (1)	23.5 (4)	14.3 (1)
The size/make-up of the Lesson study Group	25.0 (2)	12.5 (1)	16.7 (3)	42.9 (3)
The amount of time I had to devote to Lesson study	37.5 (3)	37.5 (3)	66.6 (12)	42.9 (3)
Scheduling time to meet as a group	75.0 (6)	87.5 (7)	72.2 (13)	85.7 (6)
My understanding of the Lesson study process	25.0 (2)	0	0	0
The steps in the Lesson study process	37.5 (3)	0	16.7 (3)	0
The amount of administrative support we received	50.0 (4)	0	33.3 (6)	42.9 (3)

Survey data related to the reported factors that enabled success were also disaggregated by the number of years participants' taught. These data indicate similarities to the reported factors enabling success when disaggregated by the number of years of Lesson study participation. That is, a factor that enabled success was *the size/make up of the Lesson study group* as reported in three of the four categories as shown in Table 46. Other factors also reported as enabling success regardless of the number of years of teaching experience are those factors related to the *Lesson study process* and the *amount of administrative support received.* Also notable is that the greater the number of years a teacher taught, the more likely they were to report the characteristics of Lesson study as *enabling factors*.

Table 46. Self-reported factors enabling success when participating in Lesson study disaggregated by teaching experience

Most commonly reported factors enabling success	0-5 years	6-10 years	11-20 years	21+ years
Developing a common overarching goal on which to base the research lesson/s	37.5 (3)	12.5 (1)	53.0 (9)	57.2 (4)
The size/make up of the Lesson study Group	75.0 (6)	75.0 (6)	66.7 (12)	28.6 (2)
The amount of time I had to devote to Lesson study	37.5 (3)	12.5 (1)	16.7 (3)	14.3 (1)
Scheduling time to meet as a group	12.5 (1)	12.5 (1)	27.8 (5)	14.3 (1)
My understanding of the Lesson study process	25.0 (2)	62.5 (5)	66.7 (12)	71.5 (5)
The steps in the Lesson study process	25.0 (2)	62.5 (5)	50.0 (9)	85.8 (6)
The amount of administrative support we received	25.0 (2)	62.5 (5)	55.5 (10)	42.9 (3)

In the preceding paragraphs, survey and interview transcripts results related to the challenges that teachers encountered while participating in Lesson study were presented. The factors enabling success were also presented. Additionally, these data were disaggregated to illuminate any patterns and/or emerging themes. What is most notable is the consistency with which teachers reported both the challenges and enabling factors regardless of how long they had participated in Lesson study or how much teaching experience they had. What is also noteworthy is that regardless of the challenges reported, 93.6% (n=44) of the survey respondents either *strongly agreed* or *agreed* that Lesson study helped them become a better math teacher. These data were presented in section 4.1. Additionally, as presented earlier in this chapter, 97.9% (n=4) reported that they *strongly agreed* or *agreed* that Lesson study was an effective way to continue their professional development. However, only 66.0% (n=31) plan to continue engaging in Lesson study. It was hypothesized that this discrepancy between the levels of agreement

regarding Lesson study's effectiveness as a professional development tool and the percentage of teachers who plan to continue is notable and, therefore, warrants further analysis of the data. As such, the survey data related to the challenges and/or enabling factors encountered when participating in Lesson study were further disaggregated.

In an effort to identify any patterns and/or emerging themes, these data were disaggregated to compare the challenges and enabling factors reported by those who *strongly agreed* to those who reported that they *agreed* that Lesson study was an effective way to continue professional development. The purpose of this comparison was to identify any similarities and/or differences in the data. Table 47 shows these results. These results indicate that the greatest challenge to Lesson study participation was the same in both groups—that is, *scheduling time to meet*. Also, the greatest factor enabling success was the same in both groups—that is, *the size/make up of the group*. However, a discrepancy exists between the groups when reporting the challenges and enabling factors related to the *amount of administrative support received*. Of those who *strongly agreed* that Lesson study was an effective way to continue professional development, 3.8% (n=1) reported that the amount of administrative support was a major challenge, while 29.4% (n=5) of those who *agreed* that Lesson study was an effective way to continue professional growth reported that the amount of administrative support was a major challenge. Of those who *strongly agreed* that Lesson study was an effective way to continue professional development, 38.5% (n=10) reported that the amount of administrative support was a major factor enabling success, while only 17.6% (n=3) of those who *agreed* that Lesson study was an effective way to continue professional growth reported that the amount of administrative support was a major factor enabling success. It is hypothesized that this difference in the perceptions of the challenges and/or enabling factors

related to the amount of administrative support teachers' received may account for the discrepancy between those teachers who reported Lesson study as effective, and those who plan to continue participating in it.

Table 47. Comparison of the reported challenges and enabling factors disaggregated by level of agreement to the statement: Lesson study is an effective way to continue my professional development

Most common factors	Strongly agree		Agree	
	Challenges	Enabling factors	Challenges	Enabling factors
Developing a common overarching goal on which to base the research lesson/s	4.0 (1)	40.0 (10)	0	29.4 (5)
The size/make up of the Lesson study Group	11.5 (3)	53.8 (14)	5.9 (1)	35.3 (6)
The amount of time I had to devote to Lesson study	26.9 (7)	3.8 (1)	41.2 (7)	11.8 (2)
Scheduling time to meet as a group	46.2 (12)	7.7 (2)	41.2 (7)	11.8 (2)
My understanding of the Lesson study process	0	26.9 (7)	0	11.8 (2)
The steps in the Lesson study process	0	30.8 (8)	0	17.6 (3)
The amount of administrative support we received	3.8 (1)	38.5 (10)	29.4 (5)	17.6 (3)

The survey data related the challenges and/or enabling factors associated with Lesson study participation were further analyzed to compare the results of those who *strongly agreed* that Lesson study helped them become a better math teacher to those who reported that they *agreed* that Lesson study helped them become a better math teacher. These data were analyzed to look for patterns and/or emerging themes as a result of the discrepancy between those teachers who reported that Lesson study helped them become a better math teacher and the relatively low percentage of teachers who reported that they plan to continue participating in Lesson study.

These results are shown in Table 48. These data indicate similarities to the results shown in Table 47—that is, the greatest challenges to Lesson study that were reported by both groups was *scheduling time to meet* and the *amount of time needed to devote to Lesson study*. The greatest factor enabling success that was reported by both groups was *the size/make up of the group*—that is, 52.4% (n=11) of those who *strongly agreed*, and 45% (n=9) of those who *agreed*. Similar to the data reported in Table 47, a discrepancy exists between the groups when reporting the challenges and enabling factors related to the *amount of administrative support received*. Of those who *strongly agreed* that Lesson study helped them become a better math teacher, 4.8% (n=1) reported that the amount of administrative support was a major challenge, while 15.0% (n=3) of those who *agreed* that Lesson study helped them become a better math teacher reported that the amount of administrative support was a major challenge. Of those who *strongly agreed* that Lesson study helped them become a better math teacher, 47.6% (n=10) reported that the amount of administrative support was a major factor enabling success, while only 15.0% (n=3) of those who *agreed* that Lesson study helped them become a better math teacher reported that the amount of administrative support was a major factor enabling success. It is, again, hypothesized that this difference in the perceptions of the challenges and/or enabling factors related to the amount of administrative support teachers' received may account for the discrepancy between those teachers who reported that Lesson study helped them become a better math teacher, and those who plan to continue participating in it.

Table 48. Comparison of the reported challenges and enabling factors disaggregated by level of agreement to the statement: Lesson study has made me a better math teacher

Most common factors	Strongly agree		Agree	
	Challenges	Enabling factors	Challenges	Enabling factors
Developing a common overarching goal on which to base the research lesson/s	5.0 (1)	40.0 (8)	0	35.0 (7)
The size/make up of the Lesson study Group	9.5 (2)	52.4 (11)	10.0 (2)	45.0 (9)
The amount of time I had to devote to Lesson study	23.8 (5)	4.8 (1)	35.0 (7)	10.0 (2)
Scheduling time to meet as a group	47.6 (10)	9.5 (2)	35.0 (7)	10.0 (2)
My understanding of the Lesson study process	0	28.6 (6)	0	15.0 (3)
The steps in the Lesson study process	0	33.3 (7)	0	20.0 (4)
The amount of administrative support we received	4.8 (1)	47.6 (10)	15.0 (3)	15.0 (3)

Lastly, the survey data related to challenges and/or enabling factors in Lesson study participation were disaggregated by teachers' reports of whether they planned to continue participation in Lesson study. Specifically, Table 49 shows a comparison of the challenges and enabling factors reported by those who *plan to continue* to those who *do not plan to continue.* As reported in previous paragraphs, 66.6% (n=31) of those who participated in the survey reported that they plan to continue with Lesson study. The survey data reported in Table 48 indicate similarities to the data reported in Tables 46 and 47. That is, the greatest challenge to Lesson study that was reported by both groups whether they planned on continuing with Lesson study or not was *scheduling time to meet* and the *amount of time needed to devote to Lesson study*. The greatest factor enabling success that was reported by both groups was *the size/make up of the*

group—that is, 46.7% (n=14) of those who *plan to continue*, and 42.9% (n=6) of those who *do not plan to continue*. Similar to the data reported in Tables 60and 61, a discrepancy exists between the groups when reporting the challenges and enabling factors related to the *amount of administrative support received*. Of those who *plan to continue* with Lesson study, 10.0% (n=3) reported that the amount of administrative support was a major challenge, while 21.4% (n=3) of those who *do not plan to continue* with Lesson study reported that the amount of administrative support was a major challenge. Of those who *plan to continue* with Lesson study, 33.3% (n=10) reported that the amount of administrative support was a major factor enabling success, while only 21.4 % (n=3) of those who *do not plan to continue* with Lesson study reported that the amount of administrative support was a major factor enabling success. It is, again, hypothesized that this difference in the perceptions of the challenges and/or enabling factors related to the amount of administrative support teachers' received may account for the discrepancy between those teachers who reported that Lesson study helped them become a better math teacher and/or was effective professional development, and those who plan to continue participating in it.

Table 49. Comparison of the reported challenges and enabling factors disaggregated by teachers' plan to continue Lesson study participation

Most common factors	Plan to continue		Do not plan to continue	
	Challenges	Enabling factors	Challenges	Enabling factors
Developing a common overarching goal on which to base the research lesson/s	3.4 (1)	34.5 (10)	0	35.7 (5)
The size/make up of the Lesson study Group	6.7 (2)	46.7 (14)	14.3 (2)	42.9 (6)
The amount of time I had to devote to Lesson study	26.7 (8)	6.7 (2)	42.9 (6)	7.1 (1)
Scheduling time to meet as a group	46.7 (14)	10.0 (3)	35.7 (5)	7.1 (1)
My understanding of the Lesson study process	0	23.3 (7)	0	14.3 (2)
The steps in the Lesson study process	0	30.0 (9)	0	14.3 (2)
The amount of administrative support we received	10.0 (3)	33.3 (10)	21.4 (3)	21.4 (3)

4.5.2 Cultural Barriers to Lesson Study

Overcoming the cultural barriers frequently associated with the implementation of Lesson study in U.S. schools continues to be a necessary requirement for its sustainability in this country (citation). Lesson study involves an iterative cycle of planning, teaching and reflecting; teacher practices that are common in Japan, but not necessarily readily apparent in the U.S. school system. As such, U.S. teachers, when engaging in Lesson study, are required to participate in activities that may be unique experiences for them. These experiences require a change in practice; therefore it is important to understand teachers' perceptions related to these new experiences. In the next three questions, study participants were asked how comfortable they felt

performing some of the Lesson study components that are typically associated with this PD model but also identified as cultural barriers (Chokshi & Fernandez, 2004; C. Fernandez & Chokshi, 2002; Lewis, 2002; Lewis, Perry, Hurd, & O'Connell, 2006). Specifically, they were asked about how comfortable they felt planning lessons with colleagues, how comfortable they felt being observed by colleagues, and how comfortable they felt discussing the implementation of the research lesson with their colleagues.

When asked how comfortable they felt planning with their colleagues, 79.6% (n=39) reported *very much* and 4.0% (n=2) reported *very little* or *not at all*. When asked how comfortable they felt being observed by others, 31.1% (n=14) reported *very much,* and 17.8% (n=8) reported *very little* or *not at all.* When asked about how comfortable they felt discussing the research lesson with colleagues, 73.5% (n=36) reported *very much* and 4.0% (n=2) reported *very little* or *not at all*. These data indicate that the respondents felt the least comfortable being observed by their colleagues. Table 50 shows these results.

Table 50. Perceptions of teachers comfort levels related to Lesson study participation

Quantity	Planning with colleagues	Being observed by colleagues	Discussing the lesson with colleagues
Very much	79.6 (39)	31.1 (14)	73.5 (36)
Somewhat	16.3 (8)	51.1 (23)	22.4 (11)
Very little	2.0 (1)	15.6 (7)	2.0 (1)
Not at all	2.0 (1)	2.2 (1)	2.0 (1)
Total	100 (49)	100 (45)	100 (49)

A further analysis of the data was conducted to examine the relationship between how long a teacher had been teaching and their perceptions of their comfort levels while participating in Lesson study. These data were reported in four categories[12]: teachers who taught 0-5 years; 6-10 years; 11-20 years and 21 or more years. Survey data indicate that there is a positive relationship between the length of time a teacher taught and how comfortable they felt planning collaboratively with their colleagues. Of those teachers who taught 21 or more years, 87.5% (n=) reported feeling comfortable planning with their colleagues *very much* while 62.5% (n=5) of teachers who taught 0-5 years reported feeling comfortable planning with their colleagues *very much* during Lesson study. A complete set of responses is shown in Table 51.

Table 51. Comparison of teachers' perceptions of how comfortable they felt planning lessons with colleagues and teaching experience

Response	0-5 years teaching experience	6-10 years teaching experience	11-20 years teaching experience	21+ years teaching experience
Very much	62.5 (5)	75.0 (6)	83.3 (15)	87.5 (7)
Somewhat	37.5 (3)	25.0 (2)	5.6 (1)	12.5 (1)
Very little	0	0	5.6 (1)	0
Not at all	0	0	5.6 (1)	0
Total	100.0 (8)	100.0 (8)	100.0 (18)	100.0 (8)

[12] The survey data asked teachers to report their teaching experience by selecting from a range of years. These ranges form the basis for the reporting categories.

Survey data related to teachers' perceptions of how comfortable they felt planning with their colleagues were also further analyzed to look for relationships between the number of years of Lesson study participation and comfort levels. Survey data indicate that 75% (n=3) of the teachers who participated in Lesson study for four or more years felt comfortable *very much* of the time while planning with their colleagues; 86.2% (n=25) of teachers who participated in Lesson study for 1-3 years reported feeling comfortable *very much* of the time while planning with their colleagues; and 68.8% (n=11) of the teachers who participated in Lesson study for less than one year reported feeling comfortable *very much* of the time. These data indicate that the longer a teacher participated in Lesson study, the greater the comfort level felt while planning with colleagues. Table 52 shows these data.

Table 52. Comparison of teachers' perceptions of how comfortable they felt planning lessons with colleagues and how long they participated in Lesson study

Responses	> 1 yr. of Lesson study participation	1-3 yrs. of Lesson study participation	4+ years of Lesson study participation
Very much	68.8 (11)	86.2 (25)	75.0 (3)
Somewhat	18.8 (3)	13.8 (4)	25.0 (1)
Very little	6.3 (1)	0	0
Not at all	6.3 (1)	0	0
Total	100.0 (16)	100.0 (29)	100.0 (4)

A further analysis of survey data was conducted to examine the relationship between the length of time a teacher taught and levels of comfort while being observed by colleagues during the Lesson study process. These data indicate that overall comfort levels were low and the majority of teachers in all categories reported feeling only *somewhat* comfortable. Of the

teachers who taught for 0-5 years, only 16.7% (n=1) reported feeling comfortable *very much* of the time; 37.5% (n=3) of the teachers who taught 6-10 years reported feeling comfortable *very much* of the time; 35.3% (n=6) of the teachers who taught 11-20 years felt comfortable *very much* of the time; and, 37.5% of the teachers who taught 21 or more years reported feeling comfortable *very much* of the time while being observed by colleagues. These data are reported in Table 53.

Table 53. Comparison of teachers' perceptions of how comfortable they felt being observed by colleagues during a Lesson study lesson teaching experience

Response	0-5 years teaching experience	6-10 years teaching experience	11-20 years teaching experience	21+ years teaching experience
Very much	16.7 (1)	37.5 (3)	35.3 (6)	37.5 (3)
Somewhat	83.3 (5)	50.0 (4)	41.2 (7)	50.0 (4)
Very little	0	12.5 (1)	17.6 (3)	12.5 (1)
Not at all	0	0	5.9 (1)	0
Total	100.0 (6)	100.0 (8)	100.0 (17)	100.0 (8)

The survey data related to teachers' perceptions of their comfort levels while discussing the research lesson during Lesson study participation were further analyzed to examine relationships between the length of time a teacher taught and their self-reported comfort levels. The data indicate a high level of comfort across all subjects teaching 0-20 years and a lower level of comfort for those subject who taught 21 or more years. Of those teaching 0-5 years, 75% (n=6) reported feeling comfortable discussing the research lesson *very much* of the time; 87.5% (n=7) of those who taught 6-10 years reported feeling comfortable discussing the research lesson *very much* of the time; 77.8% (n=14) felt comfortable discussing the lesson *very much* of the

time; and, 62.5% (n=5) reported feeling comfortable *very much* of the time while discussing the research lesson with colleagues. A complete set of responses is shown in Table 54.

Table 54. Comparison of teachers' perceptions of how comfortable they felt discussing the research lesson with colleagues and teaching experience

Response	0-5 years teaching experience	6-10 years teaching experience	11-20 years teaching experience	21+ years teaching experience
Very much	75.0 (6)	87.5 (7)	77.8 (14)	62.5 (5)
Somewhat	25.0 (2)	12.5 (1)	11.1 (2)	37.5 (3)
Very little	0	0	11.1 (2)	0
Not at all	0	0	0	0
Total	100.0 (8)	100.0 (8)	100.0 (18)	100.0 (8)

The survey data were also analyzed to examine any relationships between how long a subject participated in Lesson study and how comfortable each felt discussing the research lesson with colleagues. The data indicate that those teachers who participated in Lesson study for more than one year felt more comfortable discussing the research lesson. Of those who participated for less than one year, 68.8% (n=11) felt comfortable very much of the time; 75.9% (n=22) of those who participated in Lesson study for 1-3 years felt comfortable very much of the time; and, 75.0% (n=3) of those who participated in Lesson study for 4 or more years felt comfortable very much of the time while discussing the research lesson with colleagues. These data indicate a relationship between how long a teacher engages in Lesson study and perceptions of comfort levels while discussing research lessons with colleagues. Table 55 shows a complete set of responses.

Table 55. Comparison of teachers' perceptions of how comfortable they felt planning lessons with colleagues and how long they participated in Lesson study

Responses	> 1 yr. of Lesson study participation	1-3 yrs. of Lesson study participation	4+ years of Lesson study participation
Very much	68.8 (11)	86.2 (25)	75.0 (3)
Somewhat	18.8 (3)	13.8 (4)	25.0 (1)
Very little	6.3 (1)	0	0
Not at all	6.3 (1)	0	0
Total	100.0 (16)	100.0 (29)	100.0 (4)

4.6 CHAPTER SUMMARY

Chapter 4 presented the results of a study of teachers' perceptions of the role that Lesson study participation had on their teaching of elementary mathematics. Overall the data indicated teachers' perceptions of positive changes in their understanding of the skills and tasks often associated with math content knowledge and with pedagogical-content knowledge as a result of Lesson study participation. Specifically, teachers reported changes in how prepared they felt to teach math, how they understood the core math concepts their students need to learn, how they understood the connections between math concepts, and how prepared they felt to plan effectively for instruction. When reporting their perceptions of the impact that Lesson study had on their pedagogical-content knowledge, teachers cited the greatest impact in their understanding of student misconceptions in math, how prepared they felt to teach concepts rather than skills, and how often they understood how children learn math.

Teachers also reported that they engaged in activities that are commensurate with effective professional development through the Lesson study process. A majority of teachers reported that they collaborated with their peers, focused on math content during their Lesson study engagement, increased their use of reform-oriented teaching skills, were actively engaged in their own learning, and participated for long periods of time. A majority of teachers also reported that they believed that Lesson study helped them become a better math teacher, and was an effective way to continue their professional development. A majority also reported that they plan to continue Lesson study participation.

Lastly, teachers reported the challenges and/or enabling factors they encountered while participating in Lesson study. These teachers reported consistently that *time* was a major challenge—both scheduling time to meet and the amount of time needed to devote to Lesson study. The amount of administrative support the teachers received was reported as both a major challenge and major factor enabling success. The most frequently cited major factor enabling success with Lesson study was the size and make-up of the group. Overall, the survey and interview transcripts indicate that teacher' perceptions of the impact that Lesson study had on their teaching of mathematics was favorable and warrants continued engagement.

5.0 DISCUSSION OF RESULTS AND IMPLICATIONS FOR FUTURE STUDY

5.1 INTRODUCTION

This study sought to examine teachers' perspectives on the impact that Lesson study participation had on their teaching—specifically on their teaching of mathematics in an elementary school setting. This chapter presents possible explanations of the results, limitations of these results, and implications for future study.

Perception data from elementary teachers in the forms of survey data and interview transcripts served as the basis of this research study. Gathering perception data through this mixed-methods study afforded the researcher an opportunity to engage in educational research from a unique and important perspective (Shulman, 2004; Smith, Desimone, & Ueno, 2005). And, while perceptions cannot fully grasp the richness of any setting, as a starting point they generate a foundation upon which other knowledge can be added. This in turn can serve to further advance and deepen our overall understanding of the phenomenon. This study is the first step in a research agenda that can assist us in coming to understand the real need and value of this kind of professional development (Shulman, 2004). Therefore, the purpose of the study was to garner teacher perceptions in an effort to understand and interpret their engagement in Lesson study, rather than explain it. Furthermore, past research has suggested that teachers' self-reporting of the extent to which they use various teaching strategies, or engage in various

learning events, can be strongly correlated to the actual existence of these self-reported events in their classrooms (Mullens,1999). As such, teachers' self-reporting of the effect that Lesson study participation has had on their mathematics instruction provides us with insight into the overall effectiveness of engagement in this non-traditional form of professional development.

5.2 LESSON STUDY AS AN EFFECTIVE PROFESSIONAL DEVELOPMENT PRACTICE FOR ELEMENTARY TEACHERS

Chapter 2 provided a review of literature related to effective professional development. It was concluded that throughout the literature there is a shared assumption that participation in effective professional development in any field results in some form of positive change. And, sustainable change that generates new learning of one's profession would be the gold standard ((Darling-Hammond, 1997). In section 4.2, data reported teachers' perceptions of their engagement in Lesson study, and how closely in was consistent with research-based definitions of effective, or high-quality, professional development. As reported in Chapter 2, professional development is deemed effective when it is: collaborative, content-focused, reform-oriented, extended in duration, coherent, and it involves active learning (Carpenter, Fennema, & Franke, 1996; Darling-Hammond, 1992; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Elmore & Burney, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Sparks, 2002; Sparks, 2002; Sparks & Hirsh, 2000; Weiss & Pasley, 2006). These data indicated that teachers perceived themselves as having engaged in forms of Lesson study that engendered these same six characteristics of effective professional development. A majority of these teachers

also reported an increase in the frequency of how often they engaged in these practices. These findings are not surprising in that Lesson study, as it is practiced in Japan, includes all of these characteristics. Additionally, these teachers described the various Lesson study cycles in which they engaged, and reported participating in ways that were similar to Japanese methods described in the literature.

5.2.1 Increase in Reform-oriented Teaching Practices through Lesson Study

This study indicated findings related to teachers' perceptions of the impact that Lesson study participation had on their use of reform-oriented teaching practices, a characteristic of effective PD. Specifically, these teachers perceived increases in how often they used inquiry-based instruction, open-ended questions and differentiated instruction. The interview transcripts revealed that these teachers had an awareness that these strategies were often associated with best-practices in teaching, but rarely associated them with mathematics. Additionally, teachers described the planning process in which they engaged and suggested that the research that was conducted, the inclusion of "knowledgeable" and "supportive" colleagues and their shared goals encouraged them to use these best practices. They reported that the opportunities to plan with other teachers who had a better understanding of these practices, or who had more experience with these practices "enlightened" them. These teachers also described the research they conducted to plan lessons, noting that they looked for best practices in teaching mathematics, read articles pertinent to the content they planned to teach, and they researched problem-solving. Current literature related to planning for instruction suggests that the research component described by these study participants is not a common practice amongst U.S. teachers and,

therefore, may explain why teachers perceived an increase in their use of best practices, such as differentiated instruction, inquiry-based instruction and open-ended questioning. Teachers also reported that a knowledgeable and experienced building principal helped to facilitate the planning of lessons. The participation, guidance and oversight of the building principals described by the study participants may also explain why teachers perceived this positive change in how frequently they used reform-oriented teaching.

It is also important to note that teachers reported the least amount of change in their use of technology as a result of Lesson study participation. Interview transcripts indicated that teachers reported little use of technology in the lessons they planned. And, while they described using technology in varying degrees in their classrooms throughout the day, the specific lessons chosen through the Lesson study process did not have a technology component.

The results reported in section 4.2.4 indicated an additional positive impact on a teachers' use of reform-oriented teaching when they participated in Lesson study for more than one year. The data were disaggregated to examine whether or not there was a relationship between how long a teacher participated in Lesson study, and how frequently he or she reported using reform-oriented teaching strategies *very often*. While all teachers, regardless of how long they participated in Lesson study, reported positive gains in how often they used reform-oriented teaching, those teachers who engaged in Lesson study for one to three years, or four or more years reported the highest percentages of using these reform-oriented strategies *very often*. That is, the longer a teacher engaged in Lesson study, the greater the likelihood they would use differentiated instruction, inquiry-based instruction, multiple forms of assessment, and open-ended questions in their classrooms on a regular, or frequent, basis. And, while this study did not look into teachers' classrooms to ensure the validity of their perceptions, research does suggest

that there is a positive relationship between teachers' reporting of teaching events and the existence of those events (Burstein, 1995). Moreover, when teachers' are reporting an accounting of their particular behavior in a classroom rather than responding to questions that seek judgments about the quality of their work, the reliability and validity of these self-reports can be high (Mullens, 1995).

5.2.2 De-privatizing Teacher Practice Through Lesson Study

Over the past decade, research has emerged that provides insight into high-quality professional development (Desimone, Smith, & Ueno, 2006). This research suggests that professional development will be successful in changing teacher practice in important and positive ways when it focuses on a teacher's content knowledge, and on an understanding of how children learn that content (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Researchers argue that Lesson study fulfills these characteristics (Chokshi & Fernandez, 2005; Fernandez, 2005; Hiebert et al., 2003). Research also suggests that this PD model, regularly practiced in Japanese schools, poses some barriers due to its cultural nature (Lewis, 2002; Masami & Reza, 2005; Stigler & Hiebert, 1999; Watanabe, 2002; Weeks & Stepanek, 2001).

The teachers in this study were asked to report on their perceptions of how frequently they engaged in activities that are often associated with effective professional development. As reported in Chapter 2, professional development is deemed effective when it is: collaborative, content-focused, reform-oriented, extended in duration, coherent, and involves active learning (Carpenter, Fennema, & Franke, 1996; Darling-Hammond, 1992; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Elmore & Burney, 2000; Garet, Porter, Desimone,

Birman, & Yoon, 2001; Guskey & Sparks, 2002; Sparks, 2002; Sparks & Hirsh, 2000; Weiss & Pasley, 2006). In an effort to triangulate the data, teachers were asked to report how frequently they engaged in effective PD practices and how that changed as a result of Lesson study participation; interviewees were also asked to describe these practices.

A perceived increase in collaboration with colleagues was a finding in this study. In section 4.2.1, data indicated that teacher collaboration was both frequent and ongoing. That is, a very large percentage of the teachers in this study reported collaborating with their colleagues, *often* or *very often*. Additionally, in section 4.5.1 they reported that the group of colleagues with whom they participated was one of the greatest factors in making their Lesson study participation a success. Engagement in Lesson study requires teachers to select a group of colleagues with whom they meet regularly, plan lessons together, conduct research, observe each other, and analyze and reflect on their work, i.e. considerable collaboration (C. Fernandez, 2005; Lewis, 2000; Stepanek, 2001; Stigler & Hiebert, 1999). These same tasks are associated with effective PD, but not typically associated with the most common forms of professional development in which U.S. teachers engage (Carpenter, Fennema, & Franke, 1996; Darling-Hammond, 1992; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Elmore & Burney, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Sparks, 2002; Sparks, 2002; Sparks & Hirsh, 2000; Weiss & Pasley, 2006. More importantly, teacher isolation has been reported as a barrier to both Lesson study participation and to engagement in effective professional development (Elmore, 2000; Elmore & Burney, 2000; Fullan & Hargreaves, 1996; Guskey & Sparks, 2002). Therefore, for many teachers in this country, this is a new and different way in which to participate in professional development. This willingness of the teachers in this study to work together, and the subsequent reporting of the value of teacher collaboration suggests a

move towards a “de-privatizing of practice” called for in the literature (Fullan & Hargreaves, 1996). This de-privatization lays the groundwork for professional growth and development in meaningful ways. Moreover, teacher collaboration has been strongly linked to student achievement (Fullan & Hargreaves, 1996). Guskey (2000) defines PD as “processes and activities designed to enhance the professional knowledge, skills and attitudes of educators so that they might, in turn, improve the learning of students” (p. 16). So, while this study did not examine student achievement, it is acknowledged that, ultimately, it remains the primary purpose of teacher practice and is, therefore, a potential by-product of these teachers’ engagement in this collaborative practice. Regardless, the teachers in this study reported that a part of their Lesson study participation included collaboration with colleagues, and this collaboration was a very important factor in their successful engagement. Additionally, these teachers were successful in overcoming one of the most frequently cited barriers to successful Lesson study participation and engagement in effective PD. Overall, when these teachers worked together to research, plan for instruction, teach and reflect on their work, they increased the likelihood that their content-knowledge and pedagogical-content knowledge would improve (Carpenter, Fennema, & Franke, 1996; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002).

The increase in collaboration reported by the teachers in this study provides increasing opportunities for professional growth and development. Each individual teacher, while planning, teaching, observing students and reflecting on her instruction is bounded by the knowledge and skills she possesses—and these are bounded by the limited preparation she engaged in as a learner. The job of teaching itself is a complex endeavor that requires extensive skill, knowledge, experience, and sound moral judgment—a task almost too large to be accomplished in isolation

and by ones' self (Shulman, 2004). Collaboration with colleagues affords isolated teachers the opportunity to benefit from the collective knowledge, experience and skills of several others. And, in doing so, are far more likely to increase their knowledge of mathematics and of the pedagogical knowledge necessary to teach mathematics effectively.

Along with collaboration being cited as a valuable by-product of Lesson study participation, the most frequently cited factor that enabled these teachers to feel successful with Lesson study was the size and make-up of the group with whom they participated. This further suggests the importance of these findings.

5.3 LESSON STUDY AS A TOOL TO IMPROVE MATH CONTENT KNOWLEDGE OF ELEMENTARY TEACHERS

Effective professional development, as mentioned in earlier chapters, is focused on developing teachers' knowledge of the subject or subjects they must teach and how to teach them (Linda Darling-Hammond & Ball, 1998; Linda Darling-Hammond & Cobb, 1995; Elmore & Burney, 2000; Fullan, 2001; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000). Furthermore, professional development that is highly effective helps teachers become deeply immersed in the content (Sparks & Hirsh, 2000). And, the content, or core tasks of teaching, when mastered, provide teachers with the necessary skills to make important decisions about their students' progress (Darling-Hammond & Ball, 1998). Carpenter, Fennema and Franke (1996) argue that teachers' knowledge of mathematics and the development of the knowledge base related to that are important characteristics of effective PD. Lastly, Ma (1999) stressed that

teachers must possess a profound understanding of fundamental mathematics, (p. 123) in order to teach mathematics effectively.

Learning and understanding mathematics is a core feature of Lesson study engagement. Lesson study, as documented in the literature, requires that participants collaboratively plan a lesson built upon research they conduct (Stigler & Hiebert, 1999). This research into the subject matter provides opportunities for teachers to deepen their understanding of it. When asked, Japanese teachers indicated that Lesson study participation increased their subject-matter knowledge (Lewis, Perry, & Murata, 2003). Overall, the purpose of Lesson study is to produce new knowledge about content and pedagogy (Cohen & Ball, 1999).

The data reported in section 4.3 indicate that teachers' perceived an overall increase in their math content knowledge as a result of their Lesson study participation. As reported in the review of literature in Chapter 2, the teaching skills and/or competencies typically associated with mathematical content knowledge are: an understanding of the core math concepts that students need to learn, an understanding of the connections between and across math concepts, and understanding of the cognitive demands of math concepts, the ability to teach concepts rather than skills, and the ability to effectively plan for instruction (C. Fernandez & Cannon, 2005; Hiebert et al., 2003; Hiebert & Stigler, 2000; LeFevre & Bisanz, 1987; Ma, 1999; National Council of Teachers of Mathematics, 2000; Stigler & Hiebert, 1999).

5.3.1 Findings Related to Mathematical Content Knowledge: Understanding Core Concepts

While teachers indicated that they perceived themselves as acquiring an overall deeper understanding of mathematical content knowledge, the most increases reported were perceived increases in *how often they understood the core math concepts* and in *how often they understood the connections between the concepts*. One possible explanation for these perceived increases in core knowledge and mathematical connections was described in an interview with a 5th grade math teacher:

> "I've always been a really good math student myself. And I've always felt like I've understood the math. I could get it through procedure. But I don't think I've always taught why something was done the way it was to really get the nuts and bolts of the concepts—the *meatiness* of it. And, I think through Lesson study I've been able to get a better grasp of math—why it works. And, showing visuals on how it should work. And, showing multiple ways on why something is done. I think I've become better about the math content."

This teacher acknowledged the difference between knowing a procedure, and understanding the core and underlying concepts fully so that she could teach if meaningfully and in multiple ways.

Another possible explanation for these increases in content-knowledge is the acknowledgement that Lesson study requires that teachers be learners engaging in activities that promote learning such as: meaningful discussions with colleagues, research, and reflection (Chokshi & Fernandez, 2005; Lewis, 2000; Stigler & Hiebert, 1999). Lisa, another 5th grade teacher, explained this, saying:

> "With Lesson study I'm realizing that obviously we are all learners and we need to continue to make ourselves better. And I'm learning that there's a lot that I can still learn. …. we struggle quite a bit with the concepts that we have to teach, versus being able to teach the kids in a mastery-type situation. I'm learning more and more that, though…..there's still quite a bit that I can learn and Lesson study is a great way."

The acknowledgement that teachers must remain learners who seek out opportunities to improve their practice, explains why Lesson study is viewed as an effective tool. Lesson study requires that teachers remain on-going learners.

5.3.2 Findings Related to Mathematical Content Knowledge: Planning for Instruction

This study also reported another increase in teachers' perceptions of a growth in their mathematical content knowledge in section 4.3.6. These data indicated that teachers perceived an increase in *how often they felt prepared to plan for instruction* as a result of Lesson study participation. Lesson study engagement requires teachers to plan thoroughly for a lesson, including identifying goals, questions and expected student responses. In many cases, the lessons are scripted. This planning process is different from the procedures used in traditional U.S. schools. As such, this thorough and collaborative planning may account for teachers' perceptions of an increase in their feelings of how prepared they feel to plan for math instruction. Descriptions of the planning process in which Lesson study participants engaged, also support this possible explanation. Several respondents described a heightened awareness of needing to think more deeply about their planning. Laura described this saying,

> "Actually, it [Lesson study participation] makes me consider what I don't know. I think you feel less competent when you do it, because I think like, oh, man. Ok. I didn't think of that before. And I never considered that before when I planned a lesson. So when you're cruising along and you're thinking you're at a good place in your career, and you're at a good place in you're planning and thinking, here comes Lesson study to smack you in the head and say, 'Well, perhaps you should think a little more deeply about that—what you say and what you do.' I think what it's done, is it's made me think more in my planning about what the students are going to do rather than what I'm going to do."

5.3.3 Results of Long-term Engagement in Lesson Study Related to Mathematical Content Knowledge

To further understand and interpret why these data indicated an increase in teachers' perceptions of their mathematical content knowledge, the data were disaggregated and reported in section 4.3.8. The survey data were disaggregated by the number of years teachers participated in Lesson study. These data indicated that while most teachers perceived an increase in their skills and/or competencies often associated with mathematical content knowledge, regardless of how long they participated in Lesson study, more increases were reported by teachers who participated in Lesson study for one to three years, and for four or more years. Therefore, the longer a teacher participated in Lesson study, the more likely they were to perceive increases in their understanding of core math concepts, mathematical connections, the cognitive demands of math, and an overall increase in how prepared they felt to effectively plan for instruction. One possible explanation for these increases indicated over time is the in-depth planning, researching and reflecting that is typical of the Lesson study cycle (Lewis, 2000; Lewis, Perry, & Hurd, 2004; Stigler & Hiebert, 1999; Watanabe, 2002). In any given year, teachers may only work through each stage of the cycle once. Additionally, it is common to plan only a single lesson during the

cycle, focusing on one area of mathematics. Therefore, in order to experience notable increases to one's content knowledge, it is expected that participation in multiple iterations of the Lesson study cycle would increase its likelihood.

5.4 LESSON STUDY AS A TOOL TO INCREASE ELEMENTARY MATH TEACHERS' PEDAGOGICAL-CONTENT KNOWLEDGE

Carpenter, Fennema and Franke (1996) argue that teachers' knowledge of mathematics and the development of the knowledge base related to that are important characteristics of effective professional development. They further argue that in addition to a knowledge of subject matter, pedagogy and pedagogical-content, a knowledge of students' thinking is an essential element for an improvement in teaching (Carpenter, Fennema, & Franke, 1996). Understanding the conceptions, preconceptions and misconceptions that students possess about specific content assists teachers in developing their own knowledge, a key component to effective instruction (Carpenter, Fennema, & Franke, 1996). Professional development that focuses on developing skills to better understand students' thinking provides important opportunities for teachers to improve their practice (Carpenter, Fennema, & Franke, 1996; Desimone, 2009). Researchers argue that Lesson study fulfills these characteristics of effective professional development (Chokshi & Fernandez, 2005; C. Fernandez, 2005; Hiebert et al., 2003).

In section 4.4, survey data and interview transcripts were analyzed and the results presented, in an effort to discern any changes in elementary math teachers' perceptions of their pedagogical-content knowledge. To that end, they were asked to respond to questions about

teaching skills and competencies often associated with math pedagogical-content knowledge (Bass, Usiskin, & Burrill, 2002; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Cohen & Ball, 1999; Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; M. L. Fernandez, 2008; LeFevre & Bisanz, 1987; Ma, 1999; National Council for Accreditation of Teacher Education, 2006; Phillips, 2007; Schoenfeld, 2007). These teaching skills and/or competencies are: understanding how children learn math, understanding how students think about mathematics, preparedness to develop students' conceptual understanding of mathematics, use of high level math tasks for all students, use of questions that have open-ended responses for all students, acceptance of the use of alternate strategies and/or explanations from students, identifying student misunderstandings of math concepts, identifying student preconceptions of math concepts, posing real-world problems to all students, providing opportunities for students to investigate to solve problems, and discussing alternative mathematical hypotheses.

The results of this study indicate that teachers' perceived an increase in the frequency of use of each of the skills and/or competencies often associated with pedagogical-content knowledge. Furthermore, the greatest increase reported was in teachers' perceptions of how often they could identify students' misconceptions of the mathematical content they were presented. An additionally important finding was the increase in teachers' perceptions of how often they felt that they understood how children learn math. This study also reported that, when disaggregated by how long teachers participated in Lesson study, the greatest increases reported were in teachers' perceptions of how prepared they felt to teach math, regardless of how long they participated in Lesson study. However, the study also reported that the longer a teacher participated in Lesson study, the greater the gain in how prepared teachers felt to teach math. These findings are further explained below.

5.4.1 Lesson Study as a Means to Increase Pedagogical-content Knowledge: Identify Students' Misconceptions

This study reported gains in teachers' perceptions of how prepared they felt to identify student misconceptions. This skill is a key component of effective instruction and offers teachers important opportunities to develop their own knowledge of both mathematics and pedagogy related to math content. And, this is achieved while engaged in practice in their own classrooms (Carpenter, Fennema, & Franke, 1996). The ability to identify student misconceptions while they are engaged in learning provides "on the job" training for teachers—it is student and classroom specific. Furthermore, teachers are then able to respond appropriately to the needs of their students and adjust their instruction accordingly.

One possible explanation for these strong perceptions of an increase in a teachers' ability to identify student misconceptions is the unique kinds of teacher-learning that occur during Lesson study engagement. Lesson study is a form of PD that is both content specific and location specific. That is, teachers come together to identify particular gaps in learning in their own classrooms with their own students. Instruction is designed to meet the needs of students identified through this process. And, the subsequent teaching, reflecting, editing and re-teaching of the lesson is conducted in the classrooms of the teachers who are engaged in Lesson study. This creates opportunities for teachers to develop what Aristotle referred to as *phronesis*—the development of practical wisdom (Lewis, Akita, & Sato, 2010). Paula described how this practical wisdom she acquired while teaching affects what she does in her classroom now. She described how she learned to use "probes" from her colleagues during the planning phase of the Lesson study lesson that she worked on. She explained:

> I'm a huge fan now of probing. So I try to do a lot of probes now that I hadn't done before. And I can easily assess, and quickly assess, where misconceptions are going to happen ahead of time just by a quick probe. Just by walking around and seeing where kids are going on a certain problem I can see why they might struggle and that enables me to sort of step in a guide them with questioning techniques to take them, maybe, to a different direction.

This kind of on-the-job training assists teachers in building the capacity to respond to the changing needs of their learners.

Another possible explanation for teachers' perceptions of a increase in their feeling able to identify student misconceptions is what the Japanese refer to as "seeing with new eyes" (Lewis, 2000; Lewis, Akita, & Sato, 2010; Stepanek, 2001). When teachers collaborate to bring best practices to their classrooms, and then open their doors so that others can observe student learning and offer insight into the dynamic interchanges that exist during the teaching process, teachers are able to see students through "new eyes". With the help of their colleagues, teachers can gain new insight into how their students are solving problems, they can gain insight into the skills and knowledge these students bring to the task, and they can learn where their students are stumbling or confused. Lesson study engagement affords teachers the opportunity to gather the insights of many—and oftentimes, these colleagues with whom they collaborate bring different levels of understanding, experience and wisdom. Again, each teacher gains from the collective knowledge of all Lesson study members. One 6th grade teacher, Tara, captured this in her remarks about the lesson observation:

> When we were watching them in their groups is when we saw a lot of misconceptions. We saw students say that 3 divided by 7 was 35. And that 35x5 was 7 and stuff like that. So, it was neat to see, as one teacher in a room you probably wouldn't have caught all the little things that the students do and go through, and we weren't

> really able to say anything, so I kind of just got to sit back and see. And, we were able to see the other kids in the group say "No, 35x5 is not 7, it's this way: 5x7 is 35. Just one teacher in a room with 25 kids, there's no way they're going to catch all those misunderstandings.

This study participant articulated the value of having many teachers observe and offer insight into the lessons. And, her thoughts reinforce the intent of Lesson study participation—that is, it assists teachers in developing the skills necessary to see real evidence of student learning, student engagement and student achievement—a new way of seeing children (Lewis, 2002).

5.4.2 Lesson Study as a Means to Increase Pedagogical-content Knowledge: Prepared to Teach Math

This study reported that gains in teachers' perceptions of how prepared they felt to teach math, were made regardless of how long they participated in Lesson study. This by-product of Lesson study engagement is an important finding. One possible explanation for these strong perceptions is grounded in the construct of the social cognitive theory of behavioral change (Bandura, 1977). This theory suggests that teachers' self-efficacy beliefs affect several behaviors in the classroom. One's beliefs of personal competency affect his or her behavior. When teachers feel competent and confident, they are more likely to engage in appropriate tasks and make better choices. Conversely, teachers who feel less confident and competent are more likely to avoid certain tasks and behaviors. Improving knowledge and increasing opportunities for rehearsal and practice, promote self-efficacy (Mayhew & Fernández, 2007). And, Lesson study offered teachers

multiple opportunities to both improve their knowledge and practice their skills with collaboration from their peers. It is hypothesized that these experiences with Lesson study served to increase these teachers' feelings of self-efficacy which in turn increased the likelihood that they would choose to continue with Lesson study, gaining more knowledge and experience. This cycle of increasing self-efficacy and then choosing to engage in those activities that continue to promote further positive feelings of self-efficacy may explain why teachers perceived themselves as feeling more prepared to teach math.

5.4.3 Lesson Study as a Means to Increase Perceptions of Overall Ability to Teach Elementary Mathematics

This study reported that teachers perceived gains in their perceptions of the role that Lesson study played in assisting them in becoming a better math teacher. Moreover, the study also reported that the greatest increases in these perceptions occurred in teachers who had participated in Lesson study the longest, indicating a relationship between the length of time a teacher participated in Lesson study, and the gains in their perceptions of their overall ability to teach math. In section 4.4.13, it was reported that while 26.7% (n=4) of those who engaged in Lesson study for one year strongly agreed that Lesson study helped them become a better math teacher, this percentage doubled for those teachers who had engaged in Lesson study for more than one year.

A possible explanation for these strong perceptions of an increase in becoming a better math teacher as a result of Lesson study lies in the construct of social cognitive theory of behavioral change. Through his work, Bandura (1977) suggested that teachers' perceptions of

their self-efficacy affect their behavior in several ways. These feelings of competence affect the choices a teacher makes and the courses of action one might pursue. Feelings of self-efficacy also affect those tasks and situations a teacher might avoid. Bandura (1977) also suggested that individuals use past experience and knowledge to anticipate actions and predict the expected outcomes of those actions. Therefore, the improvement of knowledge, and the increase in opportunities to practice that new knowledge can increase self-efficacy. This, in turn, can assist teachers in making better choices, specifically related to instruction (Bandura, as cited in (Pajares, 1996). Lesson study provided these teachers with a means to improve their math knowledge and an opportunity to practice these new skills in a very structured setting. The resulting increase in teachers' feelings of self-efficacy might explain why they feel that they have become a better math teacher through their Lesson study participation.

5.5 CHALLENGES AND ENABLING FACTORS FOR SUSTAINABILITY OF LESSON STUDY

In Japan, one of the highest performing countries in math and science, teachers regularly participate in Lesson study, and this participation has often been cited as having a impact on the mathematics performance of their students (Fernandez, 2005; Lewis, 2000; Masami & Reza, 2005; Stepanek, 2001; Stigler & Hiebert, 1999; Watanabe, 2002). Research also suggests that this professional development endeavor, regularly practiced in Japanese schools, poses some barriers in U.S. schools due to its cultural nature. Cited in the literature, the most common barriers to implementing Lesson study across the U. S. include: lack of shared long-term goals

across staffs, lack of curricular coherence, lack of U.S. teachers' strong content knowledge, teacher isolation, and the lack of shared planning time (Chokshi & Fernandez, 2004; Lewis, 2002; Stigler & Hiebert, 1999). Fernandez and Cannon (2005) argue that another important barrier to implementing Lesson study is grounded in U.S. teachers' views of teaching; their focus on teacher behaviors rather than student behavior (p. 482). Moreover, U.S. teachers' attitudes toward collaborative, in-depth planning of lessons and self-reflective teaching practices also differ from Japanese teachers in ways (Fernandez & Cannon, 2005).

Chapter 4 reported the findings of the survey and interview transcripts when teachers were asked to report their perceptions of the challenges they faced during their Lesson study engagement. They were also asked to report the factors that they believed assisted them in feeling successful about their Lesson study participation. In section 4.5.1 these challenges and enabling factors were reported.

The study reported that, based on survey data, teachers' perceived *time* as the greatest challenge to participating in Lesson study. Time was defined as *the amount of time* needed to devote to Lesson study, and *scheduling meeting time*. This study also reported that, based on interview transcripts, lack of administrative support was perceived to be a major challenge to Lesson study engagement.

5.5.1 Time as a Barrier to Lesson Study Participation

Section 4.5.1 reported that the most frequently cited challenge to Lesson study was the amount of time teachers needed to devote to it, and the difficulty of scheduling time to meet. These findings are quite unremarkable in that it is quite rare for U.S. schools to have time for

professional development included in the school day; especially in the elementary school setting. As such, it is common for teachers who engage in Lesson study in the U.S. to do it on their own time, before or after the day ends (Lewis, 2002). This was the case for the majority of teachers who participated in both the survey and the interview portion of this study.

5.5.2 Administrative Support is a Factor in Lesson Study

It was reported in section 4.5.1 that survey data indicated that lack of administrative support was one of the most frequently cited challenges to participating in Lesson study. It was also reported by other teachers as a major factor enabling success in their Lesson study endeavors. Moreover, half of the interview respondents cited lack of support as a major challenge to their Lesson study participation, and half of the interview respondents reported administrative support as a major factor enabling success. This study, therefore, reported that the administrator plays an important role in the Lesson study process for the teachers in this study.

When teachers reported lack of administrative support as a major challenge, they reported they felt they needed support from their administrator, but did not receive it consistently. These teachers also reported that they felt that they needed guidance from their administrator to continue to participate in Lesson study, but they did not get any. Lastly, interview transcripts revealed that teachers reported administrative *turnover* as another reason for lack of support.

One possible explanation for teachers feeling they need administrative support but don't get it may be due to schools' inability to implement professional development opportunities effectively. While teachers engaged in Lesson study on their own time with their colleagues, these practices are not typical in the U.S. teaching culture and this kind of collaboration is often

ignored (Lieberman, 2000). In addition to teacher collaboration being ignored, it is rare for school systems to have support structures in place to facilitate the kind of engagement required of Lesson study (Lieberman, 2000). Principals are not prepared to assist with the implementation of Lesson study due to the lack of school-wide professional development support systems that value and promote collaboration, lengthy engagement in a PD endeavor or teacher-driven PD.

When teachers reported administrative support as a major factor enabling success, they cited their administrator's "knowledge, experience and facilitation skills" as keys to assisting them. Other interview respondents explained that the administrator assisted them with the *time* challenges noting that the administrators helped with substitute teachers and schedule coordination. These descriptions of administrative support are cited as necessary for both effective leadership and leadership for change (Elmore, 2000; Fullan, 2001; Marzano, Waters, & McNulty, 2005). The teachers in this study were describing building level administrators who possessed some of the characteristics linked to a school's success (Marzano, Waters, & McNulty, 2005). This may account for the teachers' perceptions that suggest that administrative support was a major factor that enabled their success with Lesson study.

As mentioned earlier, Lesson study requires levels and kinds of participation from teachers that are common in Japan, but unique to the teaching culture in U.S. schools. The role of the building level leader in Japanese schools is markedly absent from the literature. Furthermore, throughout the current research and literature on the development on Lesson study within the U.S., questions arise as to the role the building administrator *should* play (Chokshi & Fernandez, 2004, 2005; Maria Fernandez, 2005; M. Fernandez & Robinson, 2006; Lewis, Perry, Hurd, & O'Connell, 2006; Lewis, Perry, & Murata, 2006). This dichotomy between the importance of

effective leaders in affecting positive change in schools and the lack of clear roles for the building level leaders may account for the varying perceptions the teachers in this study.

5.5.3 Other Findings Related to Administrative Support

While it was reported in section 5.5.3 that administrative support, or lack thereof, was a notable finding in this study, additional findings related to this were reported in section 4.5.1. Upon disaggregation of the survey data, it was reported that the more strongly teachers felt that Lesson study helped them become better math teachers, the more likely they were to report that administrative support was a major factor enabling their success with Lesson study. Conversely, of those who felt less strongly that Lesson study helped them become better math teachers, administrative support was more of a challenge than an enabling factor. That is, the less strongly they felt Lesson study impacted their ability to teach math, the more likely they were to report that the lack of administrative support was a major challenge. Furthermore, it was also reported that for those teachers in this study who planned to continue participating in Lesson study, administrative support was a major factor that enabled their success. For those who reported that they do not plan to continue participating in Lesson study, administrative support was not a major factor that enabled their success. However, the lack of administrative support was reported as a major challenge by many. As mentioned in previous paragraphs, long-term engagement in Lesson study poses cultural barriers (Lewis, 2002). The support, guidance and knowledge of building level administrators may be one factor in assisting with teachers' ability to sustain this practice.

5.5.4 The Future of Lesson Study

It was reported in Chapter 4 that, overall, teachers' perceived positive changes in their understanding of the skills and tasks often associated with math content knowledge and with pedagogical-content knowledge as a result of Lesson study participation. In section 4.2.8, it was reported that 97.9% (n=46) agreed or strongly agreed that Lesson study was an effective way to continue professional development, and 92.6% (n=44) agreed or strongly agreed that it helped them become a better math teacher. However, it was reported in section 4.2.5 that only 66% (n=31) of the survey respondents planned to continue their participation in Lesson study. This is an important finding in this study as Lesson study, like all effective professional development, requires participants to commit to engaging in this process for a lengthy period of time. Unlike the more traditional forms of professional development offered in this country, Lesson study continues across years in many cases.

In section 4.2.5, it was reported that, upon the disaggregation of data related to whether or not teachers in this study planned to continue in Lesson study, all of those teachers who *strongly* agreed that it helped them become a better math teacher, planned to continue. However, only 39.1% (n=9) who agreed that it helped them become a better math teacher planned to continue. Similarly, 92.4% (n=24) of teachers who *strongly* agreed that Lesson study was an effective way to continue professional development planned to continue, but only 35.0% (7) of those who agreed that Lesson study was an effective way to continue professional development planned to continue with it. These findings suggest that there is a relationship between how strongly teachers perceived that they experienced the benefits of Lesson study and whether or not they will continue. While this is not remarkable in and of itself, it is notable that a majority of

those who merely *agreed* that Lesson study positively impacted them, do not plan to continue. Therefore, these data indicate that teachers in this study only planned to continue when they perceived *very* positive gains from their Lesson study participation.

Possible explanations for these findings include the cultural nature of Lesson study and its shift away from more traditional forms of professional development. These teachers engaged in a professional development experience that required them to behave in ways they may have never done before. It required them to collaborate with peers when they were more experienced at planning alone. It required that they commit a significant amount of time to their own professional development in their own classrooms when they were more familiar with attending workshops and conferences at other sites. It required that they research to plan a lesson rather than use textbooks and the curriculum to inform their instruction, and it required that they allow other colleagues into their classrooms; a practice that is very unique in U.S. schools. Their Lesson study participation required that they publicly reflect on their teaching and on the teaching of their colleagues, and to revise their practice based on evidence gathered in their classrooms; again, practices that are often unique in U.S. classrooms. While the teachers in this study reported that they perceived a positive impact in their math knowledge and in their pedagogical-content knowledge, they participated in a unique and challenging form of professional development.

5.6 LIMITATIONS OF THE STUDY

This study sought to explore teachers' perceptions of the role that Lesson study participation had on their knowledge growth in mathematics and in the pedagogical-content knowledge related to mathematics. This study also sought to identify these teachers' challenges and enabling factors encountered during their Lesson study participation. These findings are strictly limited to the perceptions of these study participants and are not generalized to other settings. This report sought to understand and provide some possible explanations for these teachers' perceptions, given their particular experiences with Lesson study engagement in their own schools with their colleagues. While current research suggests that there may be a link between teachers' perceptions of their skills and readiness to teach and resulting actions in their classrooms, this study was not conducted in classrooms and does not claim to report any changes in actual behavior or in student achievement (Smith, Desimone, & Ueno, 2005).

5.7 IMPLICATIONS OF THE STUDY

5.7.1 Overall Implications

It is suggested throughout the research that professional development that is enduring in nature is directly related to its effectiveness in improving teachers' content and pedagogical-content knowledge in meaningful ways (Elmore & Burney, 2000; Guskey & Sparks, 2002; Hiebert, 1999; Sparks & Hirsh, 2000). The teachers in this study perceived that their Lesson study

participation achieved this, but reported that the challenges make it difficult for many to continue without assistance. The majority of teachers reported that they plan to continue with Lesson study, but also reported that it requires a significant time commitment and the support, or involvement, of their building administrator. Therefore, the implications of this study suggest that the teachers in this study are ready to move away from the more traditional forms of professional development typically offered to U.S. teachers, and embrace a new paradigm—effective professional development in the form of Lesson Study. The implications of this study also suggest that, unlike Lesson study engagement by Japanese teachers, the teachers in this study perceive administrative support as necessary for Lesson study engagement to be sustainable. While these teachers reported strong perceptions of its positive impact on their knowledge and skills related to mathematics and also reported that they expect to persevere, despite the challenges, they cannot do it alone (Sibbald, 2009).

5.7.2 Time Constraints and the Benefits of Technological Advances

The amount of time required of Lesson study participation was reported as a significant challenge for the teachers in this study. This supports past research on the challenges of Lesson study participation (Chokshi & Fernandez, 2004; Fernandez & Chokshi, 2002; Lewis, 2002). The structure of a typical school day in U.S. schools leaves little room for teacher collaboration and dedicated time to professional development. While policymakers are beginning to acknowledge the need for teachers to engage in effective professional development, the autonomous nature of school districts, schools and teaching suggests that the likelihood of any widespread change is questionable.

It is suggested that, in addition to the role that the building leader must play in resolving the *time* challenges, the current technological resources that exist may serve to mitigate the challenge of time as well. Cameras and computers provide us with opportunities to "come together" from remote locations. Therefore, it is possible for university personnel to join a Lesson study team via the web, rather than travel. This affords Lesson study teams the opportunity to have the "knowledgeable other" called for in the literature as part of their team. The quality of video and audio recording provides us with the ability to record the teaching of lessons while capturing the discussions and the work of both the students and the teacher. For those Lesson study team members who are unable to view the lesson live, this may provide the opportunity to "observe" the public lesson without being there. This may also serve to encourage the participation of the building administrator. Lastly, software that allows for "synchronous chatting", may provide opportunities for all Lesson study members to engage in the debriefing process regardless of their location. The addition of web-based cameras may offer an additional means of coming together to debrief.

Engagement in effective professional development should not wait. Lesson study is an excellent way for teachers to enjoy the benefits of effective professional development. And, the current technological resources available to us may serve to limit the challenges others have faced.

5.7.3 A Paradigm Shift for Teachers and Instructional Leaders

Lesson study participation calls for a paradigm shift in educators' beliefs about effective professional development, and therefore, requires changes in thinking and in practice. These

changes in beliefs and actions are significant. This paradigm shift requires changes in how professional development in schools is viewed, and ultimately, implemented. The implications of this study suggest that teachers are prepared for this paradigm shift, but require that building administrators must be prepared as well. The sustainability of Lesson study is dependent upon effective building leaders who possess the skills and knowledge necessary to achieve this (Marzano, Waters, & McNulty, 2005). In the case of Lesson study, building level administrators who understand the qualities of effective professional development and how clearly Lesson study possesses those qualities and characteristics, should become knowledgeable about this practice, learn how to facilitate, monitor and evaluate it, and foster the sense of community and collaboration necessary for its sustainability (Marzano, Waters, & McNulty, 2005). Leadership for Lesson study requires new skills that extend beyond instructional leadership as it has been defined in the literature (Lambert, 1998; Marzano, Waters, & McNulty, 2005).

5.7.4 Moving Beyond Instructional Leadership

In the last two decades, the roles of instructional leaders have been a significant focus of the literature regarding educational leaders and have been defined as: resource provider, communicator, instructional resource, and visible presence (Marzano, Waters, & McNulty, 2005). Lesson study calls for a different kind of instructional leader, well beyond the current definition. It requires building leaders to move beyond the “providing”, “communicating”, “providing resources” and” being present” that are current descriptors of instructional leaders. Leading Lesson study requires building administrators to “see with new eyes”—just as the teachers in this study claimed to have done. Building administrators will need to *see* the

traditional school day differently, *see* the roles of teachers differently, and *see* their own roles differently.

In *seeing* the school day differently, building leaders need to provide dedicated time to their staff and be willing to preserve it when competing interests intercede. This requires a willingness to examine how teachers are required to spend time before and after school. All meetings that are not focused on teaching and learning need to be eliminated. The traditional format of one teacher-one class needs to be examined. Instructional methods that include co-teaching, multi-age groupings, learning centers and large group instruction may serve to free up small groups of teachers so that they are able to meet regularly. Most importantly, a building administrator must seek out new ways to organize each school day so that Lesson study teams are provided with dedicated time to meet.

Leaders of Lesson study must *see* the roles of teachers differently. Teachers must be viewed as on-going learners who are required to make professional development a priority. Building leaders must make this non-negotiable. In turn, building leaders must ensure that teachers' time is not wasted on non-professional tasks—supervising the playground, monitoring the lunchroom or overseeing bus duty. A close examination of financial resources may uncover monies to assist with this. In addition to seeing the role of teacher as professional, building leaders leading Lesson study must see teachers as active agents in their own learning. Teachers must be expected to do the necessary work of professionals—that is, know and be able to implement best practices, conduct research, have a thorough understanding of content and be willing to learn. In effecting this new view of teachers as professionals, building leaders will need to *see* their own roles differently.

Leadership for Lesson study requires building leaders to *see* themselves as "lead learners". They must be willing to immerse themselves in the work of Lesson study and become a partner in the process rather than a supporter. Building leaders who actively engage in the Lesson study process alongside their teachers send a clear message that it is important work. And, in this move from a leader of professional development to an active partner, building administrators must be willing to allow teachers to take leadership roles throughout the Lesson study process. This requires that building administrators acknowledge that they may not know something, declaring others as experts—an investment of trust and authority in staff members. In doing so, building administrators model what is expected of teachers who are engaged in effective professional development.

The sustainability of Lesson study is dependent upon building leaders generating a shared vision with professional development as a priority. Leaders of Lesson study must create an infrastructure that supports effective professional development – dedicated time; measurable goals, tangible/visible support, and a means for sharing and celebrating. They must creatively and thoughtfully examine how the school day is constructed, the roles of teachers and their own roles. Leaders must become learners who are willing to engage in the reciprocity of teaching and learning during the Lesson study process sending a clear message that on-going professional development is a non-negotiable requirement for all.

5.7.5 Suggestions for the Sustainability of Lesson Study and Other Forms of Effective Professional Development

While the teachers in this study reported positive gains in their perceptions, and also reported that they plan to continue, current research suggests that these findings are very unique. Most U.S. teachers are not engaging in this kind of PD. Teachers across the U.S. retain a great deal of autonomy in deciding when and how they will engage in professional development (Guskey & Sparks, 2002). Additionally, there is no agreement across states about the quantity and quality necessary for sustained improvement in teaching, and ultimately student achievement. The National Center for Educational Statistics (2007) reported that while forty states identified standards for PD, only fifteen states set aside time for it, and only 31 states offered some financing of professional development to all of its district. Moreover, currently, there is a body of research that clearly delineates the qualities and characteristics of effective PD. And, yet, the decision about the kinds and quality of PD in which teachers engage, remains their choice. The sustainability of Lesson study engagement, or participation in any effective PD endeavor, requires systemic changes to both the culture of U.S. teaching, and in its practice. Otherwise, the current cultural norms that exist in the U.S. educational system continue to be spawned—get your degree, get your classroom, close your door and good luck. Additionally, this same system gives implicit permission to teachers to practice in an ever-changing and dynamic field, relying almost solely on a college degree that was barely sufficient from the outset.

Systemic change requires a unique partnership across all stakeholders—policy makers, state leaders, district leaders, higher education personnel, building level leaders, school boards, teachers, parents and community members. The kind of change that is called for, if teachers are

to be expected to develop as professionals, requires a commitment from all levels of the educational community, and a concentrated effort to place effective PD in the center of its work. Developing consistently high expectations for PD across all states will begin to systematize the requirement that all teachers engage in effective professional development. Higher education can support this endeavor by developing teacher preparation programs and educational leadership programs in which effective PD, and the development of a strong knowledge base related to it, is required. Once effective PD becomes a requirement at national and state levels and is supported by the higher education system, local stakeholders share in the responsibility of paving the way so that teachers can become engaged. Effective professional development for all teachers must become part of the vision of local school districts. And, in doing so, funding, time and support will need to be provided. This change becomes the responsibility of school boards, community members, parents and teachers.

The shared burden of effecting a systems-wide change in cultural norms and in practice also lies in the teachers. Current research suggests that teachers are aware of the insufficiencies in the PD in which they have chosen to engage. Although teachers reported participating in more than forty-two hours of PD in a year, less than half reported receiving any release time to participate in these activities, and almost one-quarter reported feeling as if they received no support, time or credit for their participation (Sparks & Hirsh, 2000). Only two in five teachers reported that they were fully prepared to use their new learning in their classrooms and just one in five felt prepared when their PD involved technology (Sparks & Hirsh, 2000). The application of new learning acquired through the many hours spent participating in PD has been rare (Darling-Hammond, 1999; R. DuFour & R. Eaker, 1999). It is imperative that teachers hold themselves and each other accountable, requiring that they settle for nothing less that PD

endeavors that change their content knowledge and/or their knowledge of instruction in meaningful ways.

Furthermore, a clear distinction needs to be made between effective professional development, or professional learning, and building capacity to carry out the tasks associated with schooling and teaching. Professional development requires that teachers participate on the job, with their colleagues, actively engaged in discourse, and planning and reflection that is content-focused—its end result is a positive change in teacher knowledge and practice, and an improvement in student learning. Building capacity to carry out the tasks of schooling, while often necessary, should never be mistaken for, or accepted as, professional development. Many workshops, conferences and faculty meetings serve to build capacity to carry out a whole host of schooling or teaching tasks. For example, attending workshops to become familiar with new software, attending faculty meetings to discuss building level issues, or participating in conferences that introduce new and exciting information may build teachers' capacity to carry out new and important tasks. But, these activities are not professional development. This distinction is part of the paradigm shift that must occur across all stakeholders for engagement in effective PD, such as Lesson study, to become sustainable.

Lastly, and of equal importance, benefits will be gained throughout the entire educational community as a result of a systems-wide commitment to effective professional development. While teachers may be the only stakeholders in the system engaging in professional development, the benefits of higher achieving students will be felt at every level of the educational organization. Higher achieving students have a financial impact on communities, states and, ultimately, the country. At the local level, high student achievement draws families to communities, potentially impacting tax bases. These higher performing students generate higher

performing states with the potential of accessing more funding. And, at the national level, higher performing students fare better in the global marketplace becoming more competitive in the international job market. Overall, all stakeholders benefit from a systems-wide approach to improving student learning, when the focus is on effective, meaningful professional development of teachers.

5.8 FUTURE RESEARCH

While this study generated findings related to Lesson study participation for the teachers in this study, the limitations of this study design make it difficult to generalize these findings across populations and across other settings. Therefore, further research is indicated. Teachers in this study reported strong perceptions of an increase in their math content knowledge and in their ability to plan for and teach math. Case studies of teachers who participate in Lesson study may serve to bridge the gap between teachers' perceptions of gains from Lesson study and actual classroom data to corroborate these findings. Future research should also include studying the acquisition of new mathematical knowledge through quantitative measures and the increase in teachers' pedagogical-content knowledge through observational studies (Cooley, 1978). Lastly, the teachers in this study reported that lack of administrative support was a major barrier to their success. Therefore, future research should include the measure of the impact that leadership has on the sustainability of this practice.

While Lesson study possesses the research-based characteristics of effective professional development, it is still a very new practice in this country and requires a level of engagement that

may be new and challenging for U.S. teachers. Therefore, future research should include the study of the modifications that have been made to Lesson study implementation in this country and the effects that these changes have had on teacher knowledge and skills and on the sustainability of this professional development endeavor.

Finally, as human science research suggests, there is merit in researching human learning from a participatory perspective (O'Connor & Penuel, 2010). Future research conducted by those individuals who have engaged in Lesson study may provide meaningful and scholarly information to the education community.

APPENDIX A

EMAIL REQUEST FOR RESEARCH CANDIDATES

To: [Email]

From: gyamnitzky@verizon.net

Subject: Lesson study Participant Survey

Body: Dear Fellow Educator:

Your insight about any experience you have had with Lesson study is very important to me! I am currently a practicing educator in western Pennsylvania, like you, and I am also a doctoral candidate at the University of Pittsburgh. I am very interested in Lesson study and I am conducting a survey of teachers' perceptions of Lesson study and its impact on their teaching and knowledge of mathematics. It is my understanding that you are, or have, participated in some form of Lesson study. To that end, I am conducting a brief survey, and your responses would be greatly appreciated. Would you take about 15 minutes out of your very busy day to complete this survey?

There is no more than minimal risk to individuals who participate in this research and complete confidentiality is ensured. Your name will not be used. Instead, you will be given a code number and pseudonym to guarantee your confidentiality. The typed transcript of the interview will be entered on a computer by a transcriptionist, and any identifying information will be changed for any written reports. Only the project investigator will have access to the transcript. Your participation is voluntary. There is no compensation for participating in this research, and you may

withdraw at any time, for any reason, without penalty.

Thank you for volunteering to participate in this survey and possible follow-up interview. Please print a copy of this information for your records. By agreeing to the following statement, you acknowledge the above information and give your voluntary consent for participation.

PRIMARY INVESTIGATOR:
Gail Siragusa Yamnitzky
gyamnitzky@verizon.net
412-795-8162

ADVISOR:
Cynthia A. Tananis, Ed.D.
Associate Professor, School of Education,
412-648-7171

PLEASE COMPLETE THIS SURVEY ON OR BEFORE MARCH 17.

Here is a link to the survey:
http://www.surveymonkey.com/s.aspx

This link is uniquely tied to this survey and your email address. Please do not forward this message.

Thanks for your participation! It is greatly appreciated!

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.
http://www.surveymonkey.com/optout.aspx

APPENDIX B

LETTER OF REQUEST FOR RESEARCH CANDIDATES

Gail S. Yamnitzky
65 Kellywood Court
New Kensington, PA 15068
724-882-9101
gyamnitzky@verizon.net

Dear Teacher:

The purpose of this letter is to invite you to continue your participation in a dissertation study on Lesson study, a highly effective professional development practice. Recently, you completed a survey related to your experiences with Lesson study. Currently, I am conducting follow-up interviews with survey participants and your input is invaluable to my study.

As a reminder, I am a doctoral candidate at the University of Pittsburgh, a practicing school administrator, and a former teacher. I am exploring professional development practices that inform mathematics instruction and am most interested in Lesson study as a professional development practice. It is my understanding that you are, or have, participated in Lesson study.

The purpose of my study is to tell the story of the impact that participation in Lesson study has on teaching elementary mathematics through survey and interviews. Therefore, my intent is to conduct a series of interviews with teachers who have participated in Lesson study.

Would you be willing to participate in an interview? If so, please complete the attached consent form, and I will collect it when we meet for an interview. Your participation in my study is voluntary. The information described above is so that you can make an informed decision about your participation. Please be assured that the names, and any and all personal information of the school district and all participants, will remain strictly confidential and anonymous. You may withdraw your consent at any time. There are no foreseeable risks associated with this project, nor are there any direct benefits to you. I thank you in advance for your participation and look forward to beginning my work. Please feel free to contact me at any time.

Sincerely,

PRIMARY INVESTIGATOR:
Gail Siragusa Yamnitzky
gyamnitzky@verizon.net
412-795-8162

ADVISOR:
Cynthia A. Tananis, Ed.D.
Associate Professor, School of Education,
412-648-7171

PLEASE RETURN ONE COPY OF THIS FORM TO GAIL S. YAMNITZKY

AND KEEP THE OTHER FOR YOUR RECORDS

I have read the attached letter and I understand that:

- My participation is voluntary
- I will be interviewed
- I may withdraw my consent at any time
- Any and all information is strictly confidential and anonymous
- There are no foreseeable risks associated with this project, nor are there any direct benefits to me

I consent to be a participant in this study

SIGNATURE_____ DATE_____

PRINTED NAME_____

SCHOOL DISTRICT_____

SCHOOL BUILDING WHERE I WORK_____

DAYTIME PHONE NUMBER_____

EMAIL_____

Approved for use by the University of Pittsburgh Institutional Review Board, Protocol # 09010106

APPENDIX C

SURVEY QUESTIONS

1	What grade do you currently teach?
2	Do you currently teach math?
3	How long have you participated in a Lesson study group
4	At the time of this survey, are you part of a LS group?
5	What staff members other than yourself are/were in you LS group
6	What math concept or concepts did you include in the research lesson
7	During the time I spent participating in LS, I collaborated with my colleagues from the same grade or school very much, somewhat, very little, not at all
8	When I am teaching, I use inquiry based lessons (before) very often, often, sometimes, rarely, never
9	When I am teaching, I use inquiry based lessons (after) very often, often, sometimes, rarely, never
10	When I am teaching, I use technology (before) very often, often, sometimes, rarely, never
11	When I am teaching, I use technology (after) very often, often, sometimes, rarely, never
12	When I am teaching, I use differentiated instruction (before) very often, often, sometimes, rarely, never
13	When I am teaching, I use differentiated instruction (after) very often, often, sometimes, rarely, never
14	When I am teaching, I use different forms of assessments (before) very often, often, sometimes, rarely, never
15	When I am teaching, I use different forms of assessments (after) very often, often, sometimes, rarely, never
16	When I am teaching, I use high level math tasks (before) very often, often, sometimes, rarely, never
17	When I am teaching, I use high level math tasks (after) very often, often, sometimes, rarely, never
18	When I am teaching, I use alternate strategies and explanations for my struggling students (before) very often, often, sometimes, rarely, never

19	When I am teaching, I use alternate strategies and explanations for my struggling students (after) very often, often, sometimes, rarely, never
20	When I am teaching, I pose open-ended questions (before) very often, often, sometimes, rarely, never
21	When I am teaching, I pose open-ended questions (after) very often, often, sometimes, rarely, never
22	When I am teaching, I pose mathematical problems that have multiple solutions (before) very often, often, sometimes, rarely, never
23	When I am teaching, I pose mathematical problems that have multiple solutions (after) very often, often, sometimes, rarely, never
24	When I am teaching, I pose mathematical problems with solutions that are not obvious (before) very often, often, sometimes, rarely, never
25	When I am teaching, I pose mathematical problems with solutions that are not obvious (after) very often, often, sometimes, rarely, never
26	When I am teaching, I pose real world math problems to all of my students (before) very often, often, sometimes, rarely, never
27	When I am teaching, I pose real world math problems to all of my students (after) very often, often, sometimes, rarely, never
28	I share my new mathematical knowledge with my colleagues (before) very often, often, sometimes, rarely, never
29	I share my new mathematical knowledge with my colleagues (after) very often, often, sometimes, rarely, never
30	I share my new mathematical knowledge with my administrator (before) very often, often, sometimes, rarely, never
31	I share my new mathematical knowledge with my administrator (after) very often, often, sometimes, rarely, never
32	I understand how children learn math (before) very often, often, sometimes, rarely, never
33	I understand how children learn math (after) very often, often, sometimes, rarely, never
34	I understand the core mathematical concepts by students are expected to learn (before) very often, often, sometimes, rarely, never
35	I understand the core mathematical concepts by students are expected to learn (after) very often, often, sometimes, rarely, never
36	I understand the connections between mathematical concepts (before) very often, often, sometimes, rarely, never
37	I understand the connections between mathematical concepts (after) very often, often, sometimes, rarely, never
38	I understand the cognitive demands of mathematical concepts (before) very often, often, sometimes, rarely, never
39	I understand the cognitive demands of mathematical concept (after) very often, often, sometimes, rarely, never

40	I understand how children think mathematically (before) very often, often, sometimes, rarely, never
41	I understand how children think mathematically (after) very often, often, sometimes, rarely, never
42	I feel prepared to teach mathematics (before) very often, often, sometimes, rarely, never
43	I feel prepared to teach mathematics (after) very often, often, sometimes, rarely, never
44	I feel prepared to teach mathematical concepts rather than mathematical procedures (before) very often, often, sometimes, rarely, never
45	I feel prepared to teach mathematical concepts rather than mathematical procedures (after) very often, often, sometimes, rarely, never
46	I feel prepared to effectively plan for math instruction (before) very often, often, sometimes, rarely, never
47	I feel prepared to effectively plan for math instruction (after) very often, often, sometimes, rarely, never
48	I feel prepared to develop my students' conceptual understanding of math (before) very often, often, sometimes, rarely, never
49	I feel prepared to develop my students' conceptual understanding of math (after) very often, often, sometimes, rarely, never
50	I feel prepared to identify my students' misunderstandings of mathematical concepts (before) very often, often, sometimes, rarely, never
51	I feel prepared to identify my students' misunderstandings of mathematical concepts (after) very often, often, sometimes, rarely, never
52	I feel prepared to identify my students' preconceptions of mathematical concepts (before) very often, often, sometimes, rarely, never
53	I feel prepared to identify my students' preconceptions of mathematical concepts (after) very often, often, sometimes, rarely, never
54	I feel prepared to provide opportunities for my students to investigate to solve math problems (before) very often, often, sometimes, rarely, never
55	I feel prepared to provide opportunities for my students to investigate to solve math problems (after) very often, often, sometimes, rarely, never
56	I feel prepared to discuss alternate mathematical hypotheses with my students (before) very often, often, sometimes, rarely, never
57	I feel prepared to discuss alternate mathematical hypotheses with my students (after) very often, often, sometimes, rarely, never
58	Indicate the level of challenge each of the factors presented to successfully implementing LS – developing a common overarching goal
59	Indicate the level of challenge each of the factors presented to successfully implementing LS – the size/make up of the group
60	Indicate the level of challenge each of the factors presented to successfully implementing LS – the amount of time devoted to LS

61	Indicate the level of challenge each of the factors presented to successfully implementing LS – scheduling time to meet as a group
62	Indicate the level of challenge each of the factors presented to successfully implementing LS – understanding of the LS process
63	Indicate the level of challenge each of the factors presented to successfully implementing LS – the steps in the LS process
64	Indicate the level of challenge each of the factors presented to successfully implementing LS – amount of administrative support received
65	Is LS an effective way to continue PD – strongly agree, agree, disagree, strongly disagree
66	Did LS help you become a better math teacher – strongly agree, agree, disagree, strongly disagree
67	Do you plan to continue LS
68	Gender
69	What teaching certifications do you have
70	How many years have you been teaching
71	School district
72	School
73	Name

APPENDIX D

INTERVIEW QUESTIONS

I. Qualities of Professional Development

1. How long have you participated in Lesson study?
   a. Who was in your group?
   b. How often did you meet?
   c. Did you prepare a research lesson? If so, what was the math content of the lesson or lessons?
2. Describe your overall experience of Lesson study participation.
3. How has participation in Lesson study changed your views of professional development?
4. Thinking about past participation in professional development endeavors, how does Lesson study compare?

II. Content Knowledge

5. As a result of participating in Lesson study, how has your overall math content knowledge has changed?
6. If so, can you give specific examples of how your content knowledge has changed?
7. As a result of participating in Lesson study, do you feel more prepared to teach mathematics?
8. If so, can you give specific examples of how/why you feel more prepared to teach mathematics?
9. As a result of participating in Lesson study, do you feel more prepared to effectively plan for instruction?
10. If so, can you give specific examples of how you plan for instruction differently now?

III. Pedagogical Content Knowledge

11. As a result of participating in Lesson study, how has your overall pedagogical content knowledge changed? (That is, your understanding of how to teach mathematics effectively)
12. If so, can you give specific examples how your pedagogical content knowledge has changed?
13. As a result of participating in Lesson study, do you feel more prepared to develop your students' conceptual understanding of mathematics?
14. If so, can you give specific examples of how/why you feel more prepared to develop your students' conceptual understanding?
15. Describe a math lesson in which you used what you learned through your participation in Lesson study.

IV. Challenges and/or Enabling Factors

16. What have been the greatest challenges to participating in Lesson study?
17. What have been the greatest benefits to participating in Lesson study?
18. What advice would you give to any teacher interested in pursuing Lesson study?
19. What advice would you give to that teacher's building administrator?
20. Will you continue participating in Lesson study?
    a. Why or why not?

Approved for use by the University of Pittsburgh Institutional Review Board, Protocol # 09010106

APPENDIX E

SAMPLE CODING NOTES

To what extent are the characteristics of Lesson Study implementation in this study, consistent with research-based definitions of quality professional development?					
Interviewee	Response	Notes	Code		
	Would you just start by describing your overall experience with Lesson Study at the level that you participate in?				
1	So we met and talked about what Lesson Study was, I gave them some handouts that we had gotten at MSP. Just a general overview of what Lesson Study involved, the little cycle that it entails and talked about that. The second time we met I asked them in between those times to think about what type of topic, what kind of questions do you want to have answered or addressed. I know when we did it in the professional development we were supposed to have a, I don't know what to call it, a category and then a specific topic within that category. So, I asked them to try and think of those two things. When we met again they decided that they wanted to do measurement as their general topic and then specifically measuring to the nearest inch? So we chose that topic. So then I did the research for them. I went and found articles. I didn't ask them to do any of that. I wasn't really sure, um, I always feel guilty asking people to do work, extra work, when it was something that I started. So I found the research and gave it to them between the two times, next time.	Collaboration,	1	d	1
	What was the research on?				
1	On measurements and students, and how they measured, and what they needed for measurement. So it was a lot of the non-standard unit, and iterations and all the basics they needed to know. So, we met again after they read the research and we talked about that some, and then we started looking at what specifically, what kind of lesson you want. So they looked through their book and picked the lesson on measuring to the nearest inch. And, I don't know how many times we met, maybe five or six times, we developed the lesson, decided who was going to be the teacher, what types of activities are going to be in them. Then we used the TTLP as we planned it. Figuring out what questions they might have. That, I think, was the best part. Do you want me to do that part now?	Long in duration, content-focused	1	c	1

	G: OK. Has your participation is Lesson Study changed your idea of professional development in any way?				
2	Yeah, because I think it should really be the way a lot of professional development is run. Whether you have that structure, and not just the sharing, planning, you know, the picking each other's brains. And a lot of professional development isn't that way. A lot of it is listen to one person talk about a topic, looking at data, which is important, I know, but I'd like to see more of the Lesson Study approach. Even if it's not formally a Lesson Study. Just the 'let's get together and talk about this unit', even if they don't do the research ahead of time, just having the sense of what kind of things are going to happen. That anticipation of questioning, what kind of responses do you want to have ready.		1		
1	Prior to teaching it, the first step was agreeing on a topic in the content area of math. Deciding what area did we really need to work on. Because kids are really good at sorting in Kindergarten, they're really good at patterns. But, money has always been this glaring spot that they always have this really difficult concept of, 'why is a quarter worth more than a penny? It's just a different color." So we looked at first what content was the skill that needed done. Then we sat down and said "What can we do? How can we do it?"	content-focused	1	a	1
1	I really enjoyed the Lesson Plan Study and I enjoyed the thinking behind it. Just talking to colleagues. The communication behind it. Because teaching is lonely: you go into your own classroom, you close the door, and that's it for six to eight hours. And then you come out. And you never get to see someone else teach, and someone else reflect on it. Because everyone has their own styles. And it was nice to see, "Am I doing this right?" or "How would they do it?" and just validation that you are on the right page and you are doing the right thing. And so it, it was meaningful to me as a teacher.	collaboration	1	d	1

3	Yes. After working with the Lesson Study, that was the most that I'd ever collaborated on one single lesson. And I saw the value of so many people working together thinking about one lesson. And I remember, it was either you or Sandy, who said about "it's not about the perfect lesson to put on the shelf". Was that you? I was amazed about how much thinking you can do about one single lesson. So, I think in terms of Professional Development, when you have people think about their planning and a lesson, and they collaborate with people who are experts on it, and for me it was just the value of the collaboration. And I think that would be an important piece for Professional Development.	collaboration	1	d	1
4	far as professional development, it's another form of teaching, another way of getting ideas from other people, other teachers. And working together to create a really good lesson. It helps, as far as professional development, it helps the teachers to collaborate and to work together more. As opposed to isolated classrooms, I would say, is the biggest part of it.		1	d	1
	Do you use inquiry based instruction differently?				
1	I think I use more of it. I definitely use more of it in my classroom. More hands on activities, more of letting them find the answers themselves.	reform-based; inquiry based instruction	1	b	3
	Do you use technology differently in your classroom?				
5	Technology, I'm absolutely getting more advanced with that. We learned how to use the Smart Board, so we're using the Smart Board in math classes now. I learned how to apply certain videos that teach math in different ways. So I use videos that I found through my Google searches. I definitely use the technology in terms of me using it to teach. But I also have started taking the kids to the computer lab to utilize the computer for different games and activities for their lessons. I don't think I really emphasized that as much early on in my career as I do now. I don't think it's a result of Lesson Study, though. I probably use the computer more to do research for Lesson Study. But I don't necessarily use it as a tool any more.	technology - No	1	b	2
3	I don't think my feelings about that have changed since doing Lesson Study because we didn't incorporate technology into the lessons that we did.	technology - No	1	b	2
1	I wouldn't say it plays a large role in the Kindergarten classroom. I do use technology because I like technology: Powerpoint presentations, Smartboard, projectors. But, because of Lesson Plan Study I wouldn't say that technology was integrated into it. So I don't think it was because of that.	technology - No	1	b	2

BIBLIOGRAPHY

Bass, H. E., Usiskin, Z. P., & Burrill, G. E. (2002). Studying Classroom Teaching as a Medium for Professional Development: Proceedings of a U.S.-Japan Workshop

Bandura, A. J. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice Hall.

Carpenter, T. P., Fennema, E., & Franke, M. L. (1996). Cognitively Guided Instruction: A Knowledge Base for Reform in Primary Mathematics Instruction. *The Elementary School Journal, 97*(1), 3-20.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C.P., & Loef, M. (1989). Using Knowledge of Children's Mathematics Thinking in Classroom Teaching: An Experimental Study *American Educational Research Journal, 26*(4), 499-531.

Chokshi, S., & Fernandez, C. (2004). Challenges to Importing Japanese Lesson study: Concerns, Misconceptions, and Nuances. *Phi Delta Kappan, 85*(7), 520.

Chokshi, S., & Fernandez, C. (2005). Reaping the Systemic Benefits of Lesson study. *Phi Delta Kappan, 86*(9), 674.

Cohen, D. K., & Ball, D. L. (1999). *Instruction, capacity and improvement*. Philadelphia: Consortium for Policy Research in Education.

Cooley, W. W. (1978). Explanatory Observational Studies. *Educational Researcher, 7*(9), 9-15.

Danielson, C. (1996). *Enhancing professional practice: a framework for teaching*. Alexandria: Association for Supervision and Curriculum Development.

Darling-Hammond, L. (1997). *Doing What Matters Most: Investing in Quality Teaching*: National Commission on Teaching & America's Future.

Darling-Hammond, L., & Ball, D. L. (1998). Teaching for high standards: What policymakers need to know and be able to do. *CPRE Publications.*

Desimone, L. M. (2009). Improving Impact Studies of Teachers' Professional Development: Toward Better Conceptualizations and Measures. *Educational Researcher, Vol. 38, No. 3* (April 2009), 181-199.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of Professional Development on Teachers' Instruction: Results from a Three-year Longitudinal Study. *Educational Evaluation and Policy Analysis, 24*(Summer), 81-112.

Desimone, L. M., Smith, T., Baker, D., & Ueno, K. (2005). Assessing Barriers to the Reform of U.S. Mathematics Instruction From an International Perspective. *American Educational Research Journal, 42*(3), 501-535.

Desimone, L. M., Smith, T. M., & Ueno, K. (2006). Are Teachers Who Need Sustained, Content-Focused Professional Development Getting It? An Administrator's Dilemma. *Educational Administration Quarterly, 42*(2), 179-215.

DuFour, R., & Eaker, R. (1999). Professional learning communities at work: best practices for enhancing student achievement

Elmore, R. (2000). *Building a new structure for school leadership*: The Albert Shanker Institute.

Elmore, R., & Burney, D. (2000). Staff development and instructional improvement. In D. Burney (Ed.) (pp. 1-39): *Consortium for Policy Research in Education.*

Fernandez, C. (2005). Lesson study: A Means for Elementary Teachers to Develop the Knowledge of Mathematics Needed for Reform-Minded Teaching? *Mathematical Thinking & Learning: An International Journal, 7*(4), 265-289.

Fernandez, C., & Cannon, J. (2005). What Japanese and U.S. Teachers Think About When Constructing Mathematics Lessons: A Preliminary Investigation. *The Elementary School Journal, 105*(5), 481-498.

Fernandez, C., Cannon, J., & Chokshi, S. (2003). A U.S.-Japan Lesson study Collaboration Reveals Critical Lenses for Examining Practice. *Teaching and Teacher Education, 19*(2), 171-185.

Fernandez, C., & Chokshi, S. (2002). A Practical Guide to Translating Lesson study for a U.S. Setting. *The Phi Delta Kappan, 84*(2), 128-134.

Fernandez, M. (2005). Learning through Microteaching Lesson study in Teacher Preparation. *Action in Teacher Education, 26*(4), 36-47.

Fernandez, M., & Robinson, M. (2006). Prospective Teachers' Perspectives on Microteaching Lesson study. *Action in Teacher Education, 127*(2), 203-215.

Fernandez, M. L. (2008). Developing Knowledge of Teaching Mathematics through Cooperation and Inquiry. *Mathematics Teacher, 101*(7), 534-538.

Fullan, M. (2001). *The new meaning of educational change*. New York: Teachers College Press.

Fullan, M., & Hargreaves, A. (1996). *What's worth fighting for in your school* (2nd ed.). New York: Teachers College Press.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. S., & Yoon, K. S. (2001). What Makes Professional Development Effective? Results From a National Sample of Teachers. *American Educational Research Journal, Vol. 38, No. 4* (Winter 2001), 915-945.

Gearhart, M., & Saxe, G. B. (2004). When Teachers Know What Students Know: Integrating Mathematics Assessment. *Theory Into Practice, 43*(4), 304-313.

Gonzales, P., Calsyn, C., Jocelyn, L., Mak, K., Kastberg, D., Arafeh, S., et al. (2001). *Pursuing excellence: Comparisons of international eighth-grade mathematics and science achievement from a U.S. perspective, 1995 and 1999*. Washington, DC: U.S. Department of Education. National Center for Education Statistics.

Guskey, T. R. (2000). *Evaluating professional development* (308, Trans.). Thousand Oaks: Corwin Press, Inc.

Guskey, T. R., & Sparks, D. (2002). *Linking professional development to improvements in student learning*. Thousand Oaks: Corwin Press, Inc.

Hatch, T., & Shulman, L. S. (2005). *Into the classroom: Developing the scholarship of teaching and learning*: Jossey-Bass.

Hiebert, J. (1999). Relationships between research and the NCTM standards. *Journal for Research in Mathematics Education, 30*(1), 3-19.

Hiebert, J., Gallimore, R., Garnier, H., Givvin, K. B., Hollingsworth, H., Jacobs, J., et al. (2003). *Teaching mathematics in seven countries: Results from the TIMSS video study*. Washington, DC: U. S. Department of Education, National Center for Education Statitistics

Hiebert, J., & Stigler, J. (2000). A Proposal for Improving Classroom Teaching: Lessons from the TIMSS Video Study. *The Elementary School Journal, 101*(1), 3-20.

Hill, T. L. (2002). *No Child Left Behind Policy Brief: Teaching Quality*. Denver: Education Commission of the States.

Kennedy, M. M. (1999). Form and Substance in Mathematics and Science Professional Development. *National Institute for Science Education Brief, Vol. 3, No. 2*.

Lemke, M., Calsyn, C., Lippman, L., Jocelyn, L., Kastberg, D., Liu, Y. Y., et al. (2001). *Outcomes of Learning: Results From the 2000 Program for International Student Assessment of 15-Year-Olds in Reading, Mathematics, and Science Literacy*. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Lemke, M., Sen, A., Pahlke, E., Partelow, L., Miller, D., Williams, T., et al. (2004). *International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results From the U.S. Perspective.* Washington, DC: U.S. Department of Education, National Center for Education Statistics. .

Lewis, C. (2000). *Lesson study: The core of Japanese professional development*.

Lewis, C. (2002). Does Lesson study Have a Future in the United States? *Nagoya Journal of Education and Human Development*.

Lewis, C., Akita, K., & Sato, M. (2010). Lesson study as a human science. In N. S. f. t. S. o. Education (Ed.), *The yearbook of the national society for the study of education* (Vol. 109, Issue 1, pp. 222-237). New York: Teachers College.

Lewis, C., Perry, R., & Hurd, J. (2004). A Deeper Look at Lesson study. *Educational Leadership*(February), 18-22.

Lewis, C., Perry, R., Hurd, J., & O'Connell, M. P. (2006). Lesson study Comes of Age in North America. *Phi Delta Kappan, 88*(4), 273-281.

Lewis, C., Perry, R., & Murata, A. (2003). *Lesson study and Teachers Knowledge Development: Collaborative Critique of a Research Model and Methods*.

Lewis, C., Perry, R., & Murata, A. (2006). How Should Research Contribute to Instructional Improvement? The Case of Lesson study. *Educational Researcher, 35*(3), 3-14.

Louis, K., & Marks, H. (1998). Does professional learning community affect the classroom teachers' work and student expertise in restructured schools? *American Journal of Education, 106*(4), 532-575.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teacher's understanding of fundamental mathematics in China and the United States*. Mahway: Lawrence Erlbaum.

Marzano, R., Waters, T., & McNulty, B. A. (2005). *School Leadership That Works*. Alexandria: Association for Supervision and Curriculum Development.

Masami, M., & Reza, S. A. M. (2005). *Learning from Japanese Approach to Teachers' Professional Development: Can "Jugyou Kenkyu" Work in Other Countries?*

Mayhew, M. J., & Fernández, S. D. (2007). Pedagogical Practices That Contribute to Social Justice Outcomes. *The Review of Higher Education, Volume 31*(1), 55–80.

Mullens, J. E. (1995). *Classroom instructional processes: A review of existing measurement approaches and their applicability for the teacher follow-up survey*. Washington, DC: National Center for Education Statistics.

National Council for Accreditation of Teacher Education. (2006). *What Makes a Teacher Effective? A Summary of Key Research Findings on Teacher Preparation*: National Council for Accreditation of Teacher Education.

National Council of Teachers of Mathematics, I. (2000). *Principles and standards for school mathematics*: NCTM Publication Department.

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.

O'Connor, K., & Penuel, W. R. (2010). Introduction: Principles of a human sciences approach to research on learning. In W. R. Penuel & K. O. Connor (Eds.), *The Yearbook of the National Society for the Study of Education* (Vol. 109, pp. 1-16). New York: Teachers College, Columbia University.

Pajares, F. (1996). Self-Efficacy Beliefs in Academic Settings. *Review of Educational Research, 66*(4), 543-578.

Phillips, G. W. (2007). *Chance favors the prepared mind: Mathematics and science indicators for comparing states and nations*. Washington, D.C.: American Institutes for Research.

Pianta, R. C., Belsky, J., Houts, R., & Morrison, F. (2007). Opportunities to Learn in America's Elementary Classrooms. *Science, 315*(March), 1795-1796.

Rice, K., & Rose, G. (2009). Lesson study Provides Teachers with New Insight into Student Learning. *Math & Science Collaborative, Fifteen*, 46-49.

Schmidt, W. (2002). *Missed opportunities: How mathematics education in the U.S. puts our students at a disadvantage and what can be done about it*: Education Policy Center. Michigan State University, 201 Erickson Hall, East Lansing, MI 48824-1034. .

Schoenfeld, A. H. (2007). Problem solving in the United States, 1970-2008: research and theory, practice and politics. *Mathematics Education, 39*(May), 537-551.

Shulman, L. S. (2004). *The wisdom of practice: Essays on teaching, learning, and learning to teach*. San Francisco: Jossey-Bass.

Sibbald, T. (2009). The relationship between Lesson study and self-efficacy. *School Science and Mathematics, 109*(8), 450-460.

Smith, T. M., Desimone, L. M., & Ueno, K. (2005). "Highly Qualified" to Do What? The Relationship Between NCLB Teacher Quality Mandates and the Use of Reform-Oriented Instruction in Middle School Mathematics. *Educational Evaluation and Policy Analysis, 27*(1), 75-109.

Sparks, D. (2002). Designing Powerful Professional Development for Teachers and Principals: National Staff Development Council.

Sparks, D., & Hirsh, S. (2000). A national plan for improving professional development: National Staff Development Council.

Stepanek, J. (2001). A New View of Professional Development. *Northwest Teacher Magazine, Spring 2001*, 1-8.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.

Tananis, C. (2008). *Transformative leadership.* Paper presented at the Workshop at Grove City College, Grove City, PA.

Thousand, J. S., Villa, R. A., & Nevin, A. I. (2004). The Many Faces of Collaborative Planning and Teaching. *Theory Into Practice, 45*(3), 239-248.

Watanabe, T. (2002). Learning from Japanese Lesson study. *Educational Leadership, March 2002*, 36-39.

Weeks, D., & Stepanek, J. (2001). Lesson study: Teachers Learning Together (Vol. 2): Northwest Regional Educational Laboratory, Mathematics and Science Education Center, 101 SW Main Street, Suite 500, Portland, OR 97204. .

Weiss, I. R., & Pasley, J. D. (2006). *Scaling up instructional improvement through teacher professional development: Insights from the local systemic change initiative. CPRE Policy Briefs. RB-44*: Consortium for Policy Research in Education.