TEACHER LEARNING WITHIN UNITED STATES LESSON STUDY: A STUDY OF
A MIDDLE SCHOOL MATHEMATICS LESSON STUDY TEAM

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ABSTRACT

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Jennifer Shouffler
Janine Remillard

This qualitative case study examines the professional development practice of Lesson Study as a vehicle for teacher learning. Through observing the participation and analyzing interviews of a group of United States middle school mathematics educators as they engaged in Lesson Study, this study examines teachers’ learning with respect to a) mathematical knowledge, b) beliefs about teaching and learning, c) study of teaching resources, and d) participation in the social practice.

Despite continued efforts by educators, some researchers assert that teacher professional development in the United States has not improved classroom instruction. For this reason, researchers have looked beyond the U.S. to international models to advance teacher learning. The Trends in International Math and Science Study (TIMSS), a prominent international comparison study, has brought into awareness countries that have models for improving teachers’ practice. The Japanese model of Lesson Study (Jugyokenkyu) was identified as a highly developed form of professional learning that facilitates the transmission of expert teaching knowledge among colleagues. Researchers proposed that this Japanese professional development approach had the potential to improve teaching and learning in U.S. classrooms. Other literature also points to the Japanese model of Lesson Study as an exemplary standard of how to share knowledge of best teaching practices among teachers by providing teachers the opportunity to learn
from each other. Limited research exists examining teacher learning in cases of Lesson Study as used in U.S. school settings. This case study adds to the literature by offering an understanding of how Lesson Study influenced the learning of a group of United States middle school mathematics educators. Further, this study provides insights into how the practice of Lesson Study impacted teachers’ learning in order to offer evidence on ways Lesson Study could improve teaching and learning in other U.S. schools.
TABLE OF CONTENTS

ACKNOWLEDGEMENT .......................................................................................................................... ii
ABSTRACT ................................................................................................................................................ iii
LIST OF TABLES ....................................................................................................................................... viii
LIST OF FIGURES ................................................................................................................................... lx
CHAPTER 1: INTRODUCTION ....................................................................................................................... 1
  Research Questions ................................................................................................................................. 3
  Lesson Study as an Approach to Professional Learning ................................................................. 3
  Significance and Rationale .................................................................................................................... 8
  Sociocultural Situated Theories as a Theoretical Framework for Teacher Learning ......................................... 12
CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK .................................................... 15
  Conceptual Framework ......................................................................................................................... 16
  Professional Learning for Teachers ...................................................................................................... 17
    Attributes of Effective Professional Learning ............................................................................. 19
    Professional Learning: The Case of Mathematics Teachers .................................................. 20
  Professional Learning Communities: A Model for Professional Growth ................................... 22
  An International Model of Professional Learning: Lesson Study ............................................... 25
  Lesson Study in the United States ...................................................................................................... 27
    Improving Mathematics Instruction Through Lesson Study ............................................... 29
    U.S. Lesson Study and Its Impact on Student Learning .......................................................... 31
    Challenges for Lesson Study in the United States ........................................................................ 32
  A Theoretical Model of Lesson Study ................................................................................................. 34
  Categories for Teacher Learning ....................................................................................................... 35
    Category 1- Teacher mathematical knowledge ......................................................................... 36
    Category 2- Teacher beliefs about teaching and learning ........................................................ 38
    Category 3- Study of teaching resources ...................................................................................... 39
    Category 4- Participation in the social practice ........................................................................... 40
  Four Phases of Lesson Study ............................................................................................................. 41
    Phase 1-Investigation ...................................................................................................................... 42
    Phase 2-Planning ............................................................................................................................. 43
    Phase 3-Research lesson .................................................................................................................. 44
    Phase 4-Reflection ............................................................................................................................ 44
CHAPTER 3: METHODOLOGY AND RESEARCH DESIGN ............................................................................ 47
  Methodology .......................................................................................................................................... 48
  Research Design ................................................................................................................................. 49
  Research Site ....................................................................................................................................... 51
  Participants ........................................................................................................................................... 52
  Sampling .............................................................................................................................................. 56
  Selection criteria ................................................................................................................................. 56
  Data Collection ................................................................................................................................... 57
  Data Sources Connected to Conceptual Framework ...................................................................... 58
  Observations of Meetings ..................................................................................................................... 59

v
LIST OF TABLES

Table 2.1 Summary of Characteristics of Effective Professional Development for Teachers
Table 2.2 Summary of Characteristics of Effective Professional Development for Teachers Compared to Characteristics of Effective Professional Learning Communities
Table 2.3 Summary of Characteristics of Effective Professional Development for Teachers Compared to Characteristics of Effective Professional Learning Communities Compared to Characteristics of Lesson Study
Table 2.4 Four Categories of Teacher Learning within Lesson Study
Table 3.1 Data Sources - Participants Engaged in this Study
Table 3.2 Categories for Teacher Learning and Data Sources
Table 3.3 Teacher Survey Linked to Three Areas of Mathematical Knowledge
Table 3.4 Summary of the Descriptors for Scores 1-5 on the Surveys
Table 3.5 Summary of Data Collected for Individual Participants
Table 3.6 Coding Table - Codes Used for Data
Table 4.1 The Lesson Study Activities in Meetings 1 through 10
Table 5.1 Frequency of Use of Shared Terms by Members
Table 6.1 Teachers’ Self-scores on Mathematical Knowledge on Scale 1-5
Table 6.2 Overall Mathematical Knowledge Scores on Scale 1-5
Table 6.3 Changes in Mathematical Confidence Compared to Changes in Mathematical Knowledge for Each Participant
Table 6.4 Perceived Increase in Learning by Each Participant on Use of Resources
Table 6.5 Perceived Learning by Individual Participant Linked to Four Categories of Teacher Learning and Area of Specific Learning
Table 7.1 Identified OTLs Linked to Lesson Study Activities and Conceptual Framework
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Conceptual Framework Design</td>
<td>17</td>
</tr>
<tr>
<td>2.2</td>
<td>Lesson Study Cycle</td>
<td>42</td>
</tr>
<tr>
<td>4.1</td>
<td>Possible Student Learning Goals for the Research Lesson</td>
<td>87</td>
</tr>
<tr>
<td>4.2</td>
<td>Possible Student Content and Teaching Goals for the Research Lesson</td>
<td>87</td>
</tr>
<tr>
<td>4.3</td>
<td>Grade 8 Mathematics International Problem</td>
<td>88</td>
</tr>
<tr>
<td>4.4</td>
<td>Board Planning During the Planning Phase (Part 1)</td>
<td>91</td>
</tr>
<tr>
<td>4.5</td>
<td>Board Planning During the Planning Phase (Part 2)</td>
<td>91</td>
</tr>
<tr>
<td>4.6</td>
<td>Teaching of the Research Lesson With Observers</td>
<td>93</td>
</tr>
<tr>
<td>4.7</td>
<td>Observing the Students As They Worked</td>
<td>93</td>
</tr>
<tr>
<td>4.8</td>
<td>Final Image of the Board After the Completed Research Lesson</td>
<td>96</td>
</tr>
<tr>
<td>4.9</td>
<td>Lesson Study Planning Group Reflecting on the Research Lesson</td>
<td>96</td>
</tr>
<tr>
<td>4.10</td>
<td>Knowledgeable Other Making Final Comments on Research Lesson</td>
<td>97</td>
</tr>
<tr>
<td>5.1</td>
<td>Graph of Members Participation Levels Compared to Others</td>
<td>102</td>
</tr>
<tr>
<td>7.1</td>
<td>A Revised Conceptual Framework</td>
<td>153</td>
</tr>
</tbody>
</table>
CHAPTER 1: INTRODUCTION

We are attracted to the Japanese notion of Lesson Study because it lays out a model for teacher learning and a clear set of principles about how teachers learn. Lesson Study embodies a set of concrete steps that teachers can take, over time, to improve teaching. These steps may need to be modified to work in the United States. But we believe it is better to start with an explicit model, even if it needs revising, than no model at all. (Stigler & Hiebert, 1999, p. 150)

Lesson Study refers to the Japanese professional learning practice in which teachers progressively work to improve their teaching strategies by collaborating with colleagues to create research lessons and critique teaching methods (Takahashi & Yoshida, 2004). Lesson Study is gaining worldwide attention from educators who are seeking to help teachers improve their teaching practices (Kaiser, Burba, & Kaur, 2016). Masami Isoda (2007) provides a history of Lesson Study. Lesson Study was started in the Meiji period (1868-1912) in Japan as a teacher-led, school-based system for improving classroom instruction. In the 1880s the Japanese Ministry of Education encouraged teachers to share new methods learned from missions abroad by opening their classrooms to each other. Then in the 1920s, Japanese teachers themselves began to embrace new educational theories learned from western scholars like John Dewey. Lesson Study evolved in Japan as the process for teachers to view students’ learning in new ways, including peer learning and problem solving. In 1980s, U.S. researcher Jerry Becker began a collaborative study with Japanese researchers on open-ended problems for mathematics teaching (Hashimoto & Becker, 1999). Isoda suggests that the open approach to problem solving is now a preferred way of teaching mathematics in Japan due to research lessons developed and shared through Lesson Study. Stigler and Hiebert

This qualitative case study examined the professional development practice of Lesson Study as a system for improving teaching and learning. I analyzed the participation and the interviews of a group of United States middle school mathematics educators as they engaged in Lesson Study. This study explored what a group of teachers learned from their Lesson Study experience. I examined the collected data with respect to their a) mathematical knowledge, b) beliefs about teaching and learning, c) study of teaching resources, and d) engagement in the social practice. There is limited research examining teacher learning in Lesson Study in U.S. school settings. This case study explicates how one cycle of Lesson Study influenced the learning of one group of United States mathematics educators. In this way, my study adds to the body of literature about how Lesson Study could improve teaching and learning in other U.S. schools.

The subjects in this study were a group of middle school mathematics teachers from a central New Jersey public school where I worked as the school administrator for curriculum and instruction. Over the previous five years, I had promoted the concept of Lesson Study to the mathematics department. Among these math teachers, some had a solid grounding in Lesson Study having already participated in two cycles at our school. One teacher had the experience of traveling to Chicago and Japan to learn Lesson Study from researchers. Others of the mathematics team were just being introduced to Lesson Study through this Lesson Study experience. (See Table 3.1 for details on participants.)

This mathematics team conducted a full cycle of Lesson Study as I observed and
analyzed the process. The complete cycle of Lesson Study began with the group of teachers collaboratively investigating materials, such as state standards, textbooks, and supplemental teaching resources to be used for the research lesson. They planned the lesson, and one of them taught the lesson to a group of students as the team and others observed. Finally, the team reflected together on the effectiveness of the research lesson. (Chapter 4 and Table 4.1 describe this team’s Lesson Study activities in more detail.)

**Research Questions**

What evidence does the participation of a middle school mathematics Lesson Study team reveal about teacher learning with respect to mathematics knowledge, beliefs about teaching and learning, use of teaching resources, and participation in the social practice? What do teachers perceive that they learned from their Lesson Study participation?

**Lesson Study as an Approach to Professional Learning**

In international studies, U.S. students have compared unfavorably to students in other developed countries (National Governors Association, Council of Chief State School Officers, & Achieve, 2008). For example, in the 2006 *Programme for International Student Assessment* (PISA) study of 15-year-olds’ mathematics performance, the U.S. only ranked twenty-fifth out of thirty countries (OECD, 2007). There was also evidence that U.S. teachers had insufficient math content knowledge (Ma, 1999). The combination of these issues has put pressure on United States educators to improve teaching and learning, especially in mathematics. The effectiveness of the U.S. public school system has been under criticism by politicians, corporations, and some
parents (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). Schools in the U.S. are being challenged to find better strategies to teach. Darling-Hammond and colleagues suggest that one response to dissatisfaction with American school outcomes have been to increase standardized testing and base teachers’ evaluation on students’ test scores. However, testing the outcome does not address the need to improve the teaching. Improving the quality of teaching is a fundamental way to address America’s educational underperformance.

Educational experts have been critical of the quality of standard professional development methods intended to improve teaching in the United States. Staff development for teachers has been criticized as “one-shot” and not focused on continuous improvement (Fernandez & Yoshida, 2004; Stigler & Hiebert, 1999; Takahashi & Yoshida, 2004). For decades traditional staff development for teachers in the United States has consisted of lecture-style in-services in large auditoriums, publishers’ workshops on new textbooks, and talks on improving test scores (Darling-Hammond et al., 2009; Yoon, Duncan, Wen-Yu Lee, Scarloss, and Shapley, 2007). Missing are interactions between teachers, connections to students’ learning, and applications to the classroom (Schmoker, 2006). The usual, fragmented professional development does not facilitate cumulative learning to be built among teachers (Darling-Hammond & Richardson, 2009). Educators and researchers agree that we need a new vision for teacher professional learning that translates more directly into improved teaching practice in the classroom.

A professional learning community (PLC) is an alternative approach to the non-interactive traditional professional development (Dufour, Dufour, Eaker, & Many, 2010;
A professional learning community is a team of educators who share their collective knowledge to find ways to improve their teaching. A PLC team meets together regularly, in contrast to the standard one-time lecture attendance. The concept of professional learning communities became more popular in U.S. schools beginning in the 1990s as research began to show their effectiveness (Boyle, Lamprianou, & Boyle, 2005; Hipp, Huffman, Pankake, & Olivier, 2008; Little, 1994; Supovitz, Mayer, & Kahle, 2000; U.S. DOE, 1987).

Lesson Study is one type of professional learning community. The National Staff Development Council recognized Lesson Study as one of the best designs for developing learning communities in schools (Darling-Hammond et al., 2009). Due to this recognition, the poor international comparison data, and the desire to meet higher standards, Lesson Study gained attention from American educators. It began to gain popularity because it is a structured way teachers together could plan, observe, and evaluate classroom lessons (Lewis, Perry, Hurd, & O’Connell, 2006). Although mathematics and science educators, more than other disciplines, are using Lesson Study, it is applicable to other subjects; history and literacy teachers are practicing it as well (Halvorson & Lund, 2013; Hubbard, 2007).

Takahashi and Yoshida (2004) describe the steps for practicing Lesson Study in their article, *Ideas for Establishing Lesson Study Communities*. Lesson Study begins with teachers coming together to collaboratively design a detailed single lesson on a specific chosen topic. The topic is chosen because of its importance to the subject matter. It may be a topic that has been difficult to teach, or is foundational to the students’ learning, or is new to the curriculum. The lesson chosen for study is called the *research lesson*. One
member of the team then teaches the research lesson to a class of students while being observed by all the teachers of the lesson planning team. Educators from outside the team are often invited to observe the live lesson when it is taught to the class of students. The whole educator group then engages in a post-lesson discussion about the lesson and the observations on its effectiveness. Participants share evidence they have observed regarding student thinking and learning. Using this evidence, the research lesson can be revised, polished, and retaught. The goal of the Lesson Study is to study and plan a lesson in a deep and thoughtful way. As a result, the insights gained by studying one lesson can be generalized to influence teachers’ strategies for all lessons (Hurd & Lewis, 2011; Stigler & Hiebert, 1999; Yoshida, 1999).

Lewis and Tsuchida (1998) were some of the first researchers in the United States to describe the practice of Lesson Study in detail. They observed a group of Japanese teachers working together to polish a science lesson. The teachers planned a lesson around one clear goal of developing student scientific thinking. Then, one member taught this lesson in her classroom, as the planning team observed and recorded notes on evidence of student understanding. The group reconvened to discuss the strengths and weaknesses of the observed research lesson. They revised the lesson and re-taught the lesson to incorporate what had been learned in the first instructional attempt. These steps create a full Lesson Study cycle.

Another illustrative example can be found in the Harlem Village Academy’s Lesson Study Open House, which took place in New York City in 2016. A group of four grade 3 teachers met during preceding months to create a research lesson on the topic of division with remainders. The group met after-school for nine one-hour sessions to create
a detailed plan for how this mathematics concept should be taught to students. This math topic was chosen due to the misconceptions students had presented in the past. The group sought the support of a knowledgeable other, an expert in math education and Lesson Study, to advise them on lesson recommendations. With this advice, the teachers planned a problem-solving lesson with a real-world problem of dividing fourteen lollipops into groups of three. One teacher from the planning team volunteered to test this lesson in his third grade classroom. At math time on June 1st, 2016, Harlem Village Academy invited teachers from around the school, out-of-school educators interested in Lesson Study, and the full grade 3 Lesson Study team to observe this lesson taught live to a group of students. The observers collected evidence on student understanding and misunderstanding. Then, the whole group of educators met after to discuss the effectiveness of the lesson. The planning team took notes during the discussion in order to revise the lesson for continual improvement of their teaching.

These examples illustrate how Lesson Study embodies many of the characteristics of a high quality professional learning community as identified by the National Staff Development Council and other researchers (Cochran-Smith & Lytle, 2001; Darling-Hammond et al., 2009; Hiebert, Gallimore, & Stigler 2002; Supovitz, Mayer, & Kahle, 2000). These characteristics include collegial planning, observation of students, and reflection on teaching and learning. The practice focuses the professional learning on the classroom teaching and student understanding. Expert and novice teachers come together to share knowledge and examine their own classrooms as sites of intentional investigation. Lesson Study is a systematic, teacher-led professional development model that can be continuously practiced throughout a school and throughout a career. Lesson
Study has been identified as one of the best practices for professional learning for teachers based on these characteristics (Darling-Hammond, 2006; Graham & Ferriter, 2010).

Since its introduction to the United States in 1998, a number of U.S. schools have implemented Lesson Study. Within the first six years after being introduced to the U.S., 335 schools in 32 states across the country had conducted Lesson Study as documented by the Lesson Study Research Group at Teachers College, Columbia University (Fernandez, 2004). The list of schools included New York City Public Schools, Los Angeles Unified School District, Denver Public Schools, Palo Alto CA schools, Chicago Area schools, Little Rock AR schools, Albuquerque NM schools, Scarsdale NY School District, Boston MA schools, Millburn NJ School District, and Paterson NJ School District to name a few. The state of Florida required all identified low-achieving districts to adopt the practice of Lesson Study in 2010-2011 and provided resources to all schools in the state to enhance the implementation of Lesson Study (Haithcock, 2010). This level of interest from educators in a variety of geographic and socio-economic communities attests to the appeal of Lesson Study for U.S. schools. However, few case studies follow how U.S. schools are actually practicing Lesson Study, and if and what teachers are learning from the experience.

Significance and Rationale

Hiebert, Gallimore, and Stigler (2002) suggested that despite continued efforts by researchers and educators, current professional development in the United States has had little effect on improving classroom teaching. For this reason, researchers have looked
beyond the U.S. to international models to advance teacher learning (Darling-Hammond, 2015; Stigler & Hiebert, 1999; Wei, Andree, & Darling-Hammond, 2009). The Trends in International Math and Science Study (TIMSS), a prominent international comparison study, has brought to awareness the countries that have created successful models for improving teachers’ practice (Hiebert et al., 2003). The Japanese model of Lesson Study (Jugyokenkyu) was identified by TIMSS researchers, Hiebert, Gallimore, and Stigler, as a form of professional learning that facilitates the transmission of expert teaching knowledge among colleagues. These researchers of the TIMSS video study proposed that this Japanese professional development approach had the potential to produce the gradual but continual improvement needed in the U.S. teaching profession. In addition, the U.S. National Staff Development Council recommended the creation of professional learning modeled after Japanese Lesson Study (Darling-Hammond et al., 2009). Other literature also points to the Japanese model of Lesson Study as an exemplary standard of how to share knowledge of best teaching practices among teachers by providing teachers the opportunity to learn from each other (Darling-Hammond, 2010; Graham & Ferriter, 2010; Yoshida, 1999).

Lesson Study has been a topic of attention in news stories. It was highlighted in a National Public Radio segment (Schwartz, 2016) and in the New York Times (Green, 2014). With the growing information on the promise of Lesson Study to impact teacher learning, the model is spreading to many schools in the United States (Fernandez, 2004; Loose, 2014; Perry & Lewis, 2009; Yoshida, 2012). As more American educators engage in Lesson Study, we need a broader knowledge base about Lesson Study as practiced in the U.S. (Lewis, Perry, & Murata, 2006). Case study research provides “actionable
artifacts” which can be used as a source for Lesson Study at other educational settings (Lewis, Perry, & Murata, 2006, p.10). Many case study examples are needed in order to create a basis for further research of U.S. Lesson Study.

This information can help others see how effective practice of Lesson Study can have a long-lasting impact on teacher learning, the goal of professional development. Without more documented case studies of Lesson Study modeled in U.S. settings, research cannot evolve to assess the impact of Lesson Study on teacher learning and then, ultimately, understand its influence on student learning. More research on Lesson Study needs to be done to explore its potential for instructional improvement in the United States. Starting with this descriptive knowledge, we can proceed to understand if and how Lesson Study improves teacher learning and what activities within the practice lead to teacher learning.

Further insight is needed from research on what teachers learn when engaging in professional learning. In a review of 106 studies on professional development for math teachers, Goldsmith, Doerr, and Lewis (2014) found that most of the literature did not examine the teachers’ learning within the activities. Rather the focus was on the impact on instructional practice on student learning. Goldsmith, Doerr, and Lewis suggested that most of these 106 studies from 2005-2008 treated teacher learning as an unknown “black box” (p. 25). This means that more research is needed to examine the unknown mechanisms of teacher learning. This qualitative case study attempts to elucidate what teachers learned from Lesson Study and the opportunities that supported that learning.

Thus far, there is limited academic research on how Lesson Study influences teacher learning, particularly in the United States (Lewis, Perry, & Hurd, 2009; Lewis,
Perry, Friedkin, & Roth, 2012; Takahashi, Lewis & Perry, 2014; Takahashi & McDougal, 2016). Only one research study was found attempting to understand the impact of Lesson Study on U.S. student outcomes (Lewis & Perry, 2014). More evidence from U.S. schools is needed to understand if and how a teacher learning practice from a foreign land, Japan, can be adapted for the U.S. school culture. As one of the most prolific researchers on Lesson Study, Catherine Lewis (i.e., Lewis, 2016) leads the argument for a broader knowledge base on Lesson Study to better understand its central features and how it impacts teacher learning in the United States. Lewis, Perry, & Murata (2006) argue that the “local proof route” meets the criteria for scientific educational research to show that Lesson Study can improve teaching, teachers, and student learning.

Researchers invested in the study of Lesson Study believe that the pitfall of superficial implementation of Lesson Study can be avoided by gaining a deeper understanding of its practiced features (Lewis, Perry, & Hurd, 2009; Lewis, Perry, & Murata, 2006; Watanabe, Takahashi, & Yoshida, 2008). For example, those engaged in Lesson Study need to understand how to plan a thorough research lesson. Descriptive case studies can illustrate the activities of Lesson Study in detail and investigate the link to teacher learning and instructional improvement. Translated case studies of Lesson Study conducted in Japan can serve as models (Lewis, 2002; Yoshida, 1999). However, U.S. educators need a clearer picture of how Lesson Study is conducted in U.S. schools. Researchers have just begun to build a base of these U.S. Lesson Study cases, but more are needed (Lewis, Perry, & Hurd, 2009; Loose, 2014; Takahashi, Lewis, & Perry, 2013; Wright, 2009).

My study adds to the knowledge base by providing a “local proof” case of one
full Lesson Study cycle from beginning to end, as implemented with mathematics teachers in a New Jersey public middle school. By analyzing the participation of the teachers as they engaged in Lesson Study, I explain what teachers learned in Lesson Study. The interviews with the teachers provided further data on what learning was perceived by the teachers themselves. Since the model itself is based on practitioner knowledge, it follows that practitioners should be observed and interviewed in their own school as they engage in Lesson Study and strive to learn together.

Drawing on data including meeting observations, participant interviews, and surveys, I offer “usable, actionable, and adoptable artifacts” to demonstrate Lesson Study for other U.S. schools (Lewis, Perry, & Murata, 2006, p.5). “Local proof” of Lesson Study in this U.S. school can provide a case example for others and show the impacts on teacher learning (Lewis, Perry, & Murata, 2006, p.6).

**Sociocultural Situated Theories as a Theoretical Framework for Teacher Learning**

Social learning theory provides a theoretical basis to understand how people develop knowledge and accumulate learning over time. The sociocultural situated approach to learning has emerged from the theories of Soviet psychologist L.S. Vygotsky (1978). The main notion is the importance of the social origin of higher mental functioning (Wertsch, 1998). According to Vygotsky, every function in development happens twice, first within the social interaction (interpsychological) and later in the individual (intrapsychological). In other words, first learning happens between people and then it is internalized within the individual learner. Vygotsky believed that interactions with a teacher or peer enable a learner to advance through her/his zone of
proximal development. This zone is the gap between what a learner can achieve by herself and what she could achieve with interactions with others.

Contemporary scholars like Lave and Wenger (1991) have further developed the concept of social learning theory. The traditional view of learning has located learning solely in the mind of the individual learner. This concept separates learning from interactions within the social context. In contrast, Lave and Wenger argued that learning takes place as a situated social process. They theorized that changes are complexly linked to participation in a community and in a culture. Learning is not seen as an individual act of cognition, but a process enabled through the discourse between peers and teachers. Wenger (2010) advances this perspective of sociocultural learning by explaining how learners can work together to socially construct knowledge within communities of practice. In this sense, learning is both a process and an outcome. These theorists believed that peer learning and learning from others is not confined to children but is an integral part of formal and informal learning for adults.

A sociocultural approach of teacher learning views teachers as participants in a learning community in which they develop member identities, belonging, and skills as part of an interactional process (Battey & Franke, 2008; Lambert, 2012; Wenger, 2010). Teachers are seen as “active agents” of their own learning (Spillane, 2002, p.391). Teachers facilitate mutual learning by exchanging ideas and discussing improvements in instruction. Thus, teacher learning opportunities should emphasize reflecting as a group on instructional improvements. This way teachers can work together to understand how ideas can be translated into practice and obstacles overcome. From the sociocultural situated learning perspective, the mechanism for teacher learning focuses on teachers’ identities as
both “experts and learners in their community of practice” (Spillane, 2002, p.395). Based on this theory, teacher professional learning models should include interactions with colleagues. Lesson Study, as just such a community of practice, provides teachers with identities as experts and learners within a network of peers in which they interact to learn together. As with all learners, teachers’ learning begins as an interactive social process in which teachers can move further through their zone of proximal development via their engagement with other teachers. The social group process of learning is followed by the intrapsychological internalization of knowledge by the individual teacher.
CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

In this literature review, I focus on five main areas of literature that relate to the purposes of this study and upon which the conceptual framework is developed. After presenting my conceptual framework, I then discuss the supporting literature. I first examine research on the need for effective professional learning for teachers to improve instruction and student learning. This includes the literature related to the essential elements needed for professional learning to improve classroom practice. Since this study investigates a group of mathematics teachers, I examine the research on specific needs in mathematics professional learning. In the second section I focus on the collaborative characteristics of effective models of professional learning, such as professional learning communities. Then in the third part I examine the literature on Lesson Study, as a professional learning community originally practiced in Japan. I review the literature that explains the interest in Lesson Study by U.S. researchers as a promising model for improving teaching and learning. Fourth I review literature on the practice of Lesson Study in the United States with a focus on how math educators are exploring the benefits. This research addresses the development of Lesson Study in U.S. schools and the challenges viewed by researchers. Finally I end with a theoretical model for teacher learning in Lesson Study. I define the four teacher learning categories of this model which I will explore in this study: mathematical knowledge, beliefs about teaching and learning, use of resources, and participation in the social practice. In addition, I explain the four main phases of Lesson Study that potentially influence the teachers’ learning: investigation, planning, teaching/observing the research lesson, and reflecting. Overall, my literature review serves to examine how a collaborative practice like Lesson Study
could enable mathematics teachers to improve their knowledge, reflect on new ideas, refine their instruction, and strengthen their professional collaborations.

**Conceptual Framework**

My conceptual framework guiding this study frames Lesson Study as a potential intervening factor for the teacher-learning to student-learning process. I explore how within Lesson Study teacher learning takes place in a social process within the group and results in individual learning outcomes for the teachers. *Figure 2.1* shows how Lesson Study, with its four phases (investigation, planning, research lesson, and reflection), can be viewed as one type of professional learning community within the broader field of teacher professional learning. Sociocultural theory of teacher learning as a theoretical framework informs how teachers learn to improve their instruction through group learning, leading to a culture of collaboration. I argue that teachers’ mathematical knowledge, beliefs about teaching and learning, use of resources, and participation in the social practice can be influenced through the practice of Lesson Study. Advances in these areas can lead to instructional improvement which can lead to growth in student learning.
Academic educators believe that the critical component to improving student learning in the United States is ongoing development of teachers (Ball, 1996; Darling-Hammond, 2006; Fullan, 2016). From this perspective, preservice teacher education is merely the first step in a teachers’ career of lifelong learning to improve her instruction (Darling-Hammond, 2010). The field of education recognizes the need for teachers to engage in ongoing learning with the expectation for improved teacher performance.

Research finds examples of professional development that effectively influence teaching and learning. In a study of teachers’ attitudes and instructional improvement, Supovitz, Mayer, and Kahle (2000) found that intensive professional development of
teachers translated into student improvement. In their survey of 1,475 teachers in Ohio, this group concluded that 6-weeks of professional workshops had a positive impact on the attitudes, beliefs, and teaching practices of math and science teachers. In a longitudinal study of the impact of professional development on teacher change, Boyle, Lamprianou, and Boyle (2005) found evidence that participants in long-term professional development changed one or more aspects of their teaching strategies. Their analysis of questionnaires from 1,338 primary and secondary teachers in England revealed that sustained professional collaboration or workshops impacted teaching practices. In a review of ten American studies and one English study of the impact of professional learning on teaching practices and student learning, Vescio, Ross, and Adams (2008) found empirical evidence that well-developed professional learning (this notion will be discussed later) had a positive impact on both teaching practices and student achievement. Therefore, research suggests that professional learning opportunities can successfully impact teaching and in turn improve student outcomes. Even so, not all professional learning models have proven to be effective.

Research has shown that some professional development does not have a measurable effect on the teachers’ knowledge or instructional practices. Blank, de las Alas, and Smith (2008) examined 25 evaluation studies conducted in the period of 2004 to 2007 on teacher professional development programs in mathematics and science. Two-thirds of these professional development programs did not show measurable effects on teacher learning. Blank, de las Alas, and Smith concluded that a large number of professional learning programs lacked sufficient ongoing activities to reinforce learning for teachers when they returned to their classrooms. This large-scale review also found
that only a minority of the included programs used a school-based model for teacher learning in which teachers learned with their colleagues. This is evidence that not all professional learning has a positive impact on improving teaching. The quality and attributes of the professional learning model are critical to the outcome.

**Attributes of Effective Professional Development for Teachers**

Researchers have examined practices in professional development to determine the attributes needed to improve classroom teaching. As researchers on the *Third International Mathematics and Science Study* (TIMSS), Hiebert, Gallimore, and Stigler (2002) suggest that the best outcomes are generated from professional learning opportunities that are “long-term, school-based, collaborative, focused on students’ learning, and linked to curricula” (p. 3). Investigating an example of this approach, Supovitz et al. (2000) surveyed Ohio teachers to understand the impact of intensive math and science professional development in a statewide systemic initiative to improve teaching and learning. They found evidence that high-level professional development that involved content-rich, intensive, long-term experiences that modeled forms of preferred teaching had a positive and sustained effects on teachers’ practices in the classroom. In addition, Garet, Porter, Desimone, Birman, and Suk Yoon (2001) conducted a large-scale empirical comparison survey of 1,027 math and science teachers to understand the characteristics of professional learning that teachers identified as impacting their learning. They found the following structures significantly affected teacher learning: opportunities for active learning, collective participation with like teachers, and ongoing professional learning.
These large-scale quantitative studies on teacher learning suggest that the broad attributes needed for effective professional development are active learning, collaboration with colleagues, connection to the curriculum content, school-based models, and ongoing experiences. A limitation of these studies is the subjective nature of self-reported data from teacher surveys. Goldsmith, Doerr, and Lewis (2014) suggest that small-scale qualitative studies, such as this case study, can add to our understanding of the characteristics of effective professional learning by identifying the types of experiences that improve practice. (See Table 2.1.)

Table 2.1: Summary of Characteristics of Effective Professional Development for Teachers

<table>
<thead>
<tr>
<th>Characteristics Found</th>
<th>Research Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Long-term</td>
<td>Hiebert, Gallimore, &amp; Stigler (2002)</td>
</tr>
<tr>
<td>• School-based</td>
<td></td>
</tr>
<tr>
<td>• Collaborative</td>
<td></td>
</tr>
<tr>
<td>• Focused on student learning</td>
<td></td>
</tr>
<tr>
<td>• Aligned to curricula</td>
<td></td>
</tr>
<tr>
<td>• Content-rich</td>
<td>Supovitz, Mayer, &amp; Kahle (2000)</td>
</tr>
<tr>
<td>• Intensive</td>
<td></td>
</tr>
<tr>
<td>• Long-term experiences</td>
<td></td>
</tr>
<tr>
<td>• Model preferred teaching strategies</td>
<td></td>
</tr>
<tr>
<td>• Connected to classroom practices</td>
<td></td>
</tr>
<tr>
<td>• Active learning</td>
<td>Garet, Porter, Desimone, Birman, &amp; Suk Yoon (2001)</td>
</tr>
<tr>
<td>• Collaboration with like teachers</td>
<td></td>
</tr>
<tr>
<td>• Ongoing</td>
<td></td>
</tr>
</tbody>
</table>

Professional Learning: The Case of Mathematics Teachers

In response to U.S. math education reforms of the last twenty years, research has been dedicated to the changing role of the mathematics teacher (Ball, 1996; Chazan, Ben-
Chaim, & Gormas, 1998; Lloyd & Wilson, 1998; Remillard & Bryans, 2004). The *Common Core State Standards* (2010) and the *National Council of Teachers of Mathematics* (2000) have recommended changes in mathematics teaching to improve math curriculum and instruction. One common recommendation is for math teachers to change from traditional lecture-style teaching to problem-based instruction (CCSSI, 2010; Lesh & Zawojewski, 2007; NCTM, 2000). International comparison data showing U.S. students achieving far lower test scores in mathematics than other countries has created more pressure on U.S. math educators to improve (Lemke et al., 2001; Hiebert et al., 2003). The U.S. department of education has recommended intensive professional development to scale-up classroom reforms so U.S. students are not left behind in mathematics (Darling-Hammond et al., 2009). To ensure impact on mathematics classroom teaching, the *National Science Foundation* recommended professional learning that is “systemic, high-quality, based on research, and consistent with reforms” (Ball, 1996). Ball suggests that because many of these reforms challenge traditionally held views of math teaching and learning, profound professional learning for mathematics teachers is necessary.

Studies of mathematics teachers show what characteristics of professional development models are effective in changing their knowledge, beliefs, and practices. In a study of math teachers, Chazin, Ben-Chim, and Gormas (1998) found that the teachers reported benefits from observing classroom instruction and working with colleagues. Remillard and Bryans (2004) found that working with reform-based curriculum resources influenced teachers’ learning, and teachers benefited most from opportunities to explore these materials with others. Studies also found that changes in mathematics teachers’
learning were related to practice-focused collaboration with colleagues (Fisler & Firestone, 2006; Kazemi & Franke, 2004; Peng, 2007; Taylor, Anderson, Meyer, Wagner, & West, 2005). Although, Timperley, Wilson, Barrar, and Fung (2007) found that collaboration alone without exposure to new ideas was not sufficient to improve math instruction. The conclusion is that collaboration and new ideas are both critical components for mathematics teacher learning.

**Professional Learning Communities: A Model for Professional Growth**

Educational researchers have identified a gap between effective teaching practices and the reality of teaching practices in many classrooms (Ball & Cohen, 1999; Schmoker, 2006; Goldsmith, Doerr, & Lewis, 2014). Even though teachers are attending professional learning activities and learning about current research, they are not always translating best practices into classroom instruction. Schmoker (2006) calls this the “knowing-doing gap”. Ball (1996) points to teacher isolation from each other as the cultural characteristic that inhibits teacher improvement. Teachers are left to find their own style of math teaching. Ball suggests that this individualism makes it difficult to have any common standard for best practice. Sociocultural learning theory posits that interactions with others are important for teachers to advance through their zone of proximal development and grow in their learning. In isolation a teacher can only learn from her own experience in her own classroom, but not gain from what peer teachers are learning in their classrooms. In isolation a teacher is constrained to the lower limits of her zone of proximal development, meaning what she can achieve only by herself.

*Professional learning communities (PLCs)* have been identified by researchers as
the most promising strategy for eliminating teacher isolation and bridging this “knowing-doing gap” (DuFour and Eaker, 1998; Schmoker, 2006). Richard Dufour’s (i.e., Dufour et al, 2010) work has pointed to the importance of collaborative sharing of teachers’ knowledge and expertise. Professional learning communities are a general structure in which teachers meet together in an ongoing cycle to improve teaching and learning. The concept of a PLC is an alternative to the isolation pervading the teaching profession in the United States. Reduced isolation increases collaboration and can create learning opportunities for feedback from peers. In a PLC, teachers can provide and receive feedback as they work together to improve their practice (Roloff, 2012). PLCs are built on Etienne Wenger’s (2010) notion of a community of practice. There are many types of PLCs such as action research teams, Critical Friends, various study groups, and the specific focus of this research which is Lesson Study.

High-quality professional learning communities incorporate the same elements of other effective teacher professional development. Model PLCs expand teachers’ knowledge, result in reflection and discussion, are sustained over a period of time, are embedded in teachers’ daily work, and improve teaching in order to better meet the needs of all learners (DuFour & Eaker, 1998; Wald & Castleberry, 2000). Empirical evidence has shown that high-quality professional learning communities can have a positive impact on teaching and learning (Boyle, Lamprianou, & Boyle, 2005; Hipp, Pankake, & Olivera, 2008; Schmoker, 2006; Vescio, Ross, & Adams, 2008).

The role of the teacher as practitioner expert is central to the concept of a PLC (Cochran-Smith & Lytle, 2009). Hiebert, Gallimore, and Stigler (2002) identified features of practitioner knowledge that are valuable for colleagues. Teachers know their own
students and how they learn. Teachers are also most aware of the obstacles to learning in the classroom and develop responses directly from problems that arise. Collaboration with other teachers allows this knowledge to be communicated and shared in a communal way. It is important that professional learning experiences take advantage of individual teacher expertise to disseminate this among the community of teachers. Lesson Study is an example of professional learning that honors the central role of teachers (Watanabe, 2002). A professional learning community based on teacher expertise can facilitate teachers to build a better knowledge base by sharing it and refining it with others.

Table 2.2: Summary of Characteristics of Effective Professional Development for Teachers Compared to Characteristics of Effective Professional Learning Communities

<table>
<thead>
<tr>
<th>Professional Development</th>
<th>Professional Learning Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ongoing experiences</td>
<td>• Sustained over a period of time</td>
</tr>
<tr>
<td>• School-based</td>
<td>• Embedded in daily work</td>
</tr>
<tr>
<td>• Active learning</td>
<td>• Expand knowledge through collaboration</td>
</tr>
<tr>
<td>• Collaborative (with like colleagues)</td>
<td>• Results in reflection and discussion</td>
</tr>
<tr>
<td>• Aligned to curricula</td>
<td>• Values practitioner knowledge</td>
</tr>
<tr>
<td>• Content-rich</td>
<td>• Focus on teaching to meet needs of learners</td>
</tr>
<tr>
<td>• Connected to classroom practices</td>
<td></td>
</tr>
<tr>
<td>• Modeled preferred teaching practices</td>
<td></td>
</tr>
<tr>
<td>• Focus on student learning</td>
<td></td>
</tr>
</tbody>
</table>

(Hiebert, Gallimore, & Stigler, 2002; Supovitz, Mayer, & Kahle, 2000; Garet, Porter, Desimone, Birman, & Suk Yoon, 2001)
An International Model of Professional Learning: Lesson Study

Lesson Study is an example of a professional learning community in an advanced and structured form (Takahashi & Yoshida, 2004). It has the characteristics of high-quality professional learning. It is job-embedded, in that the teachers plan a lesson that is to be observed in one of their own classrooms with their own students. It is teacher-led, in that the teachers decide as a group which topic is important to study and research. The structured group process of Lesson Study allows teachers to view new ideas and share different perspectives about teaching and learning. Lesson Study focuses teachers on observing the research lesson through the students’ eyes, as students experience it. Lesson Study values teachers’ practitioner reasoning since it asks teachers to come together to make decisions based on educational ideas within their classroom and school.

Japanese teachers believe that the research lessons created by teachers through Lesson Study help define good teaching practice (Lewis, 2002a). As teachers engage in a full cycle of Lesson Study they have the opportunity to examine all aspects of their teaching: from investigating content standards, to reviewing curriculum materials, to planning units and lessons (Watanabe, 2002). The teachers plan, conduct, and observe a research lesson designed to bring long-term educational goals to life (Takahashi & Yoshida, 2004). Lewis and Tsuchida (1998) reported that through Lesson Study Japanese teachers changed their teaching approach in moving from lecture-style teaching towards a more “student-centered” practice. Lesson Study is a career-long professional custom for teachers in Japan. According to Yoshida’s (1999) ethnographic dissertation, Japanese teachers practice Lesson Study through their entire career, and some say they could not teach without it.
Lesson Study in Japan, in addition to being a professional learning activity, is also part of a culture of ongoing teacher learning. Watanabe (2002) suggests that Lesson Study facilitates the development of a shared professional culture that values collaborative growth. Teachers in Japan are comfortable sharing ideas and observing each other teach. Watanabe reports that by experiencing Lesson Study Japanese teachers have also learned the value of working together.

Lesson Study is so fundamental to Japanese teaching culture that there is no known translated Japanese research relating Lesson Study to student learning. United States Lesson Study experts do not know why this research is not being done in Japan. Possibly due to the Japanese educator cultural expectation, there is little question of the importance of engaging in Lesson Study in Japan. Dr. Makoto Yoshida, Lesson Study researcher and author, has speculated that the Japanese may not see the need for this investigation since the practice of Lesson Study has been part of the teaching culture for over 100 years (Yoshida, 1999). The Japanese educators would assume that working with others to improve one’s teaching would logically lead to improved student learning in the classroom.
### Table 2.3: Summary of Characteristics of Effective Professional Development for Teachers Compared to Characteristics of Effective Professional Learning Communities Compared to Characteristics of Lesson Study

<table>
<thead>
<tr>
<th>Professional Development</th>
<th>Professional Learning Communities</th>
<th>Lesson Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ongoing experiences</td>
<td>• Sustained over a period of time</td>
<td>• Culture of ongoing learning</td>
</tr>
<tr>
<td>• School-based</td>
<td>• Embedded in daily work</td>
<td>• Career-long practice</td>
</tr>
<tr>
<td>• Active learning</td>
<td>• Expands knowledge through collaboration</td>
<td>• Job-embedded</td>
</tr>
<tr>
<td>• Connects to classroom practices</td>
<td>• Values practitioner knowledge</td>
<td>• Classroom/school-based</td>
</tr>
<tr>
<td>• Collaborative (with like colleagues)</td>
<td>• Results in reflection and discussion</td>
<td>• Brings long-term goals to life</td>
</tr>
<tr>
<td>• Lines to curricula</td>
<td>• Focuses on teaching to meet needs of learners</td>
<td>• Values collaborative growth</td>
</tr>
<tr>
<td>• Content-rich</td>
<td></td>
<td>• Teacher-led</td>
</tr>
<tr>
<td>• Models preferred teaching practices</td>
<td></td>
<td>• Values practitioner knowledge</td>
</tr>
<tr>
<td>• Focuses on student learning</td>
<td></td>
<td>• Defines good practice</td>
</tr>
</tbody>
</table>

(Hiebert, Gallimore, & Stigler, 2002; Supovitz, Mayer, & Kahle, 2000; Garet, Porter, Desimone, Birman, & Suk Yoon, 2001)  
(DuFour & Eaker, 1998; Wald & Castleberry, 2000)  
(Lewis, 2002a; Takahashi & Yoshida, 2004; Watanabe, 2002)

### Lesson Study in the United States

Lesson Study has been adopted in schools in the United States and even further developed by schools which engaged in repeated cycles of Lesson Study (Loose, 2014; Yoshida, 2012; Perry & Lewis, 2009). Schools in New Jersey, Chicago, New York, and California continue to practice ongoing Lesson Study according to Lesson Study informational sites like lessonresearch.net and lsalliance.org. Some U.S. schools have
held open houses for others to view their research lessons and see the practice of Lesson Study in action (Liptak, 2002; Yoshida, 2009). The Chicago Lesson Study Alliance holds a yearly open house on Lesson Study (Lesson Study Alliance, 2017).

Educators wanting to implement and sustain Lesson Study in their school can look to articles and books on how to apply Japanese Lesson Study to a U.S. school setting (Lewis, 2006; Takahashi & Yoshida, 2004; Fernandez & Chokshi, 2002). Lewis and Hurd’s (2011) book, *Lesson Study Step by Step: How Teacher Learning Communities Improve Instruction*, has become a guide for U.S. educators to begin an implementation of Lesson Study. The state of New Jersey’s *Tool Kit for Collaborative Professional Learning in Schools and Beyond* dedicated a whole chapter to Lesson Study and describes how to practice this highly developed PLC (Killion, 2010).

One noted example of Lesson Study implementation in a U.S. school is School Number 2 in Paterson, New Jersey. This Grade K-8 Paterson school had conducted Lesson Study from 1999 through 2011 with positive results (Liptak, 2005). Researchers and educators wrote about the impact of Lesson Study on the teaching and learning in this school (Hurd & Lewis, 2011; Delisio, 2008; Stepanek et al.; Takahashi & Yoshida, 2004). One Paterson teacher spoke about how Lesson Study helped him think deeply about his teaching by anticipating student responses and planning for student errors. The principal noted how the teachers were playing an active role in researching their own questions about teaching and learning. Paterson School Number 2 in New Jersey was the first United States school to create a schedule for all teachers to participate in a Lesson Study team during their school day.

There is research that shows that schools in the United States can implement high-
quality Lesson Study that incorporates the critical mechanisms. Perry and Lewis (2009) examined the adaptation of Lesson Study in one U.S. school and found evidence that the practice could be adapted effectively. They examined a school that had sustained the practice for four years and had grown the number of participants to 63 teachers. Perry and Lewis found that the school had designed high-functioning teams by first creating authentic professional learning communities that could solve conflicts and build teachers’ knowledge. This school broke down hierarchical relationships and walls within that system that kept classroom practices private. Teachers focused Lesson Study discussions on student thinking and realized that shared lessons provided a basis for collaborative reflection about students’ progress towards learning goals.

**Improving Mathematics Instruction Through U.S. Lesson Study**

Although Lesson Study is a structured professional learning model that can be practiced by teachers in all content areas and in all grade levels, in the United States it has garnered the most interest from mathematics educators. American researchers examining international comparison studies of mathematics education uncovered Japanese Lesson Study (Hiebert et al., 2003; Stigler & Hiebert, 1999). At that time, Makoto Yoshida’s (1999) University of Chicago dissertation on elementary math Lesson Study in Japan was published in the United States. This was the beginning of the dissemination of Lesson Study in the U.S and it started in mathematics education. Since math educators were on the forefront of exploring Lesson Study from its U.S. introduction, more research data now exists on its use in math education than other content areas (Fernandez & Yoshida, 2004; Lewis, Perry, & Hurd, 2009; Stepanek et al., 2007; Takahashi, Lewis & Perry,
Inprasitha, Isoda, Wang-Iverson, and Yeap (2015) compiled a book, *Lesson Study: Challenges in Mathematics Education*, of articles from scholars studying the use of Lesson Study to improve the quality of mathematics education. Alan Bishop begins the book by identifying the idea of Lesson Study as a structure for developing the theory and practice of mathematics education. Akihiko Takahashi then explains how Lesson Study can be used to improve mathematics teaching by incorporating new strategies into the math classroom. The book also shares the history of Lesson Study in Japan and how it is being implemented with math teachers in countries around the world, like Thailand and the United Kingdom. The book by Inprasitha et al. offers perspectives on Lesson Study from academics with expertise in Lesson Study and mathematics education.

The international mathematics education journal ZDM dedicated the summer 2016 edition to Lesson Study (Kaiser, Burba, & Kaur, 2016). This special issue offered an international perspective on how Lesson Study in mathematics could develop teachers, improve teaching, advance math leadership, and link theory with practice. The articles in this ZDM issue provide readers a basis to critically consider the current research and practice of Lesson Study with the goal of discussing the future of Lesson Study within the field of mathematics education.

Takahashi and McDougal’s (2016) article, *Collaborative lesson research: maximizing the impact of lesson study*, was included in this ZDM edition, as well as other research articles on the practice of mathematics Lesson Study in the United States and around the world. Takahashi and McDougal (2016) examined through observation and self-reporting how Lesson Study was used at fifteen U.S. schools in three school districts
to implement the new Common Core Mathematics Standards. Teachers at these schools used Lesson Study as their predominant form of professional learning in math during this research study. Teachers and administrators reported satisfaction with improvements in teacher learning. The educators also noted changes in math instructional approaches and improvements in pedagogical knowledge. Takahashi and McDougal planned to continue their research with these schools.

Takahashi, Lewis, and Perry (2013) described a successful adaptation of Lesson Study with U.S. math teachers. These researchers provided one of the few descriptions of the implementation of math Lesson Study within a whole network of schools as opposed to a single school. The researchers gave details of how Lesson Study was used to facilitate a change in instruction in six groups of teachers, as they moved from direct teaching of an algorithm to teaching mathematics through problem solving. The researchers recruited groups of grades 3 through 5 teachers from Chicago-area schools to attend two four-day summer workshops and to conduct two Lesson Study cycles during 2012-2013. The study found that Lesson Study, along with related curriculum materials, helped the teachers implement new practices in the classroom. This description offers insights into how Lesson Study can change teaching strategies specifically in math. With this study, and other studies described earlier, research has begun to show the potential of Lesson Study to reform mathematics instruction in the U.S. and elsewhere.

**U.S. Lesson Study and its Impact on Student Learning**

There is limited research correlating the practice of math teacher Lesson Study to gains in *students’* math learning. However, there is one significant U.S. study that found
evidence linking the professional learning practice with positive student achievement. In this research study supported by the U.S. Department of Education, Lewis and Perry (2014) investigated the impact of three conditions on teachers’ and students’ knowledge of fractions. From twenty-seven school districts across the country, 213 teachers and 1059 students participated in this controlled research on Lesson Study. The school groups were divided into those that would engage in Lesson Study with supporting resource materials, those that would engage in Lesson Study without support materials, and those that would engage in their usual professional development. The researchers found that the fraction-focused Lesson Study intervention with supplemental resource materials positively impacted students' mathematics proficiency. This study also reported that Lesson Study positively influenced the collegial learning effectiveness of the teachers. Though this evidence is limited to one study, the What Works Clearinghouse Review concluded that this research met their most stringent criteria for evidence of impact (Gersten, Taylor, Keys, Rolfhus, & Newman-Gonchar, 2014). Only two of 643 studies reviewed by this group met their criteria. Due to this significance, Lewis and Perry returned to the data in 2017 to further explain how Lesson Study could be “scaled-up” through the use of distributed resource kits. Lewis and Perry’s study linking Lesson Study to improved teacher collaboration and improved student learning points to the promise of Lesson Study to improve student learning outcomes.

**Challenges for Lesson Study in the United States**

Now that at least 335 schools have initiated Lesson Study in the United States, according to the Lesson Study Research Group at Columbia University, researchers have
begun to examine the challenges faced in initiating and maintaining Lesson Study in U.S. schools (Fernandez, 2004). Chokshi and Fernandez (2004) theorized that the obstacles are both cultural and logistical. U.S. teachers are not accustomed to a time-consuming team examination of one lesson. Other U.S. professions such as medicine and law do form teams to delve deeply into important case studies but American teachers have not had this kind of experience. Another cultural obstacle for U.S. teachers is the value of academic freedom and individuality in their teaching styles. These teachers may have resistance to planning a lesson together fearing loss of their autonomy. Also, teachers in America have not often opened their classroom to peers. Some may feel vulnerable to criticism even though the focus of Lesson Study is on the students’ responses and not on the teachers’ actions. The other type of obstacle is logistical, such as finding teacher time to collaborate during or after-school (Chokshi & Fernandez; Lewis, 2006; Yoshida, 2012). Many state and local mandates further compete for the finite amount of professional learning time in U.S. schools.

Despite the promise of Lesson Study, the literature recognizes that schools in the United States face some challenges. There are obstacles to initiating and sustaining the culture and structures needed for long-term growth through professional learning communities like Lesson Study (Chokshi & Fernandez, 2004; Lewis, 2006; Yoshida, 2012). Lesson Study could be another example of a promising innovation that is quickly discarded as ineffective before it has been thoroughly understood, adapted, and researched in the U.S. school setting.

As teachers begin to practice Lesson Study in the United States, scholars recommend that research should shift from simply describing implementations to
examining how to fully and effectively practice Lesson Study (Lewis, Perry, & Hurd, 2009; Watanabe, Takahashi, & Yoshida, 2008). Lewis, Perry, and Hurd (2004) remind us that the ultimate goal of “Lesson Study is not just about improving a single lesson. It’s about building pathways for ongoing improvement of instruction,” (p.18). Teachers who engage in Lesson Study can learn how to better plan a lesson or what a new strategy for teaching looks like in a live classroom. However, to improve instruction in the long-term, the professional learning must be deliberate and focused. Watanabe, Takahashi, and Yoshida (2008) found that, though U.S. practitioners intended to conduct effective Lesson Study, they often missed important steps, like studying curriculum materials together as a group. Lewis, Perry, & Hurd believe that some U.S. Lesson Study practitioners have only looked at the visible features of Lesson Study. They may not understand how a Lesson Study activity like studying resources materials relates to teacher learning. This means that U.S. educators may not be taking full advantage of the depth of Lesson Study to improve instruction.

A Theoretical Model of Lesson Study

Lewis, Perry, and Hurd (2009) developed a theoretical model of Lesson Study that can be used to examine the features of Lesson Study and its impact on teacher learning. They found that Lesson Study improved teachers’ instruction in three ways: advancing teacher knowledge, improving use of instructional resources, and building a professional learning community. They connected these three categories of learning, which they termed pathways, to four phases of the Lesson Study protocol: investigation, planning, research lesson, and reflection. The research of Lewis, Perry and Hurd supported their
theoretical model of the three categories for learning within four phases, or stages, through which Lesson Study can improve instruction. The data from their descriptive case study offered a path for further research.

Categories for Teacher Learning

The three categories identified by Lewis, Perry, and Hurd (2009) provide a structure through which to examine the impact of Lesson Study on teacher learning. My research utilized similar categories to examine how one cycle of Lesson Study influenced the mathematics teachers in my school in regards to four areas of teacher learning: mathematical knowledge, beliefs about teaching and learning, use of teaching resources, and participation in the social practice (Table 2.4). I categorized teacher knowledge, beliefs about teaching and learning, and use of resources as individual outcomes. Participation in the social practice is defined as a group outcome in this research.

My conceptual framework illustrates how the practice of Lesson Study facilitates the group outcome through members’ participation in the social practice (Figure 2.1). The social-cultural situated nature of Lesson Study can then influence the individual teacher to internalize the mathematical knowledge, beliefs about teaching and learning, and use of resources practiced in the group.
Table 2.4: Four Categories of Teacher Learning within Lesson Study

<table>
<thead>
<tr>
<th>Individual Teacher Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category 1 – Mathematical Knowledge</strong></td>
</tr>
<tr>
<td>• Understanding of subject matter for teaching</td>
</tr>
<tr>
<td>• Understanding students’ mathematical thinking</td>
</tr>
<tr>
<td>• Understanding the link between content knowledge and teaching</td>
</tr>
<tr>
<td><strong>Category 2 – Beliefs about Teaching and Learning</strong></td>
</tr>
<tr>
<td>• Beliefs about teaching mathematics</td>
</tr>
<tr>
<td>• Beliefs about student learning</td>
</tr>
<tr>
<td>• Taking a learning stance towards their own practice of teaching</td>
</tr>
<tr>
<td><strong>Category 3 – Use of Teaching Resources</strong></td>
</tr>
<tr>
<td>• Mathematical tasks</td>
</tr>
<tr>
<td>• Content Standards, Textbooks, and supplemental materials</td>
</tr>
<tr>
<td>• Instructional tools</td>
</tr>
<tr>
<td>• Lesson plans</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category 4- Participation in the Social Practice</strong></td>
</tr>
<tr>
<td>• Participation patterns among colleagues, including legitimate peripheral participation</td>
</tr>
<tr>
<td>• Disposition and norms of interaction</td>
</tr>
<tr>
<td>• Member identity in a learning community</td>
</tr>
</tbody>
</table>

**Category 1- Teacher mathematical knowledge.** Lee Shulman (1986) first proposed a content knowledge unique to teaching called *pedagogical content knowledge*. Ball, Thames, and Phelps (2008) later built on Shulman’s notions by studying mathematics teachers and identifying knowledge needed for mathematics teaching. Ball, Thames, and Phelps’s research indicated the need for *specialized content knowledge*
(SCK) that is unique to teaching. They also suggested two other domains of pedagogical content knowledge: knowledge of content and students (KCS) and knowledge of content and teaching (KCT).

In this research, I conceptualize teacher mathematical knowledge as depth of understanding about the subject matter for teaching (SCK), understanding of student mathematical thinking (KCS), and understanding the link between content knowledge and teaching (KCT). I define content matter knowledge for the mathematics teachers in this study based on the research of Ball, Thames, and Phelps (2008) as well as the related research by Liping Ma (1999). Ma described the “profound understanding of fundamental mathematics” for teaching as knowledge of the simple but powerful ideas within mathematics (Ma, p. 124). A teacher with this kind of subject matter knowledge understands math meanings; they do not just know procedures and information. Using tasks developed by Deborah Ball (1988), Ma’s research revealed that this profound understanding of mathematics did not come from teachers’ studies in college, but from the work they did as teachers, working with students.

Furthermore, I include teachers’ understanding of student mathematical thinking as part of teachers’ math knowledge. Deborah Ball and her colleagues found that teachers needed to know their students, what they understood, and with what they had difficulty. Teachers gain knowledge of student math thinking by listening, observing, and interpreting students’ work and ideas (Ball, 1996). Ball suggested that teachers’ own mathematical knowledge is a resource for interpreting students’ mathematical thinking. Thus mathematics teachers need to develop both a deep understanding about mathematics and an understanding of how students learn mathematics content (KCS).
This includes understanding the pedagogical methods that are effective and how mathematical concepts build upon one another (KCT).

**Category 2 - Teacher beliefs about teaching and learning.** In addition to knowledge of the subject and of the students, teachers develop broad beliefs about teaching and learning. In this research, I conceptualize these views as beliefs about teaching mathematics and beliefs about student learning. I posit that teachers’ beliefs about how to teach should align with what research shows on best practices. Mathematics education research has shown the benefit of teaching math for understanding versus teaching by rote formulas (Lesh & Zawojewski, 2007; Schoenfeld, 1992; Van de Walle, 2001). This means that the teacher acts as a facilitator for students to construct knowledge, rather than just transmitting knowledge to students. Specifically, research has been building for decades to show that teaching through problem solving improves students’ learning of mathematics (Major & Palmer, 2001; Polya, 1945, 1980; Schoenfeld, 1992). This research shows that students learn more effectively by experiencing and solving rigorous math problems together because they are making cognitive and social connections. Thus there is a need for teachers to develop beliefs about teaching in ways that lead to best teaching practices and make math meaningful for students.

I include beliefs about student learning in how I define teacher beliefs. Ball and Cohen (1999) talk about the need for teachers to expand their “interpretive frames” when working with students to see more possibilities in what students can do (p. 7). This includes the belief that students have the capacity to think and reason.

Within the category of teacher beliefs, I also include the teachers’ *learning stance*
toward improving their practices. Cochran-Smith and Lytle (2009) argue that teachers can develop an inquiry stance towards their teaching and change their own practice. Cochran-Smith and Lytle see this idea of inquiry as a worldview and mindset, “a way of knowing and being in the world of education” (2009, p. vii). Within a community of practice like Lesson Study this would mean jointly constructing knowledge, questioning assumptions, critiquing ideas and resources, and taking on the role of researcher in reference to one’s own teaching. However, Wenger (1998) warns that interactions among teachers may not always lead to an optimistic stance. The risk is that they could use the interactions to gripe or discourage each other.

**Category 3 - Use of teaching resources.** In this study I examine how particular interactions within the Lesson Study process influence teachers’ use of curriculum resources. I define these teaching resources in a broad way, including: mathematical tasks, state and national content standards, textbooks and supplemental text-based materials, instructional tools or manipulatives, and lesson plans. Research by Janine Remillard (2012) informs how I define teachers’ use of mathematics curriculum resources. Remillard posits that teachers learn by their interactions with curriculum materials and use these materials to meet their own instructional needs. Gueudet and Trouche (2009) also found that teachers work with resources influenced their professional growth (p. 201). Furthermore, Lesson Study researchers Watanabe, Takahashi, and Yoshida (2008) emphasize the study of instructional materials as an important step in planning an effective research lesson. Watanabe, Takahashi, & Yoshida explain how Japanese teachers begin each Lesson Study by engaging in kyozaikenkyu, translated as study of instructional material. These researchers believe that the deep study
of resources step in Lesson Study leads to improvements in everyday instruction.

**Category 4 - Participation in the social practice.** In this study, I define *participation* as taking part in the social practice of Lesson Study as a learning community. In keeping with my theoretical framework based on Wenger (1998), I conceptualize the teachers’ learning as changes in their participation in the Lesson Study group.

Research has established that teachers’ participation in strong communities of practice is positively related to instructional improvement (Horn, 2005; Horn & Kane, 2015; Horn, Garner, Kane, & Brasel, 2017; Little, 2001). Different elements of such participation have been identified as important for teacher learning. Horn and Little (2010) found that teams of teachers can find collective learning opportunities through the use of structured conversations about teaching and learning. Also when Little (2003) examined groups of teachers as they participated in learning communities, she found evidence of the development of social dispositions and norms within their social practice that were conducive to teacher learning.

Dufour and Eaker (1998) describe another component of a professional learning community as a shared sense of purpose and a commitment to the group. Connected members of a learning community have a sense of responsibility for each other, also called a *member identity*. Members identify themselves as a part of the group with a needed role in the group.

Within the realm of collegial participation, Christman, Ebby, and Edmunds (2016) emphasized the importance of dissonance as a way teachers make sense of their learning and move to substantial improvement. Dissonance refers to contradictions
between beliefs and new information. These researchers defined *productive dissonance* as a means of making sense and revising teachers’ beliefs. Moments of disagreement and dispute are part of the exchange of ideas during the practice of Lesson Study, and can create dissonance which, if productive, can lead to learning.

I also included legitimate peripheral participation in my understanding of member participation in a group. Lave and Wenger (1991) described how newer members might initially participate in the social practice through low-risk tasks that are necessary and help the community of practice. In time, new members may start to take on higher task as modeled by the experienced members. Lave and Wenger suggested that membership in the community of practice is facilitated by the possible opportunities for participation for all members, new and experienced. In communities of practice, like Lesson Study, legitimate peripheral participation includes observing, listening, and doing practical tasks as opportunities for learning.

**Four Phases of Lesson Study**

Lewis, Perry, and Hurd’s (2009) theoretical model of Lesson Study also provides a description of the four main phases that make up the protocol of Lesson Study. My research examines these four main phases of Lesson Study: *investigation, planning, research lesson, and reflection* as noted in my conceptual framework *(Figure 2.1)*. Research experts in both Japan and in the U.S identify the same four phases of the Lesson Study cycle (Lewis & Hurd, 2011; Takahashi & McDougal, 2016; Stepanek et al., 2007; Wang-Iverson & Yoshida, 2005; Yoshida, 1999). Some experts add a fifth phase, *revision*, to explain the intended ongoing nature of Lesson Study for instructional
improvement. The ongoing cycle is represented by the arrows in my framework of Lesson Study. (See Figure 2.2.) Some U.S. teachers re-teach a research lesson improved through Lesson Study, but some experts feel this fifth phase of re-teaching of the research lesson is optional (Takahashi & McDougal, 2016). Since this is a debate among Lesson Study experts, my research focused on the four established main phases of Lesson Study, without the disputed fifth phase of re-teaching.

Phase 1—Investigation. During the investigation phase of Lesson Study, the teacher planning team considers the characteristics of current students and overarching goals for improved student learning (Lewis & Hurd, 2011). The teacher planning team is composed of all the teachers who will work together to investigate a unit and design a
research lesson from that unit. The research lesson is chosen based on a topic of interest from the team. It is the lesson that will be taught to a group of students later in the process. Typically, the team will spend time talking about broad goals in relation to their curriculum resources. Together, they will study their state standards, current research, curriculum documents, textbooks, and other supplemental materials to begin to consider an area of need or interest. The Japanese call this process Kyozaikenkyu, or studying their instructional materials (Watanabe, Takahashi, & Yoshida, 2008). They intend this study to mean a board investigation of all kinds of resource materials that can help improve teaching and learning for this research lesson.

**Phase 2- Planning.** After teachers have refined their goals, chosen their research topic, and studied their instructional materials, they will begin to plan the research lesson. The teachers will work together to write-up the teaching and learning plan for the research lesson in one multi-page document. The plan “guides the teaching, observation, and discussion of the research lesson, and captures the inquiry that occurs” within the planning team (Lewis & Hurd, 2011, p. 47). To inform their teaching, the group will continue to read and discuss research and instructional materials as they plan. They will debate, discuss, and even argue about the many decisions that will go into the final plan. This lesson plan differs from a traditional lesson plan because it shares the team’s learning as well as guides the teaching of the research lesson.

There is no single template for this lesson plan, but most Lesson Study teams include many of the same details in their plans. Two books, one by Catherine Lewis (2002b) and the other by Lewis and Hurd (2011), offer guides to the teaching-learning plan for Lesson Study. The plan usually begins with a list of the team members, the grade
level, and the title of the lesson. Then the plan outlines the research theme and goals for the lesson. A paragraph explains the rationale for the lesson, including why the group chose to focus on this particular topic. The topic is connected to the students’ previous learning, future learning, and the larger unit of study. The document also explains the relationship of this lesson to state or national standards. Next, the details of the lesson design are documented within a three-column chart: one column for student learning activities, one column for anticipated student responses and teacher responses, and one column for points of evaluation. The chart shows the progression of the lesson from beginning, middle, to end. Care is taken to note possible student responses or solutions, since this is a common discussion among the planning team. Finally, the plan outlines the data collection points the team would like to gather, both from their own observations of the students during the research lesson and from the outside observers.

**Phase 3- Research lesson.** The most visible part of the Lesson Study process is seeing how the lesson comes alive within a class of students. One member of the lesson planning team will teach the research lesson to a class of students, as the other members of the team observe. Often the team will also invite observers from outside the planning group, including other teachers within the school, school administrators, and others from outside the school. The role of all observers is to silently collect data on student learning as related to the goals of the research lesson so as to later provide feedback to the group on the lesson design (Lewis & Hurd, 2011).

**Phase 4- Reflection.** Following the research lesson, team members and observers conduct a post-lesson discussion to reflect on observations of student learning. Lesson Study teams often follow a protocol similar to one suggested by Lewis and Hurd (2011).
It is preferred that the discussion takes place immediately after the research lesson and in the same location, in order to recall accurate details for data collection. One team member acts as chairperson to facilitate the debriefing and to encourage the presentation of rich student data. Another member takes notes on the conversations. These notes will be used later to write up conclusions to the research lesson. Typically, the teacher who taught the lesson speaks first and shares any difficulties or insights from her perspective. Since the whole Lesson Study planning team has designed the research lesson together, the other members of the group then present their perspectives on the effectiveness of the group-created lesson. Next the discussion is opened up to the whole group of observers for comments. The chairperson focuses the discussion on the goals of the lesson and the data that participants were asked to collect. Observers from outside the planning team can ask questions of the team on lesson design choices. Finally, an expert on Lesson Study or this specific research topic, known as the knowledgeable other, is invited to conclude the post-lesson discussion with final thoughts to tie the discussion together and make suggestions for future learning (Wang-Iverson & Yoshida, 2005).

In order to maximize the impact of Lesson Study on teachers’ instruction, Takahashi and McDougal (2016) encourage U.S. Lesson Study practitioners to carefully consider certain structures within the Lesson Study cycle that are sometimes omitted in the United States. The components sometimes omitted include: determining a clear research lesson purpose, studying instructional materials, creating a written research lesson proposal, teaching a live research lesson, including knowledgeable others, and sharing results. Takahashi and McDougal suggest that attention to these components within the Lesson Study cycle (Figure 2.2) can influence stronger outcomes for improved
teacher learning and student learning.
CHAPTER 3: METHODOLOGY AND RESEARCH DESIGN

For this research study, I was interested in understanding what the experience of a group of middle school math teachers engaged in Lesson Study revealed about teacher learning from Lesson Study. Specifically, I wanted to know how this model of professional learning affected four categories of teacher learning: mathematical knowledge, beliefs about teaching and learning, study of teaching resources, and the participation in the social practice of the participants as illustrated in my conceptual framework. (See Figure 2.1.) In addition, I wanted to understand what the teachers identified as learning from the Lesson Study experience. Based on my conceptual framework, I approached this research with the belief that the professional learning model of Lesson Study is an example of a highly developed professional learning community, as suggested by researchers (Hiebert et. al., 2003; Stigler & Hiebert, 1999; Takahashi & Yoshida, 2004; Yoshida, 1999). In contrast to many loosely formed professional learning communities, Lesson Study has a structured, step-by-step protocol for teachers to examine their teaching materials, their teaching strategies, and their students’ learning.

My work as a school leader involves providing professional development for teachers. I have helped teachers in my school and other schools in New Jersey initiate Lesson Study teams for professional learning. Naturally, I was curious if and how the practice of Lesson Study was influencing the teachers’ learning. There is research evidence that professional learning community models like Lesson Study can have a positive impact on teacher learning (Hipp, Pankake, & Olivera, 2008; Lewis & Perry, 2014). I wanted to understand if engaging in Lesson Study was having a positive impact
on the teachers’ learning by looking at its influence on teachers’ mathematical knowledge, beliefs, curriculum resources, and professional participation in the social practice.

Methodology

A feasible way to examine the impact of Lesson Study on teachers in my school was to conduct a qualitative case study. Catherine Lewis and colleagues (Lewis, Perry, & Murata, 2006) assert that “local proof” in case study meets the criteria for valid scientific research in education. Conducting a qualitative research case study enabled me to develop such “local proof” regarding the impact of Lesson Study on mathematics teachers in one school location. With this study I am adding to the knowledge base of how Lesson Study is practiced in U. S. schools and elucidating its mechanisms in teacher learning. From the analysis of meeting participation, interviews, and surveys in this case study, the data converged to show evidence of teacher learning from the practice of Lesson Study.

Case study research is the appropriate method of study when the knowledge base needs to be further explored before controlled experiments can be conducted (Yin, 2014). In the instance of teacher learning in Lesson Study there is limited research (Lewis, Perry, & Murata, 2006). Also, Yin suggests that case study research is the preferred method when the researcher has little control of event behavior. Lesson Study is such a model of professional learning because its many variables are controlled by the teacher of planning team and are not controlled by the researcher. The Lesson Study cycle has no single set of outcomes. Therefore the characteristics of Lesson Study meet the criteria for qualitative case study research design.
Yin’s (2014) definition of case study validates my research methodology for the design, the data collection, and the data analysis. Yin defines case study by its features. He explains that case study inquiry “relies on multiple sources of evidence, with data needing to converge in a triangulating fashion” (p. 17). In this study, I used the data from observations of meetings with field notes, interviews, and surveys to converge as a body of evidence.

In addition, Yin (2014) explains that case study inquiry “benefits from prior development of theoretical propositions to guide data collection and analysis” (p.17). I used the theoretical model of Lesson Study developed by Lewis, Perry, and Hurd (2009) to guide my data collection and my analysis. I examined similar categories, suggested by these researchers, through which Lesson Study impacted teacher learning: changes in teachers’ mathematical knowledge, changes in beliefs about teaching and learning, changes in the use of learning resources, and changes in the social practice. I also investigated the areas of learning perceived by teachers. My case study research was an examination of this theoretical model in a middle school mathematics Lesson Study case.

**Research Design**

My research focused on the observation of teacher participation and teacher discourse as the windows into the teacher learning in Lesson Study (Dudley, 2013; Suzuki, 2012). Because teacher talk is central to teacher learning in the practice of Lesson Study, I analyzed the recordings of the Lesson Study discussions to shed light on what the group of teachers learned. Analysis of the group interactions was used to explore the influence of Lesson Study. I captured evidence of teacher learning through the group
discussions in the Lesson Study meetings. I looked for change as an indicator of the teachers’ learning. One focus of my research was the process of Lesson Study using the changes in the teachers’ participation in the group as evidence of group learning. My purpose for exploring the group discussions was to elucidate the group learning within the participation in the social practice, as illustrated in my conceptual framework.

Individual interviews were used to explore the evidence of individual teacher learning. The interviews explicated what the teachers perceived they had learned about mathematical knowledge, beliefs about teaching and learning, and use of resources, the three individual teacher outcomes illustrated in my conceptual framework. I also asked the teachers about their perceived learning related to the group participation. Surveys of the teachers further helped to examine evidence of individual changes in mathematical content knowledge. A case study helped me to investigate this teacher group in depth and within the real-world context of their own school. This research expands the knowledge base of U.S. Lesson Study by adding to the limited number of case studies currently available (Lewis, Perry, & Murata, 2006).

Descriptive details of this case were important since U.S. Lesson Study practitioners may alter the features of Japanese Lesson Study (Fernandez, Cannon, & Chokshi, 2003; Perry & Lewis, 2008). The advantage for using a case study model was the ability to view the structures of Lesson Study as practiced by a particular group of U.S. educators. In Chapter 4, I described the activities within this U.S. Lesson Study cycle beyond their surface features. Focusing my description of the features of this Lesson Study illuminated the specific influences on instructional improvement for this group of teachers.
Since qualitative case study research values the experiences of individuals, this methodology also helped me to understand the influences of Lesson Study on the individual teachers in this case (Ravitch & Carl, 2016). Often the perspective of teachers is overlooked in administrative decisions about professional development. Their voices about what they need for their own educational growth are often marginalized (Anderson, Herr, & Nihlen, 2007). A qualitative research case study approach, using observation and individual interviews, offered an opportunity to listen to teachers’ perspectives engaging in a practice within their own school. My choice of the qualitative approach aligned with my belief that teachers’ perspectives are a valuable resource into how schools could improve and institutionalize a culture of ongoing improvement.

**Research Site**

This study was conducted over a period of eight months in one site, Bernardsville Middle School in Bernardsville, New Jersey. I chose my local school setting for this research study in order to understand how teachers conducted Lesson Study within the site of their own practice. School-based Lesson Study, as opposed to regional or district-wide, is the most common form of Lesson Study practiced in the United States (Perry & Lewis, 2008). Since Lesson Study is a job-embedded form of professional learning, I believe it is important to examine Lesson Study in its intended practice setting (Lewis & Hurd, 2011; Yoshida, 1999). Examining the school-based setting also connects to my theoretical framework since I was interested in understanding teacher learning via theories on sociocultural learning, or learning within the social context. Investigating the impact of Lesson Study as a form of school-based professional
learning was my purpose in this research.

Another reason I chose this site is because I am looking to improve the teacher learning practices at my own location. I am the Assistant Superintendent of Curriculum and Instruction for the Somerset Hills School District, which includes this site of Bernardsville Middle School. Therefore, I am studying my own school. Anderson, Herr, and Nihlen (2007) suggest that school-based inquiry is best done by those that have a stake in the problem under investigation. I wanted to share the insights and observations of the teachers, those that work in the classroom. Cochran-Smith and Lytle are leaders in explaining the value of educator practitioner expertise (2009). I believe that practitioner research can inform the broader academic research and influence school change, as I believe that Lesson Study as teacher research may be able to influence classroom change.

Bernardsville Middle School (BMS), with 581 students, in Bernardsville, NJ, was the site for my research on the topic of Lesson Study. It is one of three schools in the Somerset Hills School District, which enrolls 2,014 students (shsd.org, 2017). BMS, a grade 5 through grade 8 suburban school, serves mostly white students (73.3%), followed by Latinx students (18.3%). This school district in central New Jersey ranks high academically as compared to other public schools in New Jersey and throughout the country (Newsweek, 2016; Schlager, 2016). This district also is classified high in socio-economic status, being an “I” district, the second highest level out of ten levels in socio-economic status by the New Jersey Department of Education.

**Participants**

The **middle school mathematics team** at Bernardsville Middle School was chosen
specifically over the other Lesson Study teams in my school district for several reasons. First, this group has been practicing Lesson Study for a few years. The group has created a culture of working together. Also, this group represented a range of Lesson Study experiences. Some participants were new to Lesson Study and new to teaching. Others had a few years of experience implementing Lesson Study at this school. A few teachers had joined the New Jersey Lesson Study Group to try cross-district Lesson Study. The teacher most experienced in Lesson Study was one who traveled to Japan to learn about the origin of this practice. Finally, the teachers at this school and mathematics supervisor were enthusiastic by the opportunity to reflect and gain insight. These qualities motivated my choice of the middle school mathematics team as the study subjects. (See Table 3.1.)

As the K-12 Assistant Superintendent of the Somerset Hills School District from 2010 to present, I introduced Lesson Study as a professional development model to all teachers in the district. I organized the initial workshop on Lesson Study for the teachers in 2010. Dr. Makoto Yoshida, a local author and expert on Lesson Study, explained the method to the teachers at this workshop. The next year, a volunteer group of elementary teachers decided to form a Lesson Study team in 2011 in order to explore the possibilities of this new model of teacher learning. In 2013, the district received a National Science Foundation grant to explore Lesson Study with a group of Grade 3-6 teachers of math. This group attended two week-long summer trainings on teaching math through problem solving and Lesson Study. These sessions were facilitated by lead U.S. math Lesson Study researchers, Dr. Tad Watanabe, Dr. Akihiko Takahashi, and Dr. Catherine Lewis. The Somerset Hills teacher group returned to practice a cycle of Lesson Study focused on math problem solving. Takahashi and Lewis later published their findings in an article in
Since this interaction with Lesson Study experts, the middle school math teachers at Bernardsville Middle School have been committed to conducting Lesson Study. This department has presented a research lesson each year since 2013. Three of the math teachers have attended the New Jersey Lesson Study Group meetings and participated in cross-district planning teams. Many of the teachers have observed research lessons in other districts including Greenwich Connecticut Japanese School, West Essex New Jersey High School, Madison New Jersey School District, and Harlem Village Academy New York.

I had the opportunity over the years to be involved in the planning of many of the research lessons at my school district and through the New Jersey Lesson Study Group. I attended numerous open houses with the teachers. As the school leader in charge of curriculum and instruction, I have been involved in supporting the Lesson Study work in Bernardsville Middle School. I am familiar with all the study participants, having observed their classrooms and led their meetings. I relied on my established relationship with teachers at Bernardsville Middle School to recruit participants for this study.
<table>
<thead>
<tr>
<th>Teacher (Pseudonym)</th>
<th>Number of Years of Teaching Experience</th>
<th>Current Teaching Position</th>
<th>Highest College Degree and Area of Study</th>
<th>Prior Lesson Study Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>4 years, taught grade 5 math</td>
<td>Grade 5 Mathematics</td>
<td>B.A. Mathematics</td>
<td>Part of school-based planning team for four years; Observed one research lesson in another district</td>
</tr>
<tr>
<td>Brenda</td>
<td>4 years, taught grade 5-7 math</td>
<td>Grades 5-7 Mathematics</td>
<td>B.A. Mathematics Education</td>
<td>Member of NJ Lesson Study Group for one year; Part of school-based planning team for four years; Teacher for one research lesson</td>
</tr>
<tr>
<td>Claire</td>
<td>7 years, taught grades 6-7 math</td>
<td>Grade 7 Mathematics</td>
<td>B.S. in Mathematics Education</td>
<td>Member of NJ Lesson Study Group for one year; Two weeks of training in Chicago; One week visit to Japan to observe Lesson Study; Observed many research lesson outside of district; Part of school-based planning team for five years; Teacher for one research lesson</td>
</tr>
<tr>
<td>Dan</td>
<td>11 years, taught grades 6-8 math</td>
<td>Grades 6 &amp; 8 Mathematics</td>
<td>M.S. Mathematics Education</td>
<td>Observation of research lessons at one –day workshop at Greenwich Japanese School</td>
</tr>
<tr>
<td>Ethan</td>
<td>9 years, taught grades 7-8 mathematics</td>
<td>Grade 8 Mathematics</td>
<td>M.A. Education B.A. Mathematics</td>
<td>Part of school-based planning team for five years; Observed research lessons at one –day workshop at Greenwich Japanese School</td>
</tr>
<tr>
<td>Farrah</td>
<td>27 years, taught K-8 many subjects</td>
<td>Grades 5-8 Mathematics</td>
<td>M.S. Mathematics Education</td>
<td>One week training in Chicago; Part of school-based planning team for three years</td>
</tr>
<tr>
<td>Gina</td>
<td>3 years, special education grades 5-8 math</td>
<td>Grades 5-7 Mathematics for Special Education Students</td>
<td>B.A. Special Education with some mathematics courses</td>
<td>No experience</td>
</tr>
<tr>
<td>Facilitator</td>
<td>7 years, taught grades 9-12 math; Supervisor 4 years</td>
<td>Supervisor of Math, Science, and Technology K-12</td>
<td>M.S. Mathematics Education</td>
<td>Teacher-member of a school-based planning team for 7 years; Facilitator of this school-based planning team for four years; Observed many research lessons; 2-year member of NJ Lesson Study group</td>
</tr>
</tbody>
</table>
Sampling

Since this is a study of the middle school math teachers in my own school, all the participants in this study were drawn from Bernardsville Middle School. I used convenience sampling to find available and interested participants. Convenience sampling is defined as a way to draw participants by selecting people due to ease of accessibility (Ravitch & Carl, 2016). A risk is that the sample may not accurately represent the population at large, since it would be composed of only those who volunteer. I reached out to those that fit my selection criteria to see who was interested in participating. In the end all seven teachers from the pool of seven possible teachers volunteered to participate in this study. These participants generally represented a typical group of math teachers from New Jersey, but with a higher than average experience in Lesson Study. The mathematics supervisor also participated in the Lesson Study team, but only as a facilitator of the meetings. (See Table 3.1.)

Selection Criteria

The individual participants in this study were chosen based on the school site of which they were a part, Bernardsville Middle School. All participants taught mathematics at this middle school, including five traditional math classroom teachers, one math special educator, and one math support teacher. (See Table 3.1.) The participants agreed to join the middle school math Lesson Study group for the 2016-2017 school year. They had a range of Lesson Study experiences prior to entering the study. They all agreed to be involved in the planning, teaching, and observing of the research lesson in order to complete a full cycle of Lesson Study. I collected data from this one complete cycle of
the Lesson Study process.

**Data Collection**

My case study research with analysis of teacher talk investigated Lesson Study and teacher learning by following a set of designated protocols in order to collect data. I used Yin’s (2014) *Case Study Research: Design and Methods* book to guide my data collection and analysis, and to follow a clear set of procedures. I collected data through three sources: observations with audio recordings of meetings, interviews of participants, and surveys of participants. Through these three data sources, I examined the teacher learning through four categories outlined my conceptual framework: mathematical knowledge, beliefs about teaching and learning, use of teaching resources, and participation in the social practice.

The data collection occurred over an eight-month period. I began by reaching out to possible participants during Month 1, November 2016. Through convenience sampling, I recruited any middle school teacher of math who volunteered. Details of the terms of the research were conveyed via email and in person. Thirty to forty-minute individual interviews, one per participant, were scheduled for Month 3 and Month 8, January 2017 and June 2017. During-school and after-school interview times were available to allow for various teachers’ schedules. Teachers met throughout Months 3 through 7 to conduct a full cycle of Lesson Study. I wrote researcher memos after each final interview and after each Lesson Study meeting to retain all observed data. Recordings of each interview and meetings of the Lesson Study team were professionally transcribed. I reviewed the coded data for analysis throughout the Summer and Fall of
Data Sources Connected to Conceptual Framework

Data was collected through the meetings, interviews, and surveys, as a basis to explore my conceptual framework of teacher learning in Lesson Study. The following chart illustrates my data sources as connected to my conceptual framework of the categories for teacher learning. (See Table 3.2.) For example, the meeting observations provided the primary source for evidence of the changes in the participation in the social practice. However, the interviews were also used to support this data. The interviews were used to collect data on the teachers’ changes in beliefs on teaching and learning, confidence in mathematical knowledge, and use of resources. Though, data collected from the meetings was also used as supportive data for these categories. The pre- and post-surveys addressed the possible changes in teachers’ mathematical content knowledge.

Table 3.2: Categories for Teacher Learning and Data Sources

<table>
<thead>
<tr>
<th>Four Categories for Teacher Learning</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical content knowledge</td>
<td>Main: Interviews, Surveys</td>
</tr>
<tr>
<td></td>
<td>Supporting Source: Meetings</td>
</tr>
<tr>
<td>Beliefs about teaching and learning</td>
<td>Main: Interviews</td>
</tr>
<tr>
<td></td>
<td>Supporting Source: Meetings</td>
</tr>
<tr>
<td>Use of resources</td>
<td>Main: Interviews</td>
</tr>
<tr>
<td></td>
<td>Supporting Source: Meetings</td>
</tr>
<tr>
<td>Participation in the social practice</td>
<td>Main: Meetings</td>
</tr>
<tr>
<td></td>
<td>Supporting Sources: Interviews</td>
</tr>
</tbody>
</table>
Observations of Meetings

My observations of Lesson Study planning meetings were the main source of the data for understanding the changes in the group as the members participated in the social practice, one area of my conceptual framework. I gathered this data through audio recordings and field notes. I transcribed the audio recordings of the investigation and planning meetings, the taught research lesson, and the post-lesson reflection meeting. The audio recordings were professionally transcribed in order to collect conversations verbatim.

The teachers attended ten meetings as part of this one cycle of Lesson Study: four investigation meetings, five planning meetings, and one research lesson combined with post-lesson reflection meeting. (See Table 4.1 in Chapter 4.) The detailed data collected from all observations was used to identify, integrate, and differentiate the evidence of teachers’ learning.

Throughout these ten meetings I collected data on the teachers’ verbal participation, their amount of participation and their role in the group. First, I counted the amount of verbal contributions made my each member at each meeting. I created a chart recording the number of contributions of each participant at each meeting as compared to the other members. (See Figure 5.1.) From the transcripts of the meetings, I noted the changes in the quantity of these verbal contributions of each member as the meetings progressed from the first meeting to the final tenth meeting. I then collected data on comments that suggested that members took on roles, or positions, in the group discussion. For example, some teachers made comments that led the group to the next step in the Lesson Study process and some teachers helped the group understand the
curriculum. Data was identified throughout the ten meetings that related to members finding various group roles.

Next, I collected data on the nature of the teachers’ talk within the meetings. I identified examples of disagreement within the group. I charted when these moments of dissonance occurred within the ten meeting cycle. I also collected data on comments relating to resource materials throughout the Lesson Study meetings, noting the nature of these contributions. In addition, I found that three terms were commonly used by members throughout the meetings. I collected data on these shared terms, counting who used these terms and how often the term was used in each of the ten meetings. (Figure 5.1 and Chapter 5 explores these findings.)

Then, I collected data indicative on the members’ commitment to the group. This included collecting data on the attendance at group meetings and the scheduling of the additional meeting time. I also collected data on who in the group engaged in preparations relating to this Lesson Study cycle outside of meeting time and for what purpose.

Finally, I collected data on the group’s use of questions in their discussions. I identified comments throughout the ten meetings that suggested curiosity or asked a direct question. I charted these inquiry comments and questions throughout the ten meetings to allow for analysis. (Chapter 5 presents the findings on the group outcomes.)

**Interviews**

Data from the initial and final interviews with teachers provided the evidence of how the seven teachers perceived the impact of the Lesson Study experience on their
individual learning, another area of my conceptual framework. I used two semi-structured interviews as another data source of this qualitative case study. The two interviews per participant, one at the beginning of the Lesson Study activity and one after the cycle was completed, were conducted individually and audio recorded for professional transcription. (See Table 3.5 for individual data collection summary.) Interviews provided individualized data on each teacher, rather than the group (Ravitch & Carl, 2016, p. 146). Maxwell (2013) discussed the use of a semi-structured interview process in order to create a basic plan for uniformity between interviews while allowing the possibility for follow-up questioning. I facilitated each interview through “customized replication” (Ravitch & Carl, 2016, p. 147). I asked each participant the same main questions, followed by individual probing questions. Each interview lasted a full teacher-planning period of 30-40 minutes. (See Appendix 1 and Appendix 2 for interview matrices.)

First, interviews provided data related to changes in the individual teachers’ confidence in the mathematics content of this Lesson Study, one category of learning represented in my conceptual framework. In initial and final individual interviews with the seven teachers I asked each teacher how confident she/he was with the mathematical topic of study, Grade 8 linear equations. They rated themselves with a 1-5 scale, with five being the highest level of confidence on the mathematical topic. In the final interviews, I again asked each participant the same question with the same scale. In the final interviews, I followed up these self-rankings of confidence in mathematical knowledge with the question, “Why do you score yourself with this number?” I also asked the teachers during their final interview, “Did your participation in Lesson Study impact your
confidence in the mathematical content? If so, how?” This provided further data on the individual teachers’ confidence in the mathematical content. *Table 6.1* and Chapter 6 present the changes in the initial to final self-scores related to confidence in mathematical knowledge.

Interviews with teachers also provided data related to changes in beliefs about teaching and learning, a second category of learning. To collect this data in the initial and final individual interviews with the seven teachers, I asked questions about their perceived learning related to their teaching beliefs from their participation with others in Lesson Study. Initially, before the Lesson Study process, I asked each teacher about her/his view of best teaching practices. In the final interviews, after the Lesson Study cycle was completed, I asked each teacher if he/she perceived any changes in their beliefs about teaching and student learning from the Lesson Study experience.

Additionally, interviews with teachers provided the data for me to analyze if the Lesson Study process had an impact on individual teachers’ learning to use their teaching resources. In initial and final individual interviews with the seven teachers, I asked questions about their perceived learning as related to their use of teaching resources. Initially, before the Lesson Study process, I asked each teacher which resource materials they typical use and which they find most helpful. In the final interviews, after the Lesson Study cycle was completed, I asked each teacher how they used resources in the Lesson Study process. I also asked if they perceived any influence on their future use of resource materials. The interviews with teachers offered the data of the influence of Lesson Study on use of resources, another category of learning in my conceptual framework.

Finally, I asked the teachers about their perceived group learning from
participating in the social practice. These questions helped extend my understanding of
the impact of the group learning on the individual teachers. Initially, I asked the each
teacher about her/ his typical interactions with colleagues and the benefits of these
interactions. In the final interview, I asked each teacher about the collegial interactions
during the Lesson Study participation and if they had learned from their colleagues.
Later, Chapter 6 will present my findings from these interviews related to the four
category of learning in my conceptual framework.

**Surveys**

I surveyed the teachers involved in this research study at the beginning of the first
Lesson Study meeting and at the end of the tenth and final Lesson Study meeting. The
purpose of the surveys was to assess the individual teachers’ mathematical content
knowledge before and after the Lesson Study cycle. The teachers used thirty minutes of
two scheduled meeting times to respond to the two surveys. (See Table 3.5 for summary
of data collection.) Responses to the survey questions provided the data on the teachers’
mathematical content knowledge.

The surveys’ questions were designed to capture teachers’ depth of understanding
of the mathematical content in three areas discussed by Ball, Thames, and Phelps’
(2008): specialized content knowledge (SCK), knowledge of content and students (KCS),
and knowledge of content and teaching (KCT). These three areas of mathematical
knowledge were the focus in my data collection and in my later analysis. I chose these
three areas of content knowledge because I believed them to be important areas of teacher
knowledge for lesson design and reflection, two essential phases in Lesson Study. I did
not design questions related to Ball, Thames, and Phelps’ other areas of mathematical knowledge for teaching, like horizontal content knowledge and knowledge of content and curriculum. Though this knowledge is also important for teaching, I believed this knowledge might need to be built over more time and would be less likely captured in one cycle of Lesson Study.

I examined the changes in the teachers’ mathematical knowledge through the two surveys. As the teachers began the Lesson Study cycle, I administered an initial survey asking two main mathematics questions to understand each teacher’s mathematical knowledge. (See Appendix 3 for survey.) The first question in the survey asked the teacher to write a story problem for students to solve using a systems of equations. I created this question similar to Liping Ma’s research (1999), which was also assessing teachers’ content knowledge as related to the work of Ball, Thames, and Phelps (2008). The second question in the survey presented a system of equations problem and asked five sub-questions about this problem, two related to student learning and three related to teaching. I took this example problem directly from the teachers’ classroom curriculum, *Connected Mathematics Program*. I did this to design a question most linked to the work of these teachers. Sub-questions ‘a’ and ‘b’ assess the teacher’s content knowledge related to anticipating student responses and mistakes, a typical part of lesson planning in the Lesson Study practice and linked to KCS. Sub-questions ‘c’, ‘d’, and ‘e’ assess the teacher’s content knowledge of teaching strategies to address student learning, (KCT).

I list these main questions from the survey and the sub-questions in Table 3.3. I linked the teachers’ responses to three categories for teachers’ mathematical knowledge I focused on, SCK, KCS, and KCT. After the Lesson Study cycle was completed, I then
repeated the same questions in a final survey of these teachers to identify any changes in their mathematical knowledge.

Table 3.3: Teacher Survey Linked to Three Areas of Mathematical Knowledge

<table>
<thead>
<tr>
<th>Question one</th>
<th>SCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagine you are teaching solving simultaneous linear equations, otherwise called ‘systems of linear equations’. To make this meaningful for students, sometimes teachers try to come up with a real-world situation or story-problem to show the application of some particular piece of content. Please come up with a problem for your students on this math content. What would you say would be a good story or model for this problem?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question two – Problem</th>
<th>SCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melissa and Trevor sell candy bars to raise money for a class field trip. Trevor sells one more than five times as many as Melissa sells. Together they sell 49 candy bars. Find the number of candy bars each student sells.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-question a</th>
<th>KCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the ways students may try to solve this problem?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-question b</th>
<th>KCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>What mistakes do you think students may make?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-question c</th>
<th>KCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would you address those mistakes?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-question d</th>
<th>KCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the goals of asking students to solve this type of problem?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-question e</th>
<th>KCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the important ideas that you want students to understand about solving systems of equations?</td>
<td></td>
</tr>
</tbody>
</table>

I systematically scored each teacher’s responses to the survey on a 1 through 5 scale, five being the highest level of overall mathematical knowledge. I reviewed each teacher’s responses as related to three areas of teacher learning suggested by Ball, Thames, and Phelps (2008): SCK, KCS, and KCT and the descriptors of each score shown in Table 3.4. I analyzed the survey responses to the mathematics questions. I noted changes in the survey responses, pre- and post- Lesson Study. The findings from the surveys will be explained in Chapter 6.
Table 3.4: Summary of the Descriptors for Scores 1-5 on the Surveys

<table>
<thead>
<tr>
<th>Score</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Question 1: Incorrect answer and Questions 2a and 2b: Zero or one example(s) of possible student responses and Questions 2c, 2d, and 2e: Zero or one example(s) of teaching strategies or goals for teaching</td>
</tr>
<tr>
<td>2</td>
<td>One of the following three areas- Question 1: Correct answer or Questions 2a and 2b: At least two possible student responses or Questions 2c, 2d, and 2e: At least two examples of teaching strategies or goals for teaching</td>
</tr>
<tr>
<td>3</td>
<td>One of the following three areas and a partial response to a second area- Question 1: Correct answer or Questions 2a and 2b: At least two possible student responses or Questions 2c, 2d, and 2e: At least two examples of teaching strategies or goals for teaching</td>
</tr>
<tr>
<td>4</td>
<td>Two of the following three areas- Question 1: Correct answer or Questions 2a and 2b: At least two possible student responses or Questions 2c, 2d, and 2e: At least two examples of teaching strategies or goals for teaching</td>
</tr>
<tr>
<td>5</td>
<td>Question 1: Correct answer and Questions 2a and 2b: More than three examples of possible student responses and Questions 2c, 2d, and 2e: More than three examples of teaching strategies and clear goals for teaching</td>
</tr>
</tbody>
</table>

I scored teachers who could not offer a correct problem in question one, offered limited insight on students’ responses in question two, and offered minimal insights on teaching to address student learning or the goals, a score of ‘1’ because this showed a limited amount of SCK, KCS, and KCT. I scored teachers who could create a correct problem of their own in question one, offered multiple insights on student responses in question two, and offered clear goals for teaching and addressing student learning, a score of ‘5’ because this showed mathematical knowledge in all three areas. For partially correct responses, I scored teachers on a range of ‘2’ through ‘4’. ‘4’ being responses revealing knowledge in at least two of the three areas, ‘3’ being responses revealing knowledge in one area and partially in a second, and ‘2’ being responses revealing
knowledge in only one of the three areas of mathematical knowledge. *Table 3.4*
summarizes the descriptors for each score for the teachers’ surveys.

**Table 3.5: Summary of Data Collected for Individual Participants**

<table>
<thead>
<tr>
<th>Data Instrument</th>
<th>Schedule</th>
<th>Time Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Survey</td>
<td>During first half-hour of the first Lesson Study planning meeting</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Initial Interview</td>
<td>One week before Lesson Study meetings began</td>
<td>30-40 minutes</td>
</tr>
<tr>
<td>Final Survey</td>
<td>The day after the Research Lesson was taught</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Final Interview</td>
<td>The week after the Research Lesson was taught</td>
<td>30-40 minutes</td>
</tr>
</tbody>
</table>

**Data Analysis and Coding**

I began the data analysis process by defining the criteria by which I would interpret my findings regarding teacher learning. My theoretical framework, literature review, conceptual framework, and theoretical model of teacher learning helped to narrow my foci of the study. I began by defining the four categories I used in my conceptual framework to understand teacher learning: mathematical knowledge, beliefs about teaching and learning, use of resources, and participation in the social practice. However, these categories were refined and reworked as I moved through the iterative process of analysis. For example, at one point I had a fifth category of teacher learning, “collegial interactions”, but I later realized that I needed to make “collegial interactions” a sub-category under “participation in the social practice” because the two had much overlap.
Coding

Coding was the main strategy to arrange the data into four teacher-learning categories related to my research question and conceptual framework: mathematical content knowledge (MK), beliefs about teaching and learning (B-T&L), use of resources/materials (RM), and participating in the social practice (PSP). I twice coded the transcribed data from the meetings and interviews. I considered my initial coding of the transcribed meeting data as a “first pass” through the data. I began by working with some a-priori codes developed as a part of my guiding research questions. In this first round, I hand-coded the data with some deductive macrocodes based on the categories of teacher learning identified in my first research question. I looked for evidence in the participants learning related these categories. These codes were refined as my analysis progressed.

I then re-coded the data as I entered the completed transcripts into Atlas-ti, qualitative research software. The use of Atlas-ti allowed me to better examine the large amount of data and look for patterns and convergence. I refined my macrocodes into related sub-codes as the data analysis progressed. A clearer vision of coding was emerging as I continued the analysis. I worked to develop both inductive and deductive codes as I reviewed the textual data. As I progressed, I took care to focus on the data that clearly linked to my research question, my conceptual framework, and my coded definitions. The final coding chart explains the codes used and their definitions. (See Coding Table 3.6.)

I used Atlas-ti to examine patterns in the data. The software allowed me to examine the data in detail by running comprehensive reports. For example, I ran a report
to count the number of times blackboard use was mentioned by members. Another example was frequency of using a shared term, like “teaching through problem”. This report also allowed me to assess who made these comments. This detailed analysis helped me confirm overarching patterns with refined data.

**Meeting transcripts and coding.** Coding of the meeting transcripts helped identify patterns in the group outcomes. (The findings for these group outcomes will be explored later in Chapter 5.) For example, as I began to notice the teachers taking on different roles within the group, I began to code comments relating to these various roles. I found that some comments were associated with the role of teacher-leader (TL), some with curriculum expertise (RM-CMP), and some with participating in the social practice including joking (Psp). (See Coding Table 3.6 for definitions.) The coding of the teachers’ social conversations and joking (Psp) compared to the evidence of disagreement (CI-Dis) helped reveal the changes in the nature of the group talk among the teachers.

I also found that the teachers made many comments about the resource materials in the meetings. I coded these comments to better understand the nature of this kind of talk. Some comments about the resource materials were related to the study of the classroom text (RM-CMP) and some comments referenced an alteration to the materials (RM-A). This coding led to an analysis of the nature of the teachers’ talk about the resource materials as the Lesson Study meetings progressed.

Coding supported the identification of shared terms, or a common language, used by members in the group meetings (Psp-CL). The terms of “board space” (RM-BS), “teaching through problem solving” (B-T&L), and “anticipating student responses” (CI-AR) emerged through repeated coding. Finally, coding revealed evidence in how the
group moved to an inquiry stance towards their practice. As teachers began to ask more questions of each other in the lesson planning, I coded these questions (CI-LP-Q). As the group meetings progressed many comments included evidence of an inquiry stance (B-T&L-IS). Coding facilitated my ability to capture and analyze these data patterns in the group conversations held during Lesson Study meetings.

I coded the meeting transcripts along the way as the Lesson Study process took place. Doing so helped me to refine my coding and formulate probing questions for the final interviews. In the later interviews, I asked individual teachers about specific changes I observed in the Lesson Study meetings. For example, I coded examples of dissonance during the Lesson Study meetings and asked the individual teachers about these instances.

**Interviews and coding.** My next step for data analysis was to code each initial interview before I conducted and then coded the final interview with each teacher. This allowed me to ask the teachers during their final interviews probing questions to provide further explanations of observed evidence from the Lesson Study meetings. The interviews offered the evidence of what the individual teachers’ perceived they had learned from the Lesson Study cycle, offering individual outcomes of learning. With this more complete dataset, I was able to look for further evidence of similarities and differences in my data (Maxwell, 2013).

I used the same coding strategies and tables, as I did with the meetings transcripts, to arrange the data into the categories for teacher learning from my conceptual framework. (See Coding Table 3.6.) The questions I asked during the initial interviews with the teachers, before the Lesson Study meetings began, were coded as baseline
evidence of each participant’s teaching experience (BG), mathematical knowledge background (BG-M), previous Lesson Study experience (BG-LS), and general beliefs about teaching and learning (B-T&L).

The follow-up questions during each teacher’s final interview were coded to identify the perceived changes in teacher learning obtained through the Lesson Study experience. I coded comments from the teachers that revealed evidence that the Lesson Study experience influenced teacher learning. I linked this evidence to my four categories of teaching learning in my conceptual framework: mathematical knowledge (MK-I), beliefs about teaching and learning (B-T&L-I), resource materials (RM-I), and collegial interactions (CI-I).

I used more specific codes to further refine my interview data within these categories of teacher learning. Evidence related to exploring or building mathematical knowledge was coded (MK). I also coded evidence that identified increased knowledge about the specific mathematical content of this Lesson Study, systems of equations (MK-SE). In the category of beliefs about teaching and learning, I coded evidence suggesting an inquiry stance towards practice (B-T&L-IS) and analyzing student learning (B-T&L-AS). In addition, comments from the teachers revealing perceived changes in use of specific resources were coded. This included the use of the Connected Mathematics Program curriculum (RM-CMP), use of manipulatives (RM-man), and use of the board space (RM-BS).

The teachers also shared perceived benefits and obstacles of Lesson Study through the interviews. The benefits of Lesson Study were coded as general benefits (BEN-LS), benefits from collegial interactions (BEN-CI), and benefits from observing a
research lesson (BEN-Obs). The teachers perceived obstacles to Lesson Study and its continued practice at their school (Ob-LS). The interviews provided the teachers an opportunity to share their perspective on learning through Lesson Study. Coding these interview comments facilitated my ability to capture and analyze data patterns in individual outcomes of learning.

**Table 3.6: Coding Table - Codes Used for Data**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>Background</td>
<td>Background details about the participant’s teaching experience</td>
</tr>
<tr>
<td>BG-M</td>
<td>Background-Mathematics</td>
<td>Background details on participant’s mathematical learning as related to their math knowledge</td>
</tr>
<tr>
<td>BG-LS</td>
<td>Background-Lesson Study</td>
<td>Background on participant’s Lesson Study experience, including within the school district</td>
</tr>
<tr>
<td>KO</td>
<td>Knowledgeable Other</td>
<td>Participants’ interactions with Lesson Study experts or researchers, also called Knowledgeable Others</td>
</tr>
<tr>
<td>RL</td>
<td>Research Lesson</td>
<td>Teacher’s comments about or reflections on the research lesson</td>
</tr>
<tr>
<td>BEN-LS</td>
<td>Benefit-Lesson Study</td>
<td>Evidence suggesting general benefits of participating in Lesson Study or impact on the participant</td>
</tr>
<tr>
<td>Ob-LS</td>
<td>Obstacle- Lesson Study</td>
<td>Obstacle to engaging in effective Lesson Study</td>
</tr>
<tr>
<td>Fac</td>
<td>Facilitator</td>
<td>Comments made by the Lesson Study facilitator to engage the group in participating in the social practice</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
<td>Evidence</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>TL</td>
<td>Teacher Leader</td>
<td>Evidence suggesting teacher acting as a leader to engage the group in participating in the social practice</td>
</tr>
<tr>
<td>MK</td>
<td>Mathematical Knowledge</td>
<td>Evidence of teacher exploring or building math knowledge</td>
</tr>
<tr>
<td>MK-SE</td>
<td>Mathematical Knowledge-Systems of Equations</td>
<td>Evidence of teacher exploring or building math knowledge on the research topic - systems of equations</td>
</tr>
<tr>
<td>MK-C</td>
<td>Mathematical Knowledge-Conversations</td>
<td>Evidence of teachers discussing the mathematical concepts within the lesson</td>
</tr>
<tr>
<td>MK-I</td>
<td>Math Knowledge-Influence</td>
<td>Evidence suggesting influence of Lesson Study on teacher’s mathematics content knowledge</td>
</tr>
<tr>
<td>B-T&amp;L</td>
<td>Belief - Teaching and Learning</td>
<td>Evidence of teacher’s beliefs about teaching and learning</td>
</tr>
<tr>
<td>B-T&amp;L-I</td>
<td>Belief - Teaching and Learning-Impact</td>
<td>Evidence suggesting influence of Lesson Study on teacher’s beliefs about teaching and learning</td>
</tr>
<tr>
<td>B-T&amp;L-IS</td>
<td>Belief - Teaching and Learning- Inquiry Stance</td>
<td>Evidence of the teacher presenting an inquiry stance towards their work of teaching</td>
</tr>
<tr>
<td>B-T&amp;L-AS</td>
<td>Belief - Teaching and Learning- Analyzing Student</td>
<td>Evidence of the teacher’s analysis of student thinking or responses</td>
</tr>
<tr>
<td>LG</td>
<td>Lesson Goal</td>
<td>Evidence of expressed value in the lesson goal of the research lesson as related to beliefs about teaching and learning</td>
</tr>
<tr>
<td>RM-CMP</td>
<td>Resource Materials-Connected Mathematics Program</td>
<td>Evidence of teacher’s use and study of the school’s adopted mathematics resource materials (Grade 6-8 Connected Mathematics Program), including reviewing previous or future learning within the curriculum</td>
</tr>
<tr>
<td>RM-A</td>
<td>Resource Materials-Alteration</td>
<td>Evidence of teacher’s alteration of the school’s resource materials</td>
</tr>
<tr>
<td>RM-man</td>
<td>Resource Materials-Manipulatives</td>
<td>Evidence of teacher’s use and study of math manipulatives or classroom presentation tools as resource materials</td>
</tr>
<tr>
<td>RM-BS</td>
<td>Resource Materials-Board Space</td>
<td>Evidence suggesting awareness of board space usage as a part of the classroom resource material (Bansho), including influence of Lesson Study engagement on board space usage</td>
</tr>
<tr>
<td>Psp</td>
<td>Participating in social practice</td>
<td>Evidence of the teacher’s general participation in the social practice, social conversations and joking</td>
</tr>
<tr>
<td>Psp-CL</td>
<td>Participating in social practice-Common Language</td>
<td>Evidence suggesting a common language use among teachers as they participate in social practice</td>
</tr>
<tr>
<td>CI</td>
<td>Collegial Interactions</td>
<td>Evidence of teacher’s collegial interactions with other participants</td>
</tr>
<tr>
<td>CI-AR</td>
<td>Collegial Interactions-Anticipating Responses</td>
<td>Evidence of teacher’s collegial interactions (discussions) related to anticipating students’ responses to the learning activity or problem</td>
</tr>
<tr>
<td>CI-Dis</td>
<td>Collegial Interaction-Disagreement</td>
<td>Evidence of disagreement or dissonance among teachers in planning the research lesson</td>
</tr>
<tr>
<td>BEN-CI</td>
<td>Benefit-Collegial Interaction</td>
<td>Evidence suggesting benefits of collegial interactions</td>
</tr>
<tr>
<td>CI-I</td>
<td>Collegial Interactions-Influence</td>
<td>Evidence suggesting influence of Lesson Study on collegial interactions</td>
</tr>
<tr>
<td>CI-LP</td>
<td>Collegial Interactions- Lesson Plan</td>
<td>Evidence of the teachers working collaboratively to design the lesson plan for the research lesson</td>
</tr>
<tr>
<td>CI-LP-Q</td>
<td>Collegial Interactions- Lesson Plan- Questions</td>
<td>Evidence of the teachers working collaboratively to design the teacher questions in the lesson plan</td>
</tr>
</tbody>
</table>
Evidence suggesting benefits for observing others teach (research lesson), this relates to collegial interactions

**Researcher Memos**

As suggested by Ravitch and Carl (2016), I used researcher memos as a way to analyze the collected observations and interview data. After each observation of meeting, I wrote a memo about the themes that had emerged. I read the initial and final interview of each participant and wrote a memo of my analysis on specific learning linked to my conceptual framework and categories of teacher learning. These researcher memos facilitated my analytical process through conflicting messages, discrepant data, and negative cases. This was done to foster an integrative analysis of the data (Maxwell, 2013).

**Data Charts**

In order to observe trends in the data over time, I created six data analysis charts related to my categories of teacher learning. I created one chart to examine the changes in the participation level of each member over the ten meetings. Next, I charted data on each teacher collected through the initial interview as compared to the data collected in the final interview. These data were organized in three charts relating to beliefs about teaching and learning, use of resources, and patterns in collegial interactions (a sub-category for participation in the social practice). I also created a chart to examine the changes in the teachers’ mathematical knowledge from the initial survey to the final
survey. Another chart listed the topics discussed among the participants as they interacted at each of these meetings. These charts helped me see what changed in the group and what each individual learned throughout the Lesson Study process.

All final data was viewed and compared based on my prior conjectures about how Lesson Study impacts teachers’ learning. The completed analysis showed attention to evidence including alternative interpretations (Yin, 2014). With all the data from observations, interviews, and surveys, I used qualitative analysis to conceptualize what was going on and how teachers had been influenced by the Lesson Study experience.

**Researcher Roles: Issues of Trustworthiness and Validity**

My interview methods and observation procedures enabled me to collect the data for an understanding of how Lesson Study influenced teachers’ learning and how the teachers perceived this learning. In order to avoid possible threats to the validity of my conclusions, I considered issues of trustworthiness. I saw two design elements in my research that needed to be considered when examining possible threats to validity: studying my own school and engaging in case study research.

**Study of Own School Validity**

Studying my own school made me an *insider* in my native setting rather than a disconnected outside observer. Anderson, Herr, and Nihlen (2007) suggested that academic researchers have sometimes viewed this insider practitioner research critically. Researchers may believe practitioner research to be more open to threats of validity than more controlled forms of research. Therefore, I used inquiry criteria to guard against
threats to validity.

I used the criteria suggested by Anderson, Herr, and Nihlen (2007) in their book, *Studying Your Own School*, to collect workable data from my school. I worked to create research that had *outcome trustworthiness*. This meant that my actions would lead to a more accurate understanding of a problem, in this case, improving teacher learning through Lesson Study. I *processed trustworthiness* by framing my problem in a manner that permitted ongoing learning for the school system. I believe that the data I uncovered may help others understand the impact of Lesson Study on teachers’ learning in my own school district. This evidence may help spread the knowledge of Lesson Study to other grades and departments, and possibly to other school districts. Though, I was also open to the possibility that this case study of Lesson Study would not show improvements in teacher learning for this group.

I did this research with *democratic trustworthiness*, since I worked collaboratively with a group of teachers to reflect on their practice. I worked to monitor my research through peer review to create *dialogic trustworthiness*. As suggested by Anderson, Herr, and Nihlen (2007), I sought out others in my setting to play the part of critical peers, to examine alternative explanations of the research data collected. I consulted the outside educators who came to view the research lesson, including the knowledgeable other, Dr. Yoshida.

**Case Study Validity**

Yin (2014) reported that some academics have been critical of case study research due to the possibility of “subjective judgment” (p.46). Therefore, I believe that
case study research must attend to logical research design in order to guard against such subjectivity. I used three of Yin’s (2014) tests for design validity of quality case study research: construct validity, internal validity, and external validity.

To meet the test of **construct validity**, I carefully identified and defined the specific terms and concepts I studied. I identified in my research four categories through which Lesson Study influenced teacher learning as illustrated in my conceptual framework. In the literature review, I have defined these categories such that I can connect specific evidence to teacher learning. I used multiple sources of data, observations of meetings, interviews, and surveys, as suggested by Yin (2014) to increase construct validity.

An addition, I took care to ensure **internal validity** in my research study. When I looked to explain what factors within the Lesson Study process led to teacher learning, I was aware of other factors that could have contributed to this causal relationship. For example, teachers attended a workshop outside of the Lesson Study meetings and could have learned something new in that setting. I addressed threats to internal validity by carefully designing my data analysis. As suggested by Yin (2014), I explored rival explanations as I examined my data.

Finally, I considered **external validity**, the generalizability of the findings. The goal of this study was not to generalize the Lesson Study outcomes of this planning team to other sites of practice. My research design focused on the influences of Lesson Study on one group of middle school math teachers. I was interested in examining the unknown “black box” of teacher learning (Goldsmith, Doerr, & Lewis, 2014, p.25). It was my goal to add to the broader knowledge base with one example of “local proof” of the impact of
Lesson Study on teacher learning in Bernardsville Middle School (Lewis, Perry, & Murata, 2006, p. 6).

**Observation and Interview Validity**

My study included observations of meetings and interviews of study participants. Meeting and interview transcripts were the main parts of my detailed data in understanding what the participation revealed about teachers’ learning throughout their engagement in Lesson Study. A semi-structured protocol of questioning minimized researcher bias by allowing for the discussion of possible influences not considered. I used verbatim transcripts of the recorded meetings and interviews to gain a broad and detailed picture of the evidence (Maxwell, 2013).

**Discrepant Data and Negative Cases**

Field notes, meeting transcripts, interview transcripts, survey data, and researcher memos enabled me to explore all data, even discrepant data and negative cases. I was committed to examining both the supporting and discrepant data in drawing my conclusions and making the needed modifications. Discrepant data included finding that different teachers were influenced by different features of Lesson Study. Lesson Study influenced experienced teachers in different ways compared to newer teachers. Factors other than Lesson Study experience also influenced the teachers’ learning. The design of my study included validity strategies that strengthened the quality of my conclusions. Due to the scope of this this single case study, I was careful when making any external
generalizations about the accounts (Maxwell, 2013). However, what I learned from this case can potentially help other professional learning situations, especially those engaging in Lesson Study.

**Researcher’s Role and Positionality**

My first introduction to Lesson Study was an article by Lewis and Tsuchida (1998) called *A Lesson Like a Swiftly Flowing River*. I was obtaining my degree in Mathematics Leadership in order to become a better professional developer for teachers. I was immediately impressed with the potential for Lesson Study to improve teachers’ skills and empower them to help each other by sharing their knowledge. My belief in Lesson Study only increased over the fifteen years of deepening my understanding and practice of it. I was privileged to travel to Japan in the summer of 2000 with a team of professors from the United States to see Lesson Study, or *Jugyokenkyu* in Japan, as practiced in Japanese schools. I returned with the skills to promote Lesson Study to my educator colleagues in the United States. In addition, with Dr. Makoto Yoshida, an expert researcher on Lesson Study and my Lesson Study mentor, I was a founder of the *New Jersey Lesson Study Group*. The practice of Lesson Study appealed to me for many reasons: it was a collegial professional learning community, it focused on improving teacher knowledge base and practice, and it valued practitioner contributions to the profession. It was also the first time I had seen a professional learning model that had the advantage of classroom teachers as the experts.

It was my conjecture that engaging in collaborative professional learning models like Lesson Study would have some impact on the teachers in this study. I acknowledged
that I came to this research with some positive assumptions about the efficacy of Lesson Study. I came to my rationale through my previous observations and interactions with the teachers in my school. As the Assistant Superintendent for Curriculum and Instruction, I was in charge of the professional development opportunities offered to teachers. I have introduced Lesson Study to all the teachers at my school district. I wrote the grant that allowed some of the teachers to attend workshops on math Lesson Study led by expert researchers on the topic. In addition, I have encouraged the teachers, specifically the middle school math teachers, to attend Lesson Study open houses in other districts and to join the New Jersey Lesson Study Group. The teachers view me as an advocate for the use of Lesson Study in our school district. In order to control for the reactivity of the participants and researcher bias, I chose not to conduct action research. I was not a participant or a Lesson Study facilitator in this study. My only role was to observe the interactions in this case study. I did not interfere with the experience of the participants. Since I could not altogether eliminate my influence as a researcher, I was aware of the affect and worked to understand the data collected. I was consciously looking for evidence that challenged my initial conjecture.
CHAPTER 4: DESCRIPTION OF LESSON STUDY ACTIVITIES

In this chapter, I provide an overview of the activities observed as this group of middle school mathematics teachers progressed through the stages of Lesson Study. The teachers practiced a full Lesson Study cycle by attending to the four consecutive phases of Lesson Study: investigation, planning, research lesson, and reflection. (See Figure 2.2 for Lesson Study phases.) Table 4.1 shows the Lesson Study activities practiced in the ten meetings by the group of teachers in this study.

Table 4.1: The Lesson Study Activities in Meetings 1 through 10

<table>
<thead>
<tr>
<th>Meeting (Total Time)</th>
<th>Lesson Study phase and group activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting 1 (1 hour)</td>
<td><em>Investigation</em></td>
</tr>
<tr>
<td></td>
<td>• Collaboratively brainstormed Lesson Study goals. Including: a goal for student content, a goal for student learning, and a goal for teacher learning</td>
</tr>
<tr>
<td></td>
<td>• Created a schedule of future meetings</td>
</tr>
<tr>
<td>Meeting 2 (1.5 hours)</td>
<td><em>Investigation</em></td>
</tr>
<tr>
<td></td>
<td>• Learned about the Lesson Study cycle from the knowledgeable other</td>
</tr>
<tr>
<td></td>
<td>• Studied the curriculum materials as a group</td>
</tr>
<tr>
<td></td>
<td>• Studied curriculum from previous grades</td>
</tr>
<tr>
<td></td>
<td>• Refined goals for this Lesson Study</td>
</tr>
<tr>
<td>Meeting 3 (1.5 hours)</td>
<td><em>Investigation</em></td>
</tr>
<tr>
<td></td>
<td>• Learned about mathematical content in the text related to student learning from knowledgeable other</td>
</tr>
<tr>
<td></td>
<td>• Reviewed curriculum to determine possible research lesson and focus problem</td>
</tr>
<tr>
<td></td>
<td>• Compared curriculum to other resource materials</td>
</tr>
<tr>
<td></td>
<td>• Discussed the mathematics in the solution algorithm</td>
</tr>
<tr>
<td>Meeting 4 (1 hour)</td>
<td><em>Investigation</em></td>
</tr>
<tr>
<td></td>
<td>• Reviewed curriculum to determine possible research lesson and focus problem linked to identified goals</td>
</tr>
<tr>
<td></td>
<td>• Compared curriculum to other resource materials</td>
</tr>
<tr>
<td></td>
<td>• Developed research lesson and student math problem by using two different resources</td>
</tr>
<tr>
<td></td>
<td>• Discussed the mathematics in the solution algorithm</td>
</tr>
<tr>
<td>Meeting 5</td>
<td><strong>Planning</strong></td>
</tr>
<tr>
<td>-----------</td>
<td>--------------</td>
</tr>
</tbody>
</table>
| (1.5 hours) | - Created lesson plan template  
- Selected problem for research lesson  
- Solved problem collaboratively  
- Discussed anticipated student solutions  
- Discussed lesson plan details: lesson introduction, use of manipulative, presenting student solutions, and partner work |

<table>
<thead>
<tr>
<th>Meeting 6</th>
<th><strong>Planning</strong></th>
</tr>
</thead>
</table>
| (2 hours)  | - Revised lesson plan template  
- Discussed lesson plan details:  
  - teacher questioning  
  - resource materials as tools  
  - choice of words in the problem  
  - time for lesson activities  
  - presenting student solutions  
  - organizing student solutions  
  - important solutions  
  - use of manipulative  
  - partner work  
  - board use |

<table>
<thead>
<tr>
<th>Meeting 7</th>
<th><strong>Planning</strong></th>
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</thead>
</table>
| (1 hour)   | - Updated lesson plan template with anticipated student responses and an introduction  
- Discussed possible student misconceptions  
- Debated use of a table in the introduction |

<table>
<thead>
<tr>
<th>Meeting 8</th>
<th><strong>Planning</strong></th>
</tr>
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</table>
| (1.5 hours)  | - Updated lesson plan template with possible teacher questions  
- Planned the board use  
- Shared concerns about the lesson design with the group |

<table>
<thead>
<tr>
<th>Meeting 9</th>
<th><strong>Planning</strong></th>
</tr>
</thead>
</table>
| (1 hour)   | - Members attended this additional meeting added at the last minute to make final revisions to the lesson plan.  
- Watched the short introductory video created to engage students in the problem  
- Discussed the board use as connected to the flow of the lesson and presenting students' solutions |
### Meeting 10 (2 hours)

*Research Lesson* (1 hour)
- One member taught the planned research lesson to a class of grade 8 students
- Research lesson was observed by the Lesson Study team, the facilitator, and the knowledgeable other
- Guests also joined the team to observe the research lesson, including: other teachers from the district, district administrators, and educators from outside the district
- Observers collected data on the effectiveness of the lesson and student understanding

*Reflection- Post Lesson Discussion* (1 hour)
- Discussion immediately followed research lesson
- Began with instructor’s comments on effectiveness of lesson from his perspective
- Shared examples of student understanding and misunderstanding
- Analyzed the students’ solutions as related to the design of the lesson
- Listened to comments by outside guests and final reflections by the knowledgeable other

<table>
<thead>
<tr>
<th>Total Time (14 hours)</th>
<th>5 hours for Investigation (4 meetings)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 hours for Planning (5 meetings)</td>
</tr>
<tr>
<td></td>
<td>1 hour for teaching the Research Lesson (1/2 meeting)</td>
</tr>
<tr>
<td></td>
<td>1 hour for Post Lesson Discussion (1/2 meeting)</td>
</tr>
</tbody>
</table>

### How This Lesson Study Cycle Unfolded

Lesson Study groups in the United States follow a cycle of activities as practiced in Japan and recommended by U.S. Lesson Study experts (Lewis & Hurd, 2011). This cycle has four consecutive phases or stages: investigation, planning, research lesson, and reflection. Each phase of Lesson Study makes central different activities. The reader is reminded that these phases were described earlier in Chapter 2 and in *Figure 2.2.*

Though there is a basic structure to the practice of Lesson Study, many decisions are made about the activities within the cycle. Each Lesson Study group makes choices based on their needs, interests, and beliefs about teaching as they attend to various details.
in the process of creating a research lesson. These activities may include: studying the related lessons in previous grade-levels, comparing curriculum resources, asking a knowledgeable other to present further information on curricula, planning a full unit of study, pre-teaching the research lesson, inviting outsiders to participate in the observing and reflecting, and re-teaching the lesson. This Lesson Study group practiced some of these activities (comparing resource materials and inviting a knowledgeable other) and not others (planning a full unit of study and re-teaching the lesson). The facilitator of this Lesson Study group and teachers with Lesson Study experience guided the group on which of these activities to include.

The following sections describe how this middle school mathematics professional learning community chose to practice one cycle of Lesson Study in their school. I first describe the process this group engaged in and the choices they made in their practice of Lesson Study. I do this by recounting the activities of the group as they engaged in the four phases of Lesson Study: investigation, planning, research lesson, and reflection. Each phase I define as one unit in my analysis of the activities within the Lesson Study process.

The Investigation Phase: Description of Group Activities from Meetings 1-4

The four first meetings of this Lesson Study team, five total hours of meeting time, were dedicated to the investigation phase of the cycle. During these meetings the teachers built their understanding of the curriculum and the related mathematical content as they prepared to plan a research lesson. Meeting 1 was dedicated to setting the group meeting norms and brainstorming research lesson goals. (See Figures 4.1 and 4.2.) At
this meeting the members decided that they would invite a knowledgeable other, Dr. Makoto Yoshida, to join some of their future meetings to share his expertise on Lesson Study. Dr. Yoshida did then join the group for Meeting 2 and Meeting 3. At Meeting 2, the group refined their goals, began to study their curriculum materials, and learned more about the Lesson Study process from Dr. Yoshida.

In Meeting 3, the group was again joined by Dr. Yoshida who guided the group to study the curriculum more deeply by examining the mathematics content, including that from previous grades. The group also examined how their Connected Mathematics Program resources developed the concept of linear equations as compared to other resource materials like the Japanese textbook. The group, including the knowledgeable other, discussed the mathematics behind the algorithm for solving a system of equations. This meeting ended with a conversation about how students may approach systems of linear equations problems. After Meeting 3 the group progressed without the knowledgeable other as a professional learning community sharing their own expertise.

In Meeting 4, the group revisited their dialogue on the mathematics behind the solution algorithm for a system of equations. They continued to study the teaching of this topic in various curriculum resources. They made a group decision and chose the problem for the research lesson, a basketball problem from the Japanese textbook. (See Figure 4.3.) This problem was chosen over others because the members thought the problem could be clearly understood by the students and the students may relate to the context. This led to a discussion on how to build a lesson around this problem linked to possible Lesson Study goals, to be presented in the next section. This final investigation meeting ended with an extended discussion on anticipating how students may solve this specific problem.
**Figure 4.1:** Possible Student Learning Goals for the Research Lesson

- Student Goal
  - Perseverance
  - Math thinking visible
  - Making connections (print/objects)
  - Working with data
  - Learning from their peers
  - Presentations
  - Through modeling Math
  - Seeing
  - Questioning (meta-cognition)

- Content Goal

**Figure 4.2:** Possible Student Content and Teaching Goals for the Research Lesson

- Linear Equations
- Solving Equations
- Integer Operations
- Fraction Division
- Slope

- Teacher Goal
  - CPA
  - Board use (Bancho)
  - Questioning
  - Diff instruction
  - Ts Summary
  - Teaching through problem solving
  - Formative assessment

In a basketball game, other than free throws, there are 2-point shots and 3-point shots. What are all the possible combinations of 2-point and 3-point shots if a player made 10 shots in all and scores 24 points?
(Tokyo Shoseki, 2017, p.30-31)
The Planning Phase: Description of Group Activities from Meetings 5-9

Following the investigation phase, the next five meetings of this Lesson Study team, seven total hours of meeting time, were dedicated to the planning phase of the cycle. Teachers used this time to create a detailed lesson plan for the research lesson based on their Lesson Study goals and focused on improving student learning. The following describes the main activities practiced by the group through these five planning meetings. (See also Table 4.1.)

For this Lesson Study group, Meeting 5, the first planning meeting, was dedicated to a transition from investigating their materials to beginning a lesson plan template to record their research lesson ideas. The group returned to the basketball problem, involving a system of linear equations, identified in Meeting 4, with the goal of creating a research lesson for students based on this problem. They reviewed their Lesson Study goals: making math thinking visible, perseverance in problem solving, and understanding the solution to a system of equations. With Claire’s recommendation, the group first solved the basketball problem together. The members shared with each other how they tried to solve the problem compared to what they thought students might do. In the end, the group created a three-column lesson plan template to record their planning ideas. (See Appendix 4 for final lesson plan.) At this early stage of the research lesson planning, the group briefly considered various elements in the lesson design: the introduction, the role of students, and the use of a manipulative.

The group continued to discuss and debate various details in the design of the lesson plan in Meeting 6. They first improved the wording of the main problem in the
lesson, the basketball problem. The members deliberated on the role of the teacher in the lesson, such as what questions the teacher should ask and what the teacher should write on the board. These conversations led to a discussion on organizing the various student solutions on the blackboard and which student solutions would be emphasized. The group also discussed the role of the students in this lesson, including how they might work with partners, use the worksheets, and present their ideas to the class. Finally, the group planned the time allotted to each segment of the lesson: introducing the lesson, posing the problem, solving the problem, presenting and discussing solutions, and summarizing the lesson.

In Meeting 7, the group focused on viewing the drafted lesson from the student perspective. They generated and recorded possible student solutions to the basketball problem and other problems in the lesson. The group also discussed how students might respond to the questions from the teacher about the problems. Anticipated student misconceptions were discussed and the teachers proposed possible responses to help improve student learning. This meeting ended with a lengthy debate about whether or not to give a table for organizing student solutions.

Planning the research lesson continued in Meeting 8. The group defined many of their lesson design choices from the previous lesson plan drafts. Beginning in this meeting and continuing into the next, the group planned the board usage for the research lesson, drawing the proposed layout on the board in the meeting room. (See Figures 4.4 and 4.5.) The group then made a decision to add one more unscheduled planning meeting to be held the day before the research lesson to finalize the written lesson plan. They used this extra planning meeting, Meeting 9, to allow the teacher who would teach the research
lesson to ask questions as last minute preparation before teaching the research lesson to the grade 8 students and in front of observers.

*Figure 4.4: Board Planning During the Planning Phase (Part 1)*

![Figure 4.4: Board Planning During the Planning Phase (Part 1)](image)

*Figure 4.5: Board Planning During the Planning Phase (Part 2)*

![Figure 4.5: Board Planning During the Planning Phase (Part 2)](image)
The Research Lesson Phase and the Reflection Phase:

Description of Group Activities from Meeting 10

The tenth meeting of this Lesson Study group included the last two phases of the Lesson Study cycle, teaching the research lesson and reflecting through a post-lesson discussion. I describe these two phases in this one section because the phases occurred back to back in one meeting and they are inherently connected. The next sections describe the activities of the research lesson phase and the reflection phase.

Research Lesson Phase

The Lesson Study planning team met with the invited guests for a half hour before the research lesson was to be taught to the students. The nineteen guests included the knowledgeable other (Dr. Yoshida, an international Lesson Study expert), district teachers, district administrators, and educators from outside the district interested in Lesson Study. The pre-meeting was to review the lesson plan and give the observation protocol to the guests. Their role was to observe the research lesson through the lens of the student perspective. All observers were given the written lesson plan and a student-seating chart. The observers were asked to collect data on student learning as related to this lesson’s goals and the following evaluation questions:

- Did the students recognize and understand different solutions?
- Did the students think deeply and learn from each other through presentations and discussion?
- Was the board space used effectively to present multiple strategies?
The next step was Ethan teaching the planned research lesson to the selected Grade 8 mathematics class of seventeen students, who were previously informed of the process. The Lesson Study team members and the guests stood around the perimeter of the room as they observed the lesson taught to the class. (See Figure 4.6.) They wrote notes on their clipboards. At appropriate times, observers leaned over students to view their written solutions. (See Figure 4.7.)

Figure 4.6: Teaching of the Research Lesson With Observers

![Image of observations](image1)

Figure 4.7: Observing the Students As They Worked

![Image of students working](image2)
Reflection Phase

After the students left, the final step of the Lesson Study was the reflection phase. The Lesson Study planning group and the guests used the common reference point of the observed lesson, the final board writing with student solutions, and their notes for a post-lesson discussion. (See Figure 4.8 for image of final board work.) The planning team sat in a row facing the invited guests. (See Figure 4.9.) Ethan spoke first on his perspective as the teacher of the research lesson. He shared his thoughts on how well the lesson goals for the students were generally met. He also included a self-critique about forgetting to do one presenting aspect. Following the protocol for the post-lesson discussion, other members of the Lesson Study planning team spoke next. They focused on specific students’ responses to the research lesson. In one example, Brenda compared the team’s anticipated student responses to the actual responses she observed. Dan noted the relationship between student thinking and the teacher’s questions. Claire commented on a student that had used a table in a way that they had not predicted. She wondered what would have happened if the numbers in the main math problem had been different. Farrah commented on one student’s solution process of making a list and that the student changed his strategy in the middle. Amy shared two observations of student responses. All but one member of the Lesson Study team offered verbal input.

As per the reflection protocol, after the group members shared, then the invited guests were given an opening to voice their questions and observations on student learning. One observer asked the planning team if they had expected more students to share ideas after the individual work. A math supervisor from another district explained a student response she noticed. Claire from the team attempted to analyze what this student
might have been thinking. Another outside observer with Lesson Study experience asked about the incorrect math notation used by a student. Claire explained how the planning team had anticipated this issue and had tried to address it in the plan. Invited guests were given all the time they wanted to offer their input before the next step in the protocol.

The post-lesson discussion ended with final comments from the knowledgeable other, Dr. Yoshida. (See Figure 4.10.) He explained the benefits of the research lesson in the Lesson Study process,

As teachers we don't have many occasions that we can actually observe the lesson carefully and what students are doing. And after that, discuss what they did with a group of people. So this is really one of the strengths of doing Lesson Study…. that we can be able to look at the students work very carefully. Then think about the next [teaching] things that need to be done. (Meeting 10-part 2)

Dr. Yoshida expressed appreciation of how this Lesson Study group focused on anticipating student responses but wondered what we can do when the students do not respond as anticipated. Dr. Yoshida encouraged continued learning through Lesson Study,

But, I really want to congratulate these teachers. Lesson success or not, is not the most important thing. The most important thing is what we can learn from this experience. The other thing I think we learned from here is how difficult it is to be able to see the student work carefully if you are teaching in the classroom by yourself. It’s a lot of work you need to put into [teaching]: you need to anticipate, monitor, select, order, and connect. ... If we can't practice these things everyday, so you do Lesson Study together with colleagues for a couple of years and gradually you can improve. (Meeting 10-part 2)

This was the end and the completion of the full ten-meeting Lesson Study cycle.
Figure 4.8: Final Image of the Board After the Completed Research Lesson

Figure 4.9: Lesson Study Planning Group Reflecting on the Research Lesson
Summary of the Activities in this Lesson Study Cycle

These ten meetings made up one full cycle of Lesson Study. The middle school mathematics teachers in this study chose to engage in the full implementation of activities recommended by Lesson Study experts. This included a careful study of the resource materials (kyozaikenkyu) and the benefit of input from a knowledgeable other (Takahashi & McDougal, 2016). In practicing elements of Lesson Study often overlooked by U.S. educators, the teachers in this study were able to receive a full experience of this professional learning model.
CHAPTER 5: THE SOCIAL PRACTICE OF LESSON STUDY - THE GROUP

LEARNING HOW TO FUNCTION AS A LEARNING COMMUNITY

My overarching theoretical framework of the sociocultural and situated nature of learning guided my analysis of this professional learning community and its members (Lave & Wenger, 1991; Wenger, 2010). My research question, what evidence does the participation of a middle school mathematics Lesson Study team reveal about teacher learning, led my examination of the group. I sought to understand what the teachers learned by engaging in the social practice of Lesson Study. As illustrated in my conceptual framework, I found evidence of this learning in both group and individual outcomes. The results of my analysis supported Lewis, Perry, and Hurd’s (2009) finding that engaging in Lesson Study can facilitate teacher learning. I extended this research by closely examining how the teacher learning unfolded for one Lesson Study group. I examined both the outcomes of the group learning, as well as the individual teacher learning. Through my observation and analysis of the Lesson Study meetings, I was able to gain insight into the mutual learning as the group process facilitated an exchange of ideas in their group meetings. In Chapter 6, I will explain the insights gained into individual teacher learning collected through interviews and surveys. I extend understanding in the field of teacher professional learning by illustrating how Lesson Study can serve as a vehicle for teacher learning. My analysis offers a window into how the Lesson Study process proceeded in this group of U.S. middle school mathematics teachers.

In Chapter 5, I present the evidence of the changes in the group as it evolved to become a learning community. Chapter 6 then explores the evidence of individual
learning collected through the teacher interviews and surveys. In closing, I hypothesize how the participation in the Lesson Study group process influenced the group and individual teachers’ learning through opportunities to learn. Chapters 5 and 6 reveal the progression of the impact of Lesson Study on the group process from changes in group functioning to changes in individual teachers’ learning.

In this chapter, I describe the outcomes observed in the group as the teachers learned how to participate in the social practice of Lesson Study. As the teachers engaged in collegial interactions through the Lesson Study meetings, I found evidence of changes in their participation in this social practice. These changes are the evidence of the members learning how to participate in group work as a professional learning community. Observational data from the teachers’ Lesson Study meetings served as my primary source of this analysis. I claim that the teachers learned from their participation in the social practice of Lesson Study to become a group and function as an effective community of learners.

I found evidence related to four types of changes in the group participation throughout the series of ten consecutive meetings: changes in the nature of participation, changes in the nature of talk, changes in the commitment to the group, and changes in use of inquiry for instructional improvement. I remind the reader that I described how I collected the data pertaining to the group participation in Chapter 3. The first type of change, changes in the nature of participation, included examining the verbal participation of members and how members assumed new roles within the group. Next, in examining the changes in the nature of the teachers’ talk, I looked at the movement from superficial talk to dissonance, the talk about the resource materials, and the use of
shared terms. Third, as I examined changes in the commitment to the group, I analyzed the attendance in the group, the additional meeting time, and the preparation outside of meeting time. Finally, I examined the development of a norm of inquiry, including the group’s use of questions in their discussions and the assumption of an inquiry stance towards practice. I identify these changes as examples of the group learning how to participate in the social practice of the Lesson Study group process. This chapter examines the group as a whole, as members adapted to the social practice of Lesson Study.

Changes in the Nature of Participation

In this section, I examine the changes in the nature of participation for this Lesson Study group. In analyzing the observational data, I found patterns within the group discussions. This included changes in the amount of verbal participation by members and members taking on roles as members of a group participating in the social practice. Like Little (2003), I was also looking for evidence of social dispositions and norms within the collegial interactions that were conducive to teacher learning.

Amount of Verbal Participation

As explained in Chapter 3, to understand the changes in participation level of the members throughout the meetings, I created a chart recording the number of comments made by each participant at each meeting as compared to the other members. From the transcripts of the meetings, I noted the changes in the quantity of these verbal contributions of each member as the meetings progressed from the first meeting to the
final tenth meeting. I examined changes in each member’s amount of verbal participation within the group over time. The data collected in this case study suggested that group members showed changes in their amounts of verbal participation as the group progressed. Figure 5.1 exhibits each member’s percent of total verbal participation time at each meeting in minutes as compared to their colleagues. The horizontal bars on the x-axis represents 100% of the total time of discussion at each meeting. If a participant was absent from one meeting, they are not represented on the graph for that particular meeting.

Though I found that participation varied from meeting to meeting, five of the seven members increased their verbal participation level. Data showed Farrah with the greatest increase in verbal participation. She spoke infrequently in early meetings but spoke often in the last three meetings. Gina only made a few short comments in the first few meetings, made a few longer comments in Meetings 6 and 7, and then verbalized at length in a later conversation in Meeting 9. Amy participated in the early meetings by adding only a few comments of agreement with others’ ideas. By Meeting 5 she first contributed her own ideas and continued to do so more frequency. Brenda and Dan both spoke an average amount initially but increased their number of comments when conversations related to their particular area of expertise. It is noted that two members decreased in their level of participation; Claire and Ethan were the most active members in the beginning meetings and later gave other members more time to speak. Their levels of verbalization decreased from high to average as other members increased their engagement in the conversations. The verbal participation became more distributed within the group. The changes in the group members’ levels of verbal participation in the
social practice revealed evidence of learning the culture of group functioning to allow all members an opening to participate.

**Figure 5.1: Graph of Members Participation Levels Compared to Others**

<table>
<thead>
<tr>
<th>Meeting 1</th>
<th>Meeting 2</th>
<th>Meeting 3</th>
<th>Meeting 4</th>
<th>Meeting 5</th>
<th>Meeting 6</th>
<th>Meeting 7</th>
<th>Meeting 8</th>
<th>Meeting 9</th>
<th>Meeting 10</th>
</tr>
</thead>
</table>

**Assuming Roles Within the Group**

In Chapter 3 I explained how I collected data on members developing various roles which enabled the group process. As the Lesson Study meetings progressed from the first to the tenth meeting, the teachers took on roles as members of this group. Lave and Wenger (1991) suggest that participation in a community of practice is mediated by the forms of participation accessible to the group members. Members learn to take on roles in order to facilitate the group’s functioning. These assumed roles reveal the areas of possible contribution accessible to group members. I claim that the accessibility of the roles within the practice of Lesson Study helped the group to include every member as an
active participant. Through my analysis of the data, I identified various member roles. As described in the following discussion, the most experienced members in this Lesson Study group took on roles to lead the group. These leadership roles included teacher of the research lesson and teacher-leader within the group. Less experienced members took on a variety of other roles such as curriculum expert and goal re-focuser. Others took on supportive roles that involved active listening and doing tasks for the group. These roles illustrate Lave and Wenger’s (1991) notion of legitimate peripheral participation.

**Teacher of the research lesson.** One of the experienced teachers who emerged as a leader was Ethan. Once the group had determined that they wanted to explore a grade 8 ‘solving systems of equations’ research lesson, Ethan’s experience teaching grade 8 became valuable to the group. From this point forward, Ethan tended to advise the group through his comments on what grade 8 students know and do not yet know on this mathematical topic. In one contribution he shared, “Then the combining like terms piece [is difficult]. If everything is plus they don't really make any mistakes, but if it's a minus something and then a plus something they're not looking at the signs on the left and that's ... Really, it's a challenge [for them]” (Meeting 2). By Meeting 3, the group officially designated Ethan as a leader by choosing him as the member who would teach the research lesson that would be observed. He was now responsible to teach the lesson plan for a group of students and in front of the audience of observers. Ethan appeared to respond to this new responsibility by being further engaged in the group conversations. This was noted by his physical attentiveness and by his asking more questions on details of the lesson plan. For example, Ethan asked about a teaching strategy in the lesson, “Now do you plant seeds, let them know they can investigate through a graph or do you
just kind of let them really run with it on their own?” (Meeting 5). This role responsibility influenced how Ethan spoke about the lesson, especially in the meeting right before he taught the live research lesson. In this Meeting 9, Ethan led most of the discussion by asking questions about how he should teach the lesson, “And then I added the one about the test question problem. It’s a similar style question, just to see if they could even write a system. I don’t know if that’s really our goal necessarily. What do you think?” (Meeting 9).

The important leadership role of teacher of the research lesson assumed by Ethan influenced the nature of his questions and encouraged the group to attend to lesson details as they collaborated. Not only did this assumed role influence Ethan, but his enactment of this role helped the group to be very specific in the lesson planning.

**Comedian.** In addition to teacher of the research lesson, Ethan also took on a secondary role of comedian. Right from the first meeting, referring to a famous math problem about brownies from the Connected Mathematics textbook, he joked about Dr. Yoshida’s upcoming visit, “We could always cook him a batch of brownies” (Meeting 1). Ethan would often make jokes that elicited laughter from the group. After a discussion about a problem involving farm animals and the need to make the problem connected to real life, Ethan joked, “I can bring in some goats” (Meeting 4). In Meeting 6, Ethan made fun of the intensity and detail of the debate about the use of the chart, “It's a Seinfeld episode with a chart.” All the members had a good laugh at this.

Ethan’s use of humor may have served to relieve tension in the group and improve collegial interaction. His secondary role of comedian helped Ethan find support for his other important group role as teacher of the research lesson. Interestingly, this
role could have been devastating to the group functioning if enacted by a less central member, but given Ethan’s clear and demonstrated engagement in the process, it seemed to relieve group tension and build comradery.

Teacher-leader. Claire was the other experienced teacher who was informally chosen as a leader by the group. Claire had expertise with Lesson Study, based on training in Japan and Chicago under Lesson Study experts. Due to her extensive experience with Lesson Study, she was able to help the group follow an established Lesson Study protocol by serving as internal teacher-leader within the group. When the facilitator explained how he wanted to play a less dominant role within the group, Claire jumped in to lead the others, “Last time we said we were going to look at the CMP units on the linear topics. Maybe from sixth, seventh, and eighth [grade] we could pull in all the units that have linear relationships in it and see what we want to do” (Meeting 2). Claire, with her experience in Lesson Study, was leading the group to being to investigate the resource materials (kyozaikenkyu), the first feature of the Lesson Study cycle (Lewis, Perry, & Hurd, 2009). She would guide the group through the established four-phase protocol (investigation, planning, research lesson, and reflection) starting with the first. This was an example of how Claire was able to help the group in the role of teacher-leader to guide the practice Lesson Study in alignment with the recommendations of Lesson Study experts. She taught the other members about the elements of best Lesson Study practice.

Curriculum expert. Two members of the group, Brenda and Dan, assumed roles available to them as curriculum experts. They had less specific experience with Lesson Study, but had deep knowledge of the curriculum materials. Using their curriculum
knowledge they played essential roles in helping to further the group’s investigation of the resource materials, in the first phase of Lesson Study. These two members played essential roles in contributing to the group process. The role of curriculum expert did not require extensive Lesson Study experience or leadership skills, like the role of teacher-leader. However, it did require deep knowledge and analysis of the current curriculum materials, the Connected Mathematics Program. This pattern illustrates Lave and Wenger’s (2001) notion that members of a community of practice take on roles accessible to them.

Brenda, having taught grade five and six mathematics, used her extensive knowledge of the curriculum from those grades to help the group understand students’ previous learning. It is recommended by Lesson Study experts that teachers study previous learning content so as to develop an understanding of the coherence of the curriculum and improve instruction (Takahashi & McDougal, 2016). Initially in Meeting 1, as a younger teacher in the group, Brenda was a listener. She found her voice in Meeting 2 when she began offering information about the mathematics from previous grades, “Sixth grade is the Variables and Patterns unit. They start writing expressions and equations with variables” (Meeting 2). Brenda provided the group curriculum knowledge when she interjected, “In sixth grade it wasn't really about, ‘what does this intersection mean?’ It's, ‘oh look, the intersections are here’ " (Meeting 2). She continued to assume this role throughout the first four investigation meetings. Her input was welcomed by the group and thus reinforced her role as a curriculum expert. Her comments helped the group to study the curriculum progression in a deeper way and helped the other members build vertical curriculum knowledge, the understanding of the
curriculum throughout the grades (Ball, Thames, & Phelps, 2008).

The second curriculum expert was Dan who had eleven years of experience teaching mathematics in another district. He had unique expertise of previous versions of the Connected Mathematics Program and contributed his recall of the most interesting problems he had come across related to linear equations. Being a resource of problems was a valuable contribution to the group. He had no Lesson Study specific experience and was a new teacher at this school. He took on the role that was suited to his expertise and provided curriculum information that was needed by the group. For example, in this exchange Dan recalled a problem that was useful to the group:

Dan: There used to be a bakery problem in the older version of CMP where they had to figure out how many cakes they had to sell to make a certain amount of money.
Claire: No, that's not in there anymore.
Dan: That's gone? That was really good problem.
Brenda: Can you find those old books?
Dan: Yeah.
Brenda: Someone probably has the old book in school.
Claire: Oh yeah?
Facilitator: I have the old eighth grade ones.
Dan: This was a seventh grade problem. I'm pretty sure it was from *Moving Straight Ahead*.
Facilitator: The blue book, probably?
Dan: Where they actually did some system of equation stuff and it might be a good introduction to systems of equations. (Meeting 2)

Both Dan and Brenda provided valuable contributions to the social practice of Lesson Study by assuming the role of curriculum expert. These two teachers found accessible roles that enabled them to be meaningful contributing members to the group. Their participation furthered the in-depth conversations about the curriculum materials, which is a critical part of Lesson Study, called kyozaikenkyu in Japanese (Watanabe,
Takahashi, & Yoshida, 2008). Despite the fact that these two teachers had minimal Lesson Study experience, they were helpful to the group practice of investigating the resource materials.

**Goal re-focuser.** One member of the Lesson Study team eventually found herself a needed role as goal re-focuser, a type of disciplinarian for the group. Farrah expressed in her initial interview that she did not feel a part of the school mathematics teaching team because she taught math support classes, rather than the traditional grade-level classes taught by the others. She implied that she foresaw having difficulty fitting in with the group. Farrah had some experience in Lesson Study and had taught mathematics in the school for twenty-seven years. Farrah spoke less often in the early meetings. In Meeting 5, Farrah took on a role that helped the group stay on task. For example, after some tangential joking by Ethan, Farrah got everyone back to the task, “All right, we're getting punchy, guys. Let's get back on topic. If we work hard we can get this part complete” (Meeting 5). The group responded by refocusing on their task. This comment illustrated the beginning of Farrah developing her role in the group as goal re-focuser. As the meetings progressed further, she continued to effectively remind the others to focus on the Lesson Study work. As one teacher starting out feeling disconnected from her fellow math teachers, Farrah found a way to play a key role needed by that group and which was symbolic of the group’s inclusion and respect for her.

**Legitimate peripheral participation.** Not all members participated verbally in all the meetings. I assert that the less-verbal members attending the Lesson Study meetings still were participating in the social practice and had needed roles in the group. Some members were contributing and learning through a role of legitimate peripheral
participation. As Lave and Wenger (1991) contend, newcomers to a community of practice can learn from more experienced members and participate in the group through simple but useful tasks. In my research, I observed two members who contributed to the social practice of Lesson Study through such legitimate peripheral participation (LPP). Amy did not verbalize her own ideas to the group in the first four meetings. In Meeting 5 she helped the group by typing and entering others’ ideas into the lesson plan template. This was a necessary group task in order to organize the group’s ideas for the research lesson.

Gina also showed evidence of LPP when she sat silently but attentively through the first three meetings. Her observed active body language and frequent nods revealed her engagement which was needed to support the discussion of the others. Speakers need listeners. Eventually, in Meetings 6 and 9, Gina found an opening to share needed expertise from her special education perspective. She again helped the group process at the very end with the task of making the photocopies needed for the research lesson. Thus, Gina was engaging in legitimate peripheral participation. Therefore, even members of this community of practice who were less verbal, participated in roles that met the needs of the group. LPP can provide an initial stage of helping the group from which members can progress to become more active contributors in the group, such as demonstrated by Amy and Gina (Lave and Wenger, 1991). The changes in the participation, both changes in the amount of verbal participation and in assuming group roles, revealed evidence of group learning how to include and benefit from all the members.
Changes in the Nature of the Teachers’ Talk

In this next section, I describe the changes in the nature of the teachers’ talk as they participated in the social group practice of Lesson Study. I explained in Chapter 3 on my methods, I observed changes in the group interactions as the meetings progressed from the first meeting to the tenth meeting. Norms of engagement, or verbal interactions, evolved as the teachers participated in the ongoing collegial exchanges. First, I found evidence of the nature of talk progressively changing from superficial talk to comfortable dissonance and debate. Second, I found evidence of changes in the way the teachers spoke of the textbook and resource materials. Third, data suggested the development of increasing use of shared terms by group members.

Superficial Talk to Dissonance

As the meetings progressed from one through ten, the group changed with increasing socialization as well increasing dissonance. In the first four meetings, the teachers did not participate in social conversations about activities outside of school. They spoke briefly with one peer or got to work investigating the resource materials. It was not until Meeting 5 that the teachers took time for a full group social conversation. This session started out with much laughter and socializing. The group talked for the first five minutes about Amy’s new home. Members shared snacks and joked. This congeniality first evident in Meeting 5 then continued through to the final tenth meeting. Sharing food and information about themselves was evidence of a growing level of cohesion within the group.

Simultaneous to the increase in social bonding, I also observed an increase in the
group members critically evaluating each other’s opinions. Initially the facilitator encouraged the group to share all possible ideas. In early meetings there was little evaluation of ideas by the members; all ideas were accepted. I would characterize the conversations in the first three meetings as “happy talk”. The teachers made comments in support of others’ ideas. For example, Farrah said, “I think there’d be a lot of good conversation out of Lesson 1.3” (Meeting 3). Amy agreed, “You could have a lot of stuff on the board from that lesson” (Meeting 3). As the meetings progressed, members began to express differing opinions. For example, by Meeting 5 the talk had changed to the point where teachers were questioning each other directly. Brenda asked the group to reconsider a lesson decision they had made, “But when they write the total number of points, are you trying to get them to write those expressions like Claire was writing, 2x1 + 3x9?” (Meeting 5), implying that she thought this was not the best strategy.

In later meetings the group began to show a higher-level of dissonance; ideas were openly evaluated and some members’ idea were rejected by the group. One example of this dissonance was presented in Meeting 7 on the topic of using a table to help students organize their solutions. In this meeting, the knowledgeable other, Dr. Yoshida, suggested that giving a table may be a helpful tool for the students to see a common solution for a system of equations. The members began to debate how a table could be introduced, either presenting it through guided teaching or generating it through students’ discovery. Claire and Brenda asked Dr. Yoshida some questions about how a table would be used in the lesson (Meeting 7). Dr. Makoto Yoshida suggested introducing the table to the students early in the lesson. Brenda then remarked, “Yeah, that’s different from what we were saying before” (Meeting 7). She was noting a conflict in what the group had
discussed about teaching through problem solving before Dr. Yoshida had spoken at this meeting. Claire then verbalized her concern about guiding the students too much with an early use of a table. Farrah also pushed the issue, “We’re trying to help them understand the need for the table” (Meeting 7). Farrah was noting the conflicting teaching beliefs presented, giving the students a table to use versus allowing them to discover a table on their own. This meeting revealed a progression from just asking opposing questions to discussing conflicting ideas more directly, and even expressing dissonance with the expert.

This was not the last time the group would disagree about the use of the table in the research lesson; the debate continued in Meeting 8. Claire began writing on the blackboard to plan the lesson, “Using the table is helpful” (Meeting 8). This again brought up the disagreement about the use of the table to record student solutions. Farrah recommended more of a student-driven solution without the teacher introduction of the table. Farrah recommended, “After they generate the equations, you generate the different solutions from the class, if we want to keep the lesson student driven.” Ethan sided with Farrah, “We give them the x and y, like [Farrah] was saying, if we want to see what they would come up with. It would be interesting to see if they come up with the two conditions without given a table” (Meeting 8). Ultimately, the group did not side with their knowledgeable other’s recommendation. They chose not to guide the students by giving them the table. This resolution of the debate revealed the members’ growing confidence in their own expertise and their learning through dissonance.

The debated issues were connected to topics deemed important by the group members, such as blackboard planning and teaching through problem solving. The
opened-nature of the Lesson Study process encouraged discussions that allowed group members to experience conflict between their own ideas and ideas of other members. This dissonance made visible the thinking of the members and provided a learning opportunity to change their own beliefs (Chazan et al., 1998; Christman, Ebby, & Edmonds, 2016; Lewis, Perry, & Hurd, 2009).

**Talk About the Resource Materials**

The data revealed evidence of changes in how the teachers talked about the resource materials: moving from speaking about the text as written, to analyzing the text, to changing how to use the text. During the first four meetings, the teachers spent time pursuing the *investigation* phrase of Lesson Study, studying the curriculum materials and other resources. Initially, the teachers discussed only factual information directly from the curriculum. For instance, Brenda showed a clear understanding of the Connected Mathematics materials by recalling details in curriculum for the group, “We just launched linear equations in 6th grade, understanding the relationship between two different variables” (Meeting 1). Dan also helped the group with his knowledge of the text,

> That's what I wanted to bring in... We looked through the *Say It with Symbols* [unit] and it really looks like a topic about noticing a linear pattern, getting them to write an equation with it. If [our goal] is about solving equations, then this is more in the *Solving Systems* unit. (Meeting 2, lines 472-474)

After recalling information from the text, the teachers began to verbalize their *understanding* of the problems as written in the text. For example, Ethan talked about a grade 8 problem from the text later in Meeting 2, “In part A they're just giving them a certain number of shirts and caps and then here's a profit. In part B, it starts to talk about
each of those answers from part A being a point [of intersection].” Up until this stage in Meeting 2 the group talked about the text without critical analysis.

Then the group changed to discussing the authors’ meaning. Brenda questioned the text, “I don’t understand why in that problem … What’s the purpose of them showing both equations solved for C?” (Meeting 3). In this same meeting Dan expressed not understanding a problem solution in the Japanese text as compared to the Connected Math text, “Why does this Japanese textbook hold the two point shots constant?” (Meeting 3). These verbalized questions provided evidence that the members were changing their talk to critically analyzing the resource materials and wanting to understand at a greater level.

This questioning then evolved to a deeper study of the text and the authors’ philosophy. Dan analyzed the text and surmised, “Yeah, I think [Lesson] 1.3 is just kind of like walking them through the two different equations, step by step”, implying that was guiding the students (Meeting 4). Claire continued this type of talk about the text, “Right, that’s the first time that they’re seeing this because if you look back at [Lesson] 1.1 and 1.2 they’re really just focusing on a similar equation in different ways to write that equation, so now you have the slope intercept form versus standard form” (Meeting 4). Ethan then spoke about the text critically, “Yeah, it doesn’t allow itself for a whole lot of variety of outcomes. It’s like do this and then do this and then do this” (Meeting 4). This led the group to consider how to alter the problems from the text to better align to their teaching through problem solving goal.

The data from the four investigation meetings of the Lesson Study group revealed changes in how the teachers spoke about the resource materials as they became more
comfortable in analyzing the text. Data showed the teachers progressing from accepting the text as written, to talking about altering the text to meet their needs for lesson design. This change in talk about the text suggested that the teachers were learning how to study the curriculum in a deeper way by unpacking it. Remillard and Geist (2002) found that the work of unpacking the resource materials offered openings in the curriculum for teachers to learn. (This will be explored further in Chapter 7.) The practice of Lesson Study included opportunities through the investigation feature for teachers to talk about how to use the text to better meet their teaching needs.

**Shared Terms**

Textual data collected from the transcribed Lesson Study meetings revealed evidence of the development of shared terms among group members. Cobb, Wood, Yackel, and McNeal (1992) suggest that meanings for these terms grow out of the social interactions within the group. Member’s personal meanings around these shared terms are formed in the process of the social practice. There is evidence that through the group dialogue understandings of the terms are normative and interpretations become compatible; meanings are “taken as shared” (Cobb, Wood, Yackel, & McNeal, 1992, p.3). In analyzing the data I found two terms used by a few members in the early meetings which became commonly used by most group members as the meetings progressed. The terms identified were teaching through problem solving and board use. A third term, anticipating student responses, was also analyzed for use among members but not found to be a common term. Table 5.1 shows the change in the frequency of use of only the two commonly used terms over the ten meetings.
Table 5.1: Frequency of Use of Shared Terms by Members
(count and who contributed)

<table>
<thead>
<tr>
<th>Meeting</th>
<th>“Teaching through problem solving”</th>
<th>“Board use/Board space”</th>
<th>“Anticipating student responses”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(count)</td>
<td>(count)</td>
<td>(count)</td>
</tr>
<tr>
<td></td>
<td>(Claire)</td>
<td>(Claire, facilitator)</td>
<td>(Claire)</td>
</tr>
<tr>
<td>Meeting 1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(Claire, facilitator)</td>
<td>(Claire, facilitator)</td>
<td>(Claire)</td>
</tr>
<tr>
<td>Meeting 2</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(Claire and Ethan)</td>
<td>(Dan, facilitator)</td>
<td></td>
</tr>
<tr>
<td>Meeting 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Meeting 4</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(Claire, Dan)</td>
<td>(Brenda, Dan, Facrah, facilitator)</td>
<td></td>
</tr>
<tr>
<td>Meeting 5</td>
<td>0</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>(Claire, Ethan, Brenda, Amy, Gina)</td>
<td></td>
<td>(Claire)</td>
</tr>
<tr>
<td>Meeting 6</td>
<td>5</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(Dan, Claire, Brenda, Amy)</td>
<td>(All participants)</td>
<td></td>
</tr>
<tr>
<td>Meeting 7</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(Claire)</td>
<td>(Claire)</td>
<td></td>
</tr>
<tr>
<td>Meeting 8</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(Farrah, Gina, Claire, Dan, Brenda)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meeting 9</td>
<td>2</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(Dan, Ethan)</td>
<td>(All participants, except Gina)</td>
<td></td>
</tr>
<tr>
<td>Meeting 10</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(Ethan, Claire, Brenda, Dan, Amy)</td>
<td>(Ethan, Dan, Brenda)</td>
<td>(Claire)</td>
</tr>
</tbody>
</table>

**Teaching through problem solving.** Initially, only Claire and the facilitator of the Lesson Study group used the term *teaching through problem solving*. In Meeting 1, Claire spoke about her vision for the lesson,

> Maybe a *teaching through problem solving* lesson, where students are presenting, talking about their work, and you as the teacher are tying these solutions together, creating that bridge from one kid's solution to another and the different methods.

As the group members worked more closely together in the meetings, others began to use the term *teaching through problem solving*. Even Amy, who was not a very
verbal participant, used *teaching through problem solving* to describe the lesson,

> We're giving them a chance to work together through our *teaching through problem solving*. They're going to share their ideas, they're going to show their work under the projector, then through our questioning and allowing certain students to stand out during the whole group... (Meeting 6)

Teachers using the *teaching through problem solving* term displayed an unspoken common understanding of its meaning, a way of teaching mathematics by solving a problem as the focus of the lesson. By the end of the ten meetings all participants had used the *teaching through problem solving* term at least once. This increasing use of a common term was evidence of change in the group, with implications of changes in their teaching beliefs and values.

**Board use.** This Lesson Study group began to speak about the *board use* as an important teaching tool for the lesson. They also used an interchangeable variation of this term, *board space*, in their conversations. In all data points collected the terms of *board use* or *board space* were used to describe the blackboard as an important resource for teaching, a tool used to illustrate the lesson progression and connect students’ solutions. In Meetings 1 through 5, a few members spoke about the term and concept of *board use*. Then in Meeting 6 and Meeting 9, there were extensive discussions on *board use* involving all participants. The evidence that the term *board use* was used with increasing frequency and by more members as the meeting processed had implications for a shared value of the board space in teaching the research lesson. Claire ‘s quote was especially characteristic of the expression of the term *board use*,

> I think this is definitely a problem for *board use* and having students come up and telling that story on your board is going to be very vital to pulling everything together and making ... [students’] math thinking visible. (Meeting 6)
Later, Amy exclaimed with emotion her learning about the meaning of the term, “the board space must tell a story” of the lesson (Meeting 9). Finally, Farrah expressed her understanding of what she had learned through the group interactions about the use of the board to show a progression of student responses,

What you have to think about is what do we want to say on the board space and what do we want to just be presented and have a conversation about. Like, what's going to be recorded on the board because if there's nothing anywhere and then all of a sudden there's this system of equations, what's the story that we're telling on the board? (Meeting 9)

It is noted that board use is an important part of lesson planning for Japanese teachers (Wang-Iverson & Yoshida, 2005). The term bansho refers to the use of the blackboard space to help the teacher tell a story of the lesson, highlight students’ solutions, and summarize the lesson. The teachers with Lesson Study experience in this group, like Claire and Ethan, would have been exposed to the emphasis on board usage in Lesson Study. By Meeting 6, Dan, an inexperienced Lesson Study member, even used the Japanese term for blackboard use, bansho, during Meeting 6 to refer to the planning of the board space. The textual data from this Lesson Study case suggested that members of this group evolved to share the traditional Japanese value of the blackboard as a central teaching resource.

**Anticipated student responses.** Another term that I examined was anticipating student responses. One member, Claire, used this term with increased frequency as the meetings progressed. However, through further analysis I did not find that other members were adopting this term into a common phrase. Though, the group did practice the philosophy of anticipating student responses within their Lesson Study practice. In my analysis I looked further at the use of this term but did not find that it evolved to the level
of a shared term for this group.

I posit that the development of shared terms among participants in this Lesson Study group reflected a set of common beliefs about teaching and learning developed through the group interactions. Research on groups in general suggested that this set of common beliefs enables a group to function successfully (Langfield-Smith, 1992). Shared language linked to beliefs was an integral part of group identity. This Lesson Study group developed collective terms around their core values of teaching through problem solving and the use of the blackboard. These beliefs were central to this group’s functioning and encompassed all the members. This progressive change in the shared terms reflected the learning of shared teaching values (Cobb, Wood, Yackel, and McNeal, 1992).

Changes in Commitment to the Group

Several pieces of data suggested that the teachers developed a commitment to the group as they worked together through the Lesson Study cycle. This included three areas of evidence of commitment to the group that helped the group functioning: consistent attendance by members, willingness to extend meeting time, and motivation to prepare outside of scheduled meeting time. The interactions among the group members showed evidence of the teachers developing a member identity with a desire to present a well-built research lesson for the group.

Attendance

All seven members of this Lesson Study team demonstrated commitment to the group through a high-level of attendance at the ten meetings, which totaled fourteen
scheduled hours. Claire, Ethan, and Brenda attended all meetings in full. Gina was only fifteen minutes late to one meeting due to a conflicting meeting in another department. Dan and Farrah missed one meeting each due to illness. Amy was the only member to miss two meetings. She was absent from school on those days, “calling out sick”.

Overall, the teachers’ high-level of attendance suggested commitment to the group process of Lesson Study.

**Additional Meeting Time**

Commitment to the group practice was also evident when the members made the decision to schedule an additional meeting for last-minute preparation for the final research lesson. The decision was made at the end of Meeting 8 to hold one more meeting before teaching the research lesson to the students and observers. The team felt that details, such as the homework and lesson sequence, needed to be more thoroughly planned. All members attended extra Meeting 9 to finalize the lesson plan for the research lesson to be taught the next day. The group used this extra meeting time to support Ethan who had the pressure to teach the lesson in front of the audience. The motivation to meet one more time revealed a high-level of commitment to the group and to presenting a high-quality research lesson.

**Preparation Outside of Meeting Time**

Data revealed that members used their own time to prepare for the research lesson. This was evidence that participants were committed to the group process and to creating a high-quality research lesson. The first piece of related data included the work
of Brenda and the creation of an introductory video for the research lesson. In Meeting 5, Ethan suggested that a video of a basketball player might help the students understand the context of the basketball problem. Others agreed. After an unsuccessful search for a video clip on the internet, Brenda volunteered to create her own video for the group, “I'll make a video of myself…I'll use a Little Tikes [child size basketball equipment]. That'll get them interested” (Meeting 5). Later, in Meeting 9, Brenda showed her one-minute video of herself shooting little basketballs into the little hoop. As the group watched the video they laughed together and complimented Brenda on her work. By creating this video on her own time, Brenda showed her commitment to the group. The members’ overwhelmingly positive response to her video showed their appreciation of her doing work outside the group.

Another piece of data supporting this finding of members’ commitment to the group by doing work outside the group included the efforts of Ethan. He refined the lesson plan on his on time. In Meeting 9, Ethan reported to the group that he had changed some elements of the lesson plan on his own, including the homework, student worksheets, and teacher’s questions. Evidence of his commitment to the group process was the fact that he brought this changes back to the group discussion seeking the group’s input and approval. This quote from Ethan characterized how he presented his refinements to the group, “Then I just added a couple other things on there that I thought maybe we could go through and see if they were good enough” (Meeting 9). Ethan’s work outside the group and his deference to the group’s approval was evidence of his commitment to the group process.

Another group member who was working on the lesson plan outside the group
time was Claire. In Meeting 7, Claire explained to the group that she practiced teaching the basketball problem to her husband at home. He was a basketball fan not a mathematician. Claire challenged her husband to solve the following problem:

In a basketball game, [Brenda] made a total of 10 shots and scored 24 points. How many 2-point shots and how many 3-point shots did she make?

Claire enthusiastically opened up Meeting 7 with her story about how her husband approached solving the math problem, as insight in how students might approach the problem. She explained how her husband had at first solved the problem incorrectly because he had focused on finding a solution for the $2x + 3y = 24$ equation first. She pushed her husband by questioning him and his algebraic thinking,

Yes. I want to bring up something interesting. We talked about which equation are the students going to focus on more, the $x + y = 10$ or the $2x + 3y = 24$, and then towards the end I think I brought up, what if they only really fixate on that 24 equation and that was the first time we really thought about that. Guess What? I did the problem with my husband and guess what he focused on? He wanted to create 24 and even gave an answer that didn't add up to 10; and he was like, ‘Oh, yeah, it has to add up to 10’. (Meeting 7)

Claire then went on to explain her analysis of your husband’s mathematical thinking as related to understanding how grade 8 students might solve the problem,

Because $x + y = 10$, you don’t even spend time thinking about that, that's so basic. It's more enticing to think about ‘2 times what, plus 3 times what, can give me 24’ and then seeing afterwards if that gives me 10. It was just proof that somebody just hearing for the first time, that was what he was drawn to, was really trying to figure out that combination to give you 24. He found the answer quickly, but… I literally did the problem with him as a teacher. How do we represent things that change in math, oh with variables? So, let's create different variables for the 2-point shots and 3-point shots. He did and he said, "$x + y = 10$" and then it was the $2x + 3y = 24$ that he struggled with. That was through teacher questioning where he then came up with the equation himself and I said, "What was that answer that you said? 6 and 4.” I said, "What's so special about that combination and is it the same as 4 and 6?" He was like, "Oh, that's a good question. Well, no, because the $x$ has to be the 6 ... or whatever it is.” Those questions are really what extended the conversation because you're right. He got the answer right away, but it was
those questions that I think that's where we should spend time. I know last time we wrote down 8 questions what we should really be asking. How do we differentiate with these questions, given different entry points, but not tell them too much? I think that would be a good thing to focus on today. (Meeting 7)

Claire’s initiative to try the problem even at home was evidence that she was thinking deeply about the group’s math problem outside of the Lesson Study meeting. The group’s reaction to Claire’s story triggered a group discussion about how the students might react to the mathematics problem. Claire was another teacher who did extra group work outside of the meeting time as evidence of commitment to the group.

The dedication of the members to attend meetings and work on the group objectives outside of the meeting time is evidence of their commitment to the group purpose and commitment to each other. This showed that the participants developed a group member identity as define by Dufour and Eaker (1998). The members developed a sense of belonging to this Lesson Study group as they participated in meetings and worked to refine the research lesson together (Battey & Franke, 2008; Wenger, 2010). The members took responsibility both in and outside of the meetings to support their colleagues and create an effective research lesson. This illustrates how individual teachers came together and changed into committed group members, with a shared purpose and a bond of responsibility to the Lesson Study group.

Development of a Norm of Inquiry

Several pieces of data suggested that the Lesson Study process facilitated a norm of inquiry that developed within the group. Initially, this was evidenced by comments that included a language of interest or curiosity through the research lesson development
process. I identified this through the increased use of questioning among group members as they spoke about the lesson plan. Later, the norm of inquiry evolved to include a stance towards instructional improvement.

**Use of Questions**

Norms of inquiry emerged as the teachers participated in Lesson Study meetings over time. I found that the group developed a pattern of interacting based in questioning that challenged each other’s ideas. This norm of questioning was initially modeled by the group’s facilitator. In the first meeting he used multiple questions to engage members in a discussion about the mathematics content topic of study. He asked questions to get the group brainstorming. As an example, he asked, “Are you still interested in linear equations or is there something else you want to explore? Is there a problem of practice, or a problem in the content, or something that we want to research or study?” (Meeting 1). Later when the facilitator moved to a less active role in the group, Claire, the most experienced Lesson Study practitioner in the group, took on the role of questioner. She began to lead the group with this same norm of using questions to stimulate group dialogue. Claire used questions similar to the facilitator to encourage others to express opinions during the planning of the lesson. In one example, she said, “We start with a lesson, but should we start with a goal?” (Meeting 2). Claire used questions like this to look for input from the group. She continued this norm of questioning to elicit opinions in the subsequent meetings. In Meeting 8, Claire asked the others, “Should we even ask this second type of problem in the research lesson?” These questions from the facilitator and a teacher-leader set the group norm of eliciting an open exchange of ideas through a
questioning stance.

As the meetings progressed, other teachers took on this norm of using questions to interact in the group with the goal of refining the research lesson. In Meeting 6 when the team began discussing the numbers within the problem, Dan asked, “Well, how does that meet our goal of the lesson if we change the numbers to be more difficult?” Farrah posed an important question in Meeting 8 that encouraged reflection about a lesson decision based on multiple student solutions, “What if no one comes up with a different solution?” For Brenda, questions were used as a tentative way to present her opinion. In asking the group about the student solutions included in the lesson plan, Brenda posed her suggestion in a question form, “I think you want them to come up and use substitution, is that right? Are they writing their strategies on the board?” (Meeting 8). This inquiry format was the means by which the group developed to consider lesson design choices.

A question by one member led the group to discuss the possible student solutions to the problem. As the lesson plan developed in Meeting 6, Dan’s posed a question that interrupted the flow of the conversation, “What are the different solutions that they’ll come up with? Can we list them?” (Meeting 6). Amy thought some students would start to approach the problem by randomly guessing. Ethan’s opinion was that other students might set up a table to be more systematic in finding their solution. Claire also questioned if there were other student responses the group had not thought of yet, “Is a table the only way they [the students] are going to represent this?” (Meeting 6). In Meetings 8, as the lesson plan progressed further, the group discussed possible student misconceptions and
how the teacher might respond. Ethan described how he would respond to a student who mistakenly only focused on one condition in the problem. Questions from the group prompted rich discussions on anticipated student responses, an important skill for teachers (Ball, Thames, & Phelps, 2008).

Question by the group members interrupted the flow of the discussion and prompted deeper mathematical conversations. In Meeting 4, the group participated in an intense discussion about the meaning behind a mathematical algorithm. This collegial interaction began with the members working to solve a system of equations problem from the textbook. The teachers discussed their solution steps aloud. They began by using the ‘subtraction method’ to find the point of intersection for two equations with two unknown variables. This led to a question about why the subtraction algorithm was the best method for finding the solution. When trying to understand why this algorithm worked, Ethan remarked, “Does that bother anyone else? Am I the only one?” (Meeting 4). This question led the group into a mathematical conversation questioning the algebraic manipulation in a system and wondering how it is possible to subtract seemingly unlike terms. This provoked two teachers to verbalize their analysis of the mathematical reasoning behind this algorithm, expressing pleasure in their new understanding of why the algorithm worked.

As the meetings proceeded, others teachers began to show comfort in revealing what they did not comprehend. They used the group norm of questioning to inquire about concepts that they themselves did not clearly understand. Claire shared that she did not understand the mathematical algorithm for solving systems of equations. In Meeting 6,
she asked the others, “But why does it work?” She was trying to understand the mathematics in a deeper way for herself. Dan exposed his uncertainty when he asked the group, “What is our goal before we write the system? I am having trouble” (Meeting 8). The norm of exposing their own knowledge gaps aloud facilitated changing from surface talk to a deeper analysis of the materials, lesson choices, and members’ own understanding. This norm of asking questioning progressed to the point where the teachers could ask their own questions exposing their vulnerability in what they did not know. This enabled the group members to learn from each other. The developing of this norm of using questions provided the group with a means to interact with and learn from each other’s expertise.

**Inquiry as a Stance Towards Practice**

Another example of the norm of inquiry was evident in the stance of ‘teacher as researcher’ which evolved in the group. The following are some representative examples of group members expressing an inquiry stance.

Claire, an internal leader, modeled for the group her inquiry stance towards the Lesson Study investigation work. She explained her desire for understanding what students know and can do. This seemed to prompt Ethan to begin to look at the Lesson Study work through a lens of inquiry. The following is their exchange in Meeting 2.

Claire: I would love to see if they learned what they [the grade 8 students] were supposed to learn last year and the year before with Connected Math and see if they could then write a system of equations. 
Ethan: That would be kind of cool to see who [which students] can make that connection. 
Claire: Ok, you’re in 8th grade, you just had two full years prior to this of many problems with graphing and writing equations and you know, the Connected Math style of ‘what do you notice’. So it would be nice to see what they would just do.
This early use of inquiry-focused language by Claire modeled for the group the position of teachers as researchers using an inquiry stance towards their teaching and towards student learning. Ethan increasingly used this inquiry stance in his comments. In one example he explicitly described to the others how much he valued an emphasis on inquiry in his teaching,

“It's always interesting to see the kids that have a systematic approach. Like they make a table, or they make one guess. They can literally make one guess, and then they make an adjustment, and then their next guess is the correct one. It's always interesting to see their choices.” (Meeting 3)

Other members of the group eventually embraced the group norm of inquiry stance. Farrah spoke about her desire to design a lesson that is more open-ended, “That would be a more interesting conversation and more interesting things to see at the board…” (Meeting 6). Data revealed Dan using inquiry stance language in Meeting 8, “We give them the x and y, we want to see what they would come up with. It would be interesting to see if they come up with the two conditions [the two equations].” Finally, Brenda verbalized her inquiry stance of curiosity towards the students’ learning in the final post-lesson discussion. She presented her view on the homework problem, “In fact, I was anxious to see how they would solve that problem actually because you don’t split 27 in half and get that pretty whole number” (Meeting 10-part 2).

These transcript excerpts suggest development of an inquiry stance within the group. Early on this was modeled by experienced Lesson Study members and adopted by less experienced members as the group progressed, as evidenced by Brenda’s comment in the final reflection phase of Lesson Study. The Lesson Study process and especially the final steps of observing a research lesson followed by reflecting on evidence of student
learning reinforced the teacher mindset of inquiry stance. Experienced Lesson Study members in this group have internalized the inquiry way of thinking about teaching and learning for themselves and their students. The group process of Lesson Study facilitated the members coming together to embrace an inquiry way of thinking of the type described by Cochran-Smith and Lytle (2009).

**Summary of Group Learning Outcomes Within Lesson Study**

In this chapter, I examined the Lesson Study group as a whole. I looked at the patterns of change in the group as the Lesson Study meetings progressed. I observed that the group moved towards giving members a space to talk and roles to contribute to the group process. The group developed a style of talking that allowed the members to debate ideas and share expertise. The nature of the group talk facilitated opportunities for the group to develop shared values on use of the curriculum materials and pedagogical beliefs. From the group process, emerged an enthusiastic sense of commitment to the group goals evidenced by members doing extra beyond the scheduled meeting time.

Finally, there was evidence of a broadening of the group’s mindset to one of an inquiry stance towards their teaching practice and view of student learning. The evidence of their effectiveness as a group is that the members learned to come together to successfully complete a full cycle of Lesson Study.
CHAPTER 6: INDIVIDUAL TEACHER LEARNING FROM THE LESSON STUDY PROCESS

In addition to examining group changes as the members evolved to become a learning community in Chapter 5, I also sought to understand what the individual teachers learned through their engagement in Lesson Study. This analysis was guided by the four categories for teacher learning in my conceptual framework: mathematical knowledge, beliefs about teaching and learning, use of resources, and participation in the social practice. Data from the initial and final interviews with teachers provided the evidence of how the seven teachers perceived the impact of the Lesson Study experience on their individual learning. (See Appendix 1 for initial and Appendix 2 for final interview questions.) Also, the initial and final mathematical survey offered further insight about specific changes in the teachers’ mathematical knowledge. (See Appendix 3 for survey.)

I remind the reader of the theoretical framework of a sociocultural, situative view of learning. This guided my interpretation of how participating in the group process of Lesson Study could influence individual teacher learning. I see learning as a social process of the Lesson Study group. This chapter focuses on the individual teacher learning within three categories: mathematical knowledge, use of resources, and beliefs about teaching and learning. I also examine how the participation in the social practice, a group learning outcome, influenced the individual teacher learning. These categories and this relationship are identified in my conceptual framework.
Evidence of Individual Teacher Learning Related to Mathematical Knowledge

Interviews with teachers and mathematical surveys provided the data for me to consider teacher learning related to the mathematical knowledge of the individual teachers in this study. Changes that could be attributed to Lesson Study include teacher confidence and knowledge of mathematical content.

In my Chapter 2 literature review, I defined mathematical knowledge in this study using the theories of Ball, Thames, and Phelps (2008). Their research indicated the need for specialized content knowledge (SCK), which is unique to teaching. These researchers also described two domains of pedagogical content knowledge within their framework: knowledge of content and students (KCS) and knowledge of content and teaching (KCT).

I remind the reader that as discussed in my methods, Chapter 3, I chose to focus on these three areas of mathematical knowledge in my data collection and in my analysis. I did this because I believed them to be important areas of teacher knowledge for lesson design and reflection, two phases in the Lesson Study process. In the methods chapter I describe the construction of the survey questions as a way to examine the changes in the teachers’ mathematical knowledge through the two surveys, before and after the participation in Lesson Study.

Mathematical Confidence

In initial and final individual interviews with the seven teachers I asked each teacher how confident she/he was with the mathematical topic of study, Grade 8 linear equations. (See Appendix 1 for interview matrix.) They rated themselves with a 1-5 scale, with five being the highest level of confidence on the mathematical topic. In the final
interviews, I again asked each participant the same question with the same scale. *Table 6.1* shows the changes in the initial to final self-scores related to confidence in mathematical knowledge.

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Initial Score</th>
<th>Final Score</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Brenda</td>
<td>2</td>
<td>4</td>
<td>+ 2</td>
</tr>
<tr>
<td>Claire</td>
<td>4</td>
<td>3.5</td>
<td>- .5</td>
</tr>
<tr>
<td>Dan</td>
<td>3.5</td>
<td>4</td>
<td>+ .5</td>
</tr>
<tr>
<td>Ethan</td>
<td>4</td>
<td>4.5</td>
<td>+ .5</td>
</tr>
<tr>
<td>Farrah</td>
<td>3</td>
<td>4</td>
<td>+ 1</td>
</tr>
<tr>
<td>Gina</td>
<td>2.5</td>
<td>4</td>
<td>+ 1.5</td>
</tr>
</tbody>
</table>

Five of the seven teachers perceived an increase in their confidence in their mathematical knowledge through engaging in this Lesson Study. Three teachers reported their confidence in their mathematical knowledge had increased by .5 of a point to a 1 full point, revealing a small level of increased confidence. Two teachers, Brenda and Gina, perceived a larger impact on their confidence in mathematical knowledge with a 1.5 to 2 point increase on the five-point scale. One teacher, Amy, perceived no change in confidence in her mathematical knowledge. Interestingly, Claire rated herself lower on the scale of confidence about her mathematics knowledge, moving down from a 4 to a 3.5.

In the final interviews, I followed up these self-rankings of confidence in mathematical knowledge with the question, “Why do you score yourself with this
I also asked the teachers during their final interview, “Did your participation in Lesson Study impact your confidence in the mathematical content? If so, how?” Three teachers stood out in their ability to articulate their own learning process as related to mathematical knowledge developed through Lesson Study.

First, Gina, who gave herself a 1.5 point increase, articulated why she scored herself higher on confidence in mathematical knowledge at the end of the Lesson Study cycle. She reported that she now was able to solve the mathematical problems in the final survey, an example of specialized content knowledge (SCK). When asked if she increased in her math knowledge, Gina said, “Oh yes! I definitely did. I think I can tell from actually the [initial and final survey] question that you gave.” She added, “When I was doing it the first time …I had no idea… the second time I was actually able to do it.” In addition to a perceived increase in common content knowledge, Gina also said, “I think [I have] more in depth questions for myself.” She was describing a questioning stance for her own mathematical learning. A third aspect of Gina’s growth in mathematical knowledge was evident when she recalled in detail how one guest had analyzed a student’s solution. She described how this observer connected the math content to students’ learning, “I think he took it even further than what any of us were thinking. He really looked at how the students’ eyes were and that's how you really need to look when you're teaching” (Gina, Final Interview). Gina was noticing how this observer modeled an interpretive frame to analyze student’s solutions (Ball & Cohen, 1999). Gina was considering her knowledge of content and knowledge of students (KCS).

Another teacher, Brenda, who gave herself a 2 point increase, described in her final interview why she scored herself higher on mathematical knowledge at the end of
the Lesson Study cycle, “I feel like I understand more about how systems of equations are working”, an example of specialized content knowledge (SCK). Brenda reported that the conversations in the planning phase made her think about the problems, “those variables are changing and how challenging that can be for students” (Brenda, Final Interview). In this comment, Brenda was relating her knowledge of content to student knowledge (KCS). Brenda also shared how she learned that the stories in which the equations were embedded, such as the basketball problem, deepened students’ understanding. This understanding of learning mathematics embedded in a meaningful story is an example of Brenda reflecting on content knowledge linked to teaching (KCT).

Curiously, one teacher, Claire, scored herself lower in her confidence of mathematical knowledge by half a point at the end of the Lesson Study process. She explained how she grew to understand what she did not know. She now wondered aloud about the algorithm for solving systems of equations. She asked in her final interview, “Why does this even work?” She was inquiring about mathematical content knowledge for her own understanding and at a deeper level than she had prior to this Lesson Study experience. This was evidence of specialized content knowledge (SCK). She was less confident because she now knows there is more to know.

Although Claire was the only participant that perceived that her confidence in her knowledge of mathematical content had decreased as a result of the Lesson Study process, she was not the only one to report gaining greater access to what she did not know. Brenda and Gina also discussed the mathematical content learning they had obtained through Lesson Study and the questions they were left with about the
mathematics of linear equations. These teachers were offering evidence of additional learning in developing a self-awareness of what they now know and what they needed to learn about mathematical content.

Mathematical Knowledge

In addition to interview questions about confidence in the mathematical knowledge, I also examined the changes in the teachers’ mathematical knowledge through two surveys. As the teachers began the Lesson Study cycle, I administered an initial survey asking two main mathematics questions to understand each teacher’s mathematical knowledge. (See Chapter 3 on my methods for the survey design.) The first question in the survey asked the teachers to write a story problem for students to solve using a system of equations. The second question in the survey presented a system of equations problem and asked five sub-questions about this problem related to student learning and teaching. I list these main questions from the survey and the sub-questions in Table 3.3 in Chapter 3. I remind the reading that I linked the teachers’ responses to three categories for teachers’ mathematical knowledge identified by Ball, Thames, and Phelps’ (2008): specialized content knowledge (SCK), knowledge of content and students (KCS), and knowledge of content and teaching (KCT). After the Lesson Study cycle was completed, I then repeated the same questions in a final survey of these teachers to identify any changes in their mathematical knowledge. Table 3.4 in Chapter 3 describes how I created a scale with descriptors to capture the extent to which each teacher changed in her/his knowledge of mathematical content. I scored each teacher’s overall survey
responses from a 1 through 5 on the scale, five being the highest level of overall mathematical knowledge.

Table 6.2 illustrates a comparison of each teacher’s level of mathematical knowledge as presented in their initial versus final survey. The teachers came into the survey with various degrees of mathematical understanding about the topic of study, systems of linear equations. They also finished the Lesson Study cycle with various degrees of mathematical knowledge. My findings revealed changes between the initial survey and final survey for six of the seven teachers. One teacher, Claire, did not show any significant change in her responses.

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Initial Score</th>
<th>Final Score</th>
<th>Change</th>
<th>Area of Increase in MK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>1</td>
<td>3</td>
<td>+2</td>
<td>SCK, KCS</td>
</tr>
<tr>
<td>Brenda</td>
<td>3</td>
<td>5</td>
<td>+2</td>
<td>SCK, KCT</td>
</tr>
<tr>
<td>Claire</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>Dan</td>
<td>2</td>
<td>4</td>
<td>+2</td>
<td>SCK, KCS</td>
</tr>
<tr>
<td>Ethan</td>
<td>4</td>
<td>5</td>
<td>+1</td>
<td>KCT</td>
</tr>
<tr>
<td>Farrah</td>
<td>3</td>
<td>4</td>
<td>+1</td>
<td>KCT</td>
</tr>
<tr>
<td>Gina</td>
<td>1</td>
<td>3</td>
<td>+2</td>
<td>SCK, KCS</td>
</tr>
</tbody>
</table>

As I reviewed the teachers’ individual final surveys as compared to their initial surveys, I noticed patterns in the specific areas of growth in mathematical knowledge. Three teachers showed growth in their ability to offer insights into students’ possible responses to the problem (KCS). For example, Gina was only able to come up with one possible response initially, but was able to identify three more detailed student responses,
including a predicted misconception, in her final survey. Four teachers showed growth in their specialized content knowledge. These teachers had initially found difficulty creating a story problem for students that modeled a need for a system of equations as a solution. In his initial survey, Dan incorrectly used three variables for two equations. In the final survey this teacher was able to create a simple, but clear story-problem with two equations and two variables. This revealed learning in the area of specialized content knowledge (SCK), the ability to create mathematically correct problems for students. In example of growth in the area of content knowledge related to teaching, initially Brenda was not able to state a clear goal for student learning linked to solving systems of equations. However, in the final survey she was able to explain that students must be able to understand that one coordinate pair must satisfy the constraints of both equations in a system. She was also able to articulate how she would, through teacher questioning, address students’ misconceptions on this goal. Through the surveys, three teachers in this study showed evidence of learning how to decide what to do about student learning difficulties, or content knowledge and teaching (KCT).

As I reviewed the changes in the teachers’ confidence in their mathematical knowledge as compared to the evidence of changes in the mathematical knowledge from the pre and post surveys, I noticed some differences. (See Table 6.3.) For two teachers, the changes in mathematical confidence were similar to the changes in mathematical knowledge. However, for five participants, the data revealed a greater increase in mathematical knowledge than an increase in confidence in the mathematical knowledge. For example, though Amy did not perceive an increase in her mathematical confidence in her interview, her survey revealed a 2-point increase in her mathematical knowledge.
Interestingly, teachers’ perceptions of their change in mathematical knowledge did not consistently align with data collected through the surveys of their change in mathematical knowledge. (See Table 6.3.) Some of the participants increased their mathematical knowledge more than they thought.

Table 6.3: Changes in Mathematical Confidence Compared to Changes in Mathematical Knowledge for Each Participant

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Change in Mathematical Confidence</th>
<th>Change in Mathematical Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>0</td>
<td>+2</td>
</tr>
<tr>
<td>Brenda</td>
<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>Claire</td>
<td>-.5</td>
<td>0</td>
</tr>
<tr>
<td>Dan</td>
<td>+.5</td>
<td>+2</td>
</tr>
<tr>
<td>Ethan</td>
<td>+.5</td>
<td>+1</td>
</tr>
<tr>
<td>Farrah</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>Gina</td>
<td>+1.5</td>
<td>+2</td>
</tr>
</tbody>
</table>

The data from this study revealed an increase in confidence in mathematical content for five out of the seven teachers and an increase in mathematical knowledge for six of these teachers. The teachers showed growth in different areas of mathematical knowledge, SCK, KCS, and/or KCT. In her research, Liping Ma (1999) found that teachers need a profound understanding of mathematics, not just the ability to do math procedures. Deborah Ball (1996) posits that teachers need a deep understanding of student mathematical thinking. Teachers also need to understand the link between teaching and student learning (Ball, Thames, & Phelps, 2008). These different types of mathematical knowledge were intertwined in overall knowledge of mathematics related to the teaching practice.
Evidence of Individual Teacher Learning Related to Beliefs About Teaching and Learning

In this study, I conceptualized beliefs about teaching and learning into two aspects: beliefs about teaching mathematics and beliefs about student learning. I defined important beliefs as those that align with research on best practices in mathematics education. In my literature review, I found that best practices in mathematics education research emphasized student capacity for reasoning, teaching for understanding, teaching to facilitate student construction of knowledge, and teaching problem solving (Lesh & Zawojewski, 2007; Major & Palmer, 2001; Schoenfeld, 1992; Polya, 1945, 1980; Van de Walle, 2001). One component in teacher learning often cited in the literature involves teachers developing an inquiry stance towards teaching (Cochran-Smith & Lytle, 2009). Taking an inquiry stance involves teachers believing themselves to be learners and researchers in seeking out ways to improve teaching and learning. Teachers with an inquiry stance towards their teaching identify problems, ask questions, explore strategies, and evaluate their work.

I saw evidence that participation in Lesson Study offered the individual teachers opportunities to develop and refine their beliefs about teaching and learning. As the teachers investigated materials and planned a lesson collaboratively, they had the chance to offer their ideas with a rationale based on their beliefs about teaching and learning. Debating about the design of the lesson with others offered openings for the individuals to articulate beliefs about best practices in mathematics teaching. Interviews provided evidence that individual teachers perceived that Lesson Study had an impact on their beliefs about teaching and learning.
In initial and final individual interviews with the seven teachers, I asked questions about their perceived learning related to their teaching beliefs from their participation with others in Lesson Study. Initially, before the Lesson Study process, I asked each teacher about her/his view of best teaching practices. (See Appendix 1 for initial interview matrix.) In the final interviews, after the Lesson Study cycle was completed, I asked each teacher if he/she perceived any changes in beliefs about teaching and student learning from the Lesson Study experience. (See Appendix 2 for final interview matrix.) Although all seven teachers spoke about their beliefs about teaching and learning in the final interview, three teachers reported changes in their beliefs that they attributed to the Lesson Study experience. These three examples represent the ways that Lesson Study can impact teachers’ beliefs about teaching and learning.

Though Amy did not report that Lesson Study impacted her math knowledge or use of resources, she did see an impact on her beliefs about teaching. Amy expressed in her final interview how the Lesson Study process made her reflect on her own teaching beliefs. In contrast to her initial interview, she expressed now wanting students to uncover their own mistakes, “We don’t want to give them too much information” (Amy, Final Interview). This aligns with a discovery approach to teaching mathematics. Amy expressed an increased belief in students’ ability to reason on their own.

Brenda expressed that Lesson Study allowed her to share her beliefs as the group designed the research lesson. She thought that what the group embraced in the Lesson Study meetings often aligned to her beliefs about teaching. She suggested that articulating her beliefs aloud and listening to others’ beliefs helped to reinforce her
already held beliefs. Brenda also thought that the process made her reflect on her own beliefs about student learning when she returned to her classroom, evidence of an inquiry stance. She expressed her belief of planning lessons from a student perspective as they had done in Lesson Study,

I think that’s a big part of teaching through problem solving; it’s not just the lesson that you are doing and your objectives… that are so important. What are the students doing… all our discussions about that made me think about it more. (Brenda, Final Interview)

Claire reported an influence from Lesson Study on her beliefs about teaching. She referred to this particular Lesson Study cycle as well as the cumulative impact of her six years of Lesson Study experiences. She articulated what she believed she learned from Lesson Study: practicing her teaching goals and values, her inquiry stance, leading others as a teacher-leader, examining student thinking, and gaining new ideas to try out in her class. She said,

Then when you see it in action in Lesson Study, it is kind of that wake-up call again of, ‘Oh yeah, this is what makes me motivated as a teacher. This is what makes me happy when I’m teaching. This is what makes my students happy.’ It is so easy to get in a rut. It sparks that again. (Claire, Final Interview)

What Claire was expressing was her strong belief in the multiple benefits of Lesson Study.

The participants in this study were asked about how Lesson Study impacted their beliefs about teaching and learning. Their comments acknowledged that Lesson Study facilitated a reflection about beliefs. However, there was not compelling evidence that Lesson Study changed the participants’ beliefs.
Evidence of Individual Teacher Learning Related to Use of Resources

I remind the reader that in my Chapter 2 of my literature review I defined *use of resources* in this study as the ways teachers study and use their wide array of teaching resources, such as: local and national teaching standards, textbooks, supplemental materials, lesson plans, and instructional tools. In Chapter 4, I explained how in the investigation phase the Lesson Study group studied their textbook, examined how the curriculum, built learning through the grades, and compared their materials to other curriculum resources. In the planning phase, the members designed a manipulative tool, debated the use of the blackboard, and created multiple versions of a lesson plan. Interviews with teachers provided the data for me to analyze if the Lesson Study process had an impact on individual teacher’s learning to use teaching resources.

In initial and final individual interviews with the seven teachers, I asked questions about their perceived learning as related to their use of teaching resources. Initially, before the Lesson Study process, I asked each teacher which resource materials they typically use and which they find most helpful. (See *Appendix 1* for initial interview matrix.) In the final interviews, after the Lesson Study cycle was completed, I asked each teacher how they used resources in the Lesson Study process. I also asked if they perceived any influence on their future use of resource materials. (See *Appendix 2* for final interview matrix.) The interviews with teachers offered the evidence of the influence of Lesson Study on use of resources. Five teachers perceived influence on their use of resources. Two did not. Those that experienced influence did so in three different areas: the use of the classroom textbook, use of alternative textbooks, and use of the
board as an instructional tool. (See Table 6.4.)

Two teachers perceived learning related to the use of their own school textbook and materials, the *Connected Mathematics Program*. In her final interview, Gina commented on a new learning of the importance of studying her own textbook to choose the right problem to teach for student learning. Farrah reported that from exploring the previous grades’ *Connected Mathematics* materials she now understood how to connect her students’ learning to previous grade-level goals. Both of these were examples of teachers learning from the study of their own curriculum materials.

Five of the seven teachers reported learning from their interactions with the alternative resource materials, such as the Japanese textbook. They learned that outside resources might enrich their teaching. Dan reported in his final interview learning that the Japanese text was a rich resource for teaching through problem solving. Farrah also said that she would like to use the Japanese text to find challenging problems of the week for her classes. Claire reported that being exposed to different materials through Lesson Study made her want to improve the *Connected Mathematics* materials that she has been using. She explained how it helped her see different ways of teaching and motivated her to want to advance her practices. Gina, who teaches special education mathematics, and Ethan, who teaches regular education mathematics, both expressed learning how to use outside resources to improve their teaching. Gina said, “That's actually my goal for next year, to use more outside resources. I think going around and seeing what is out there. … is there a better problem out there that might influence my students’ learning and their styles” (Gina, Final Interview).

The most powerfully perceived influence of Lesson Study for the teachers was
about the use of the blackboard. Three teachers reported that the discussions about the board use had an impact on their future use of this instructional tool. Ethan said that the Lesson Study discussions around planning the blackboard, “definitely sticks in my mind more than anything else. What is the board going to look like?” (Ethan, Final Interview). Ethan said for the future he wanted to pre-plan the board space and use the board as a tool: to show multiple solutions, to summarize lesson, and to facilitate student note taking. He reported that learning about the board use was his “greatest learning” from the Lesson Study experience (Ethan, Final Interview).

Gina also spoke about the impact of the Lesson Study experience on her value of the board use. When asked about the impact of Lesson Study, she said, “for sure the board space”. Adding, “…I can tell I’m erasing a lot in my classroom and I don’t have enough [board] space. …I am trying to prepare better on where things are going to be [on the board]” (Gina, Final Interview).

Dan was another teacher who volunteered that the use of the board in the Lesson Study experience influenced his thinking. He recalled the detailed planning of the board space when the Lesson Study group was trying to figure out how to use the board to help the students understand the system of equations. Dan said he was so influenced by these conversations that he even spoke of the use of the board when he met with the principal for his end-of-year review. He reported this was the greatest area of impact for him from the Lesson Study experience.
Table 6.4: Perceived Increase in Learning by Each Participant on Use of Resources

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Classroom textbook</th>
<th>Alternative Textbooks</th>
<th>Blackboard as instructional tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brenda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claire</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dan</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ethan</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Farrah</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Gina</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

These teachers from the Lesson Study group reported various kinds of learning as a result of their interactions with the resource materials. The data suggested that the some teachers were influenced by interactions with their resource materials and in this way learned to use these materials to meet their own teaching needs.

Evidence of Individual Teacher Learning Related to Participation in the Social Practice

In this study, Chapter 2, I defined *participation in the social practice* as the group outcome of teachers taking part in Lesson Study as a professional learning community. In my conceptual framework, *figure 2.1*, I illustrated how the collegial aspect of the group process influenced the individual teachers’ learning. The group format offered the individual teachers the opportunities to learn from each other through discussions. Interviews with teachers provided the data of what the teachers perceived they learned from the social interactions as they investigated, planned, taught, and reflected on a
research lesson. This section focuses on the individual impact of the group learning to participate in Lesson Study on the teachers’ perceived learning.

In initial and final individual interviews with the seven teachers, I asked questions about the perceived learning from the participation with others in Lesson Study. Initially, before the Lesson Study process, I asked each teacher about her/his typical interactions with colleagues and if they viewed any benefits through these interactions. (See Appendix 1 for initial interview matrix.) In the final interviews, after the Lesson Study cycle was completed, I asked each teacher to describe his/her interactions during Lesson Study process. I followed up this question by asking if he/she learned anything from the others, from whom did they learn, and what they learned. (See Appendix 2 for final interview matrix.) The interviews with teachers offered the evidence of the influence of Lesson Study on their social practice. In reviewing the teachers’ final responses on this topic, after Lesson Study, all teachers perceived influence on their learning from the interactions with others. I categorized these responses into two central areas of learning: learning to have positive feelings for each other, or increased collegiality, and learning that fellow teachers could also teach and learn from each other.

Six out of the seven teachers expressed developing positive feelings about their colleagues as a result of the ten-meeting Lesson Study group experience. Three teachers communicated their positive feelings in terms of having enjoyed the others. Other individual comments included: feeling more comfortable, feeling closer, having respect for, and trusting. Two teachers perceived that they had built friendships, including getting closer to the other teachers and feeling less isolated. The two teachers who were not traditional classroom teachers both expressed feeling more a part of the mathematics
team after engaging in Lesson Study.

After the Lesson Study cycle, all seven teachers reported that they had learned from their peers. One teacher perceived that in addition to learning from her peers, she had taught her peers. I claim that the teachers in this study grew to see each other as learners and teachers of each other. The comments on new learning acquired as an outcome of the Lesson Study interactions included a variety of perceived benefits from the others’ expertise, such as the following. Brenda saw a benefit in hearing others’ perspectives and others’ goals. Claire said she learned from the cross-grade discussions and now speaks with a lower grade teacher about student learning. Farrah said she now would go to peers with math questions or teaching strategy questions. Two teachers said they learned particularly from Claire. In return, Claire said she found a benefit in sharing her understanding about Lesson Study with the others. Gina said she learned specific ideas from Claire and hoped to use these in her classroom. Dan said he now saw his colleagues as a resource, especially Claire. He explained,

I think [Claire] had really a lot to offer because she seemed to know a lot about Lesson Study. But also, she knew quite a bit about systems [of equations]. So I learned some things from her. But I think the main thing that I learned from everybody is that there is more than one way to teach a particular lesson. And both ways can be successful, and it really depends on what you want to get out of it. (Dan, Final Interview)

The experience of engaging in the social practice of Lesson Study taught the teachers that they could use each other as resources.

Summary of the Individual Teacher Learning from Lesson Study

Lesson Study has multiple potentials for learning. Through the group interactions
of the Lesson Study process the group was offered opportunities for individual teacher learning. In this chapter, my research was focused on examining the individual teacher learning with respect to four categories: mathematical knowledge, beliefs about teaching and learning, use of resources materials, and participation in the social practice. Within these four categories, different teachers reported different aspects of learning. *Table 6.5* presents the area of specific learning identified by each teacher, linked to the four categories of teacher learning. Overall my findings support the potential of the Lesson Study model for teacher professional learning. I found evidence of changes in mathematical confidence and knowledge, use of resources materials, and participation in the social practice that the teachers’ attributed to Lesson Study. Though I could not find evidence of changes in beliefs, teachers did perceive that Lesson Study helped them to reflect on their views in this area. Social participation in the Lesson Study learning community facilitated various aspects of learning for individual teachers.
Table 6.5: Perceived Learning by Individual Participant Linked to Four Categories of Teacher Learning and Area of Specific Learning

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Mathematical Knowledge</th>
<th>Beliefs about Teaching and Learning</th>
<th>Use of Resources</th>
<th>Participation in Social Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Areas of Learning:</td>
<td>Areas of Learning:</td>
<td>Areas of Learning:</td>
<td>Areas of Learning:</td>
</tr>
<tr>
<td></td>
<td>Mathematical Confidence (MC), Specialized Content Knowledge (SCK), Knowledge of Content and Students (KCS), Knowledge of Content and Students (KCS)</td>
<td>Belief about Teaching (BT), Belief about Student Learning, (BSL), Inquiry Stance (IS)</td>
<td>Classroom Textbook (CT), Alternative Textbooks (AT), Blackboard as Instructional Tool (BIT)</td>
<td>Increased Collegiality (IC), Learning From Peers (LFP)</td>
</tr>
<tr>
<td>Amy</td>
<td>SCK, KCS</td>
<td>BT</td>
<td>IC, LFP</td>
<td></td>
</tr>
<tr>
<td>Brenda</td>
<td>MC, SCK, KCT</td>
<td>BSL, IS</td>
<td>LFP</td>
<td></td>
</tr>
<tr>
<td>Claire</td>
<td>BT, IS</td>
<td>AT</td>
<td>IC, LFP</td>
<td></td>
</tr>
<tr>
<td>Dan</td>
<td>MC, SCK, KCS</td>
<td>AT, BIT</td>
<td>IC, LFP</td>
<td></td>
</tr>
<tr>
<td>Ethan</td>
<td>MC, KCT</td>
<td>AT, BIT</td>
<td>IC, LFP</td>
<td></td>
</tr>
<tr>
<td>Farrah</td>
<td>MC, KCT</td>
<td>CT, AT</td>
<td>IC, LFP</td>
<td></td>
</tr>
<tr>
<td>Gina</td>
<td>MC, SCK, KCS</td>
<td>CT, AT, BIT</td>
<td>IC, LFP</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 7: DISCUSSION

Participants in this study were able to practice a full cycle of Lesson Study as recommended by experts (Lewis & Hurd, 2011; Perry & Lewis, 2009; Takahashi & Yoshida, 2004). This case study offered insight into what Goldsmith, Doerr, and Lewis (2014) called the “black box” of teacher learning, by examining one cycle of Lesson Study as practiced by a group of U.S. middle school mathematics teachers. In the process, the teachers were able to access multiple aspects of learning including: mathematical knowledge, beliefs about teaching and learning, use of resources, and participation in the social practice.

There were three important insights about teacher learning within Lesson Study that educators could take from this study. The first was that different teachers learned different things as they engaged in the Lesson Study practice. This differentiation suggested the richness of Lesson Study as a learning model for teachers. The variations in learning could also be attributed to the fact that members each participated differently in the practice and started from different places in their own learning. The next insight was that there were identified evidence of group learning and evidence of individual teacher learning, which were interrelated in the learning process. The third insight was that there was evidence of group learning and individual teacher learning suggesting opportunities to learn (OTLs) within the Lesson Study experience. I expanded upon this third insight in this chapter, linking the evidence of group and individual teacher learning to the identification of OTLs in the activities of this Lesson Study. The data from this area also suggested that the most opportunities to learn were available to the teachers in the investigation phase of the Lesson Study cycle. This evidence has implications for the
application of Lesson Study in other settings.

**Teacher Learning Through Lesson Study**

In this study, the data revealed that the participants gained knowledge in different categories. (See *Table 6.5.*) No one teacher experienced learning in all four categories of learning. For example, Amy did not reveal an increase in learning mathematical knowledge nor perceive a change in how she would use her resource materials, but she acknowledged an increase in collegiality and learning from her peers. Claire did not perceive a change in her mathematical confidence but spoke about learning from the review of alternative resources. I posit that the richness of Lesson Study offered many openings for participants to learn at their individual levels and meet their individual learning needs. Just like an effective student lesson, Lesson Study offered differentiated learning for teachers. The beginners, like Gina, learned from experienced colleagues through legitimate peripheral participation; and the experienced colleagues, like Claire, learned how to be teacher-leaders (Lave & Wenger, 1991). I found evidence of individual teacher learning in three categories: increased mathematical confidence and mathematical knowledge, awareness of the uses of various resource materials, and learning to participate in the social practice. The data also suggested that Lesson Study offered the participants in this study an opportunity to reflect on their beliefs about teaching and learning. The members collectively learned to become a functioning group and gained group learning through participating in the social practice of Lesson Study.

The *knowledgeable other* for this Lesson Study group offered further richness to the learning experience for those ready to listen to expertise beyond the knowledge
contained within the group. For example, Dr. Yoshida explained the mathematics behind the system of equations algorithm and articulated the essence of the Lesson Study learning process of which he is a published expert (Fernandez & Yoshida, 2004; Takahashi & Yoshida, 2004). In the interviews, three participants, Claire, Dan, and Ethan, acknowledged learning from the knowledgeable other in the Lesson Study process. Dan explained in his final interview the impact that the knowledgeable other had on the group learning, “But when he came in as like as outside source, to kind of throw his ideas in, I felt like that was a good thing. Because … threw [in] his idea, which was one that we had gone back and forth on a couple times and it just forced us to think.”

Situated learning taking the form of professional learning communities like Lesson Study can be limited by the knowledge and expertise of the members (Takahashi & McDougal, 2016). The knowledgeable other expanded the group knowledge to a higher level with fresh ideas. This is why experts recommend to include a knowledgeable other in the Lesson Study learning community (Watanabe & Wang-Iverson, 2005).

**Group Learning and Individual Teacher Learning in Lesson Study**

Through my research, I also found that the participants in this study were able to access both group learning and individual teacher learning. These aspects influenced each other within the Lesson Study process. A revised conceptual framework, *figure 7.1*, now illustrates the interrelationship between group learning and individual teacher learning with the two-ended arrows. I believe that group learning and individual learning came together to allow the teachers to experience the fullest possible learning experience within this Lesson Study.
The individual teachers in this study brought to the group their knowledge and expertise. Even though this was at varying levels in this diverse teacher group, each could contribute what they knew about how to best teach the collective research lesson, thus influencing the group learning presented through the Lesson Study activities. The members took on roles to facilitate the group functioning. They were all active members as they engaged with the others to negotiate the creation of an effective research lesson. The active teacher-leader, Claire, shared her knowledge of best Lesson Study practices which encouraged the group to explore possible student responses to the proposed mathematical problem. The engaged note-taker, Amy, documented these student
responses in a model lesson planning template, helping the group to consider the lesson flow and how the teacher would response to these solutions. Gina, as an active listener, spoke when she could offer her expert knowledge of special education. These colleagues were resources for the group learning. The members influenced how the group functioned and became a high-quality professional learning community. Hiebert, Gallimore, and Stigler (2002) recommend the model of Lesson Study for just such opportunities for teachers to share their expert teaching knowledge with others.

Ultimately, this group of teachers in this study embraced the Lesson Study model and its purpose as a learning process. The power of the group format facilitated member motivation, enthusiasm, and creativity. Thus, the group learning was influencing the individual teachers. The morale of this group was also good as evidenced by times when they were joyful and laughing. This effective group Lesson Study setting was the basis for the individual teacher learning.

**Opportunities to Learn as Evidenced by Group and Individual Learning**

I posit that the interactions in the Lesson Study meetings were the pathways of learning opportunities for the teachers as they grew to function as a group and increase individual learning (Remillard & Geist, 2002). To further examine this underlying nature of the group and individual teacher learning in this study, I used the concept of opportunities to learn (OTLs) based Greeno and Gresalfi’s (2008) definition. These researchers described OTLs as the affordances that are available to the teachers as they engage in dialogue and interaction with resources. Greeno and Gresalfi suggest that OTLs can influence a learner’s participation and practice. Horn and Kane (2015) also
examined how OTLs within teachers’ collaborative learning activities supported change in future practice. These researchers found that active participation by teachers as they collectively struggled to learn contributed to the richness of the opportunities to learn for the group. OTLs took place during active deliberation and when teachers were making connections within their learning. I postulate that this was true for the Lesson Study participants in this study.

Using the evidence of group and the individual teachers learning from Chapters 5 and 6 as my data, I looked backward to examine the multiple opportunities for this learning for the participants as they engaged in the process of Lesson Study. OTLs are the activities in Lesson Study that provided teachers opportunities to struggle with their beliefs and/or make connections with new knowledge (Greeno & Gresalfi, 2008). I looked for activities with one or more of the following characteristics to guide my analysis of OTLs: exposure to new knowledge or different opinions, decision making or judgment calls, and questions interrupting the flow of the discussion process. I chose these characteristics because they invited further exploration, produced tension in the group, and required deliberation. These characteristics were similar to the characteristics used by Remillard and Geist (2002) in their research. These researchers also looked for openings in teachers’ work that enabled learning. I also drew from other research on learning opportunities for teachers (Grossman et al., 2009; Horn, 2005; Horn & Kane, 2015; Remillard & Geist, 2002). The following sections explain the OTLs embedded in the Lesson Study cycle that linked to my findings on group learning outcomes and then on the individual teacher learning. These were the OTLs members were exposed to in this Lesson Study and, if taken up, could have influenced the group and individual learning.
Table 7.1 links these identified OTLs that I found in my analysis with this group’s Lesson Study activities I presented in Chapter 4.

**OTLs Leading to Group Learning Outcomes**

In order to identify the specific OTLs in the Lesson Study cycle that participants may have taken up to lead to the group learning outcomes, I reviewed the evidence of group learning identified in my research of this Lesson Study team. In Chapter 5, I presented group outcomes of learning in four areas: changes in the nature of participation, changes in the nature of talk, changes in the commitment to the group, and changes in use of inquiry for instructional improvement.

The changes in the nature of participation of this group included changes in the amount of verbal participation by members. I looked for evidence of activities related to social dispositions and norms within the collegial interactions that were conducive for this type group learning; I found that in Meeting 1 and 2 this group learned from each other and the knowledgeable other about the norms and protocols of Lesson Study. These norms included allowing all members to express ideas and valuing all expressed ideas. As more experienced members of this group modeled these protocols early on in the first meetings, newer members of this group built knowledge of Lesson Study norms. The Lesson Study activities that connected to this group learning were: collaboratively brainstorming Lesson Study goals in Meeting 1 and learning about the Lesson Study cycle from the knowledgeable other, Dr. Makoto Yoshida, in Meeting 2. I identify these two activities as OTLs that precipitated the group learning to encourage verbal participation from all members.
Changes in the nature of participation of this group also included the members assuming roles as they participated in the social practice of Lesson Study. Roles such as teacher-leader and curriculum expert were organically developed as the members found a space to talk and a supportive function within the group. I found two specific Lesson Study activities in Meeting 5 that promoted this group learning to take on roles: members modeling norms for collaborative discussion and the practice of distributed leadership. However, this opportunity to learn a role within the group may have been a part of the ongoing activities as the members participated in the social practice of the full Lesson Study cycle.

Next, in my findings, I identified changes in the nature of the group talk. I found evidence of the nature of talk progressively changing from superficial talk to comfortable dissonance and debate. As the group became more comfortable and trusting, they were able to develop a culture of sharing expertise, debating ideas, and questioning teaching strategies. Activities such as debating guided instruction versus a problem-solving approach to math instruction in Meeting 6, discussing the use of a table in the lesson introduction in Meeting 7, and sharing individual concerns and struggles about the lesson design with the group in Meeting 8 were opportunities to learn how to interact in rich group discussions. These OTLs offered the members a chance to reflect and comment on debated topics thus facilitating group learning.

I also found evidence of changes in the way the teachers spoke of the textbook and resource materials. The group moved from speaking about the text as written, to analyzing the text, to changing how to use the text. Multiple activities in Lesson Study may have contributed to this evolution of group talk. Most of these took place in the
investigation phase of Lesson Study, in Meetings 2 through 4. By studying the curriculum materials together, reviewing the curriculum to determine the research lesson and focus problem, and comparing the curriculum to other resource materials the group had the OTL about the curriculum in a deeper way. I believe the study of the materials encouraged the group learning to analyze and use their resource materials in new ways.

The increased participation of the members and the rich nature of the talk enriched the opportunities to learn and the subsequent individual learning, described in more detail later. As one example, the high-level of group talk created an opportunity to learn through the collective examination of the curriculum materials. For individuals, like Farrah, this facilitated learning how mathematical knowledge was built in the previous grade-levels. This example also illustrated the interrelationship between OTLs, group learning, and individual teacher learning.

In addition, I found evidence of the group learning to use shared terms like “board space” and “teaching through problem solving”. Knowledge was socially constructed through the group participation in the Lesson Study community and in the group culture. As suggested by Cobb, Wood, Yackel, and McNeal (1992), the member’s made meaning of these shared terms within the social practice. There may not have been just one activity or OTL that led to the group finding meaning in these common terms; the full social practice of the Lesson Study may have encouraged this type of group learning outcome.

Finally, my findings pointed to an increased commitment to the group and the development of an inquiry stance as an outcome of the group learning to function more effectively. The agreement to add an additional meeting to the Lesson Study schedule,
Meeting 9, revealed the development of a group identity through the collective desire to present an effective research lesson. Many ongoing activities of this Lesson Study group may have supported the group members developing an inquiry view towards their practice. These included: developing and modeling group norms, engaging in repeated debates, and developing trust by sharing concerns. Since Lesson Study involves practitioners coming together to create a research lesson, it follows that all the activities would be OTLs to look at the teaching practice through a researcher lens. It may be difficult in both areas, learning to develop an inquiry stance and developing a commitment to the group, to point to just one OTL among the Lesson Study activities that facilitated this group learning.

In summary, I believe that my data in Chapter 5, suggesting that this group learned to function effectively, was influenced by many of the OTL activities presented in the Lesson Study cycle. OTLs taken up by the group led to increased group effectiveness. My theoretical framework of socio-cultural learning theory can explain how the teachers in this study accessed the group learning outcomes and the OTLs through the group experience of Lesson Study. My conceptual framework, in figure 2.1 and revised in figure 7.1, illustrates how the group moved from engaging in Lesson Study, to gaining group learning outcomes, to creating a culture of collaboration. It seems that areas of this group’s learning were influenced by the overall participation in the social practice of the activities involved in the Lesson Study cycle, though most of the specific OTLs that could be identified leading to group learning were focused in the investigation phase of Lesson Study, seven out of the fourteen noted. As the Lesson
Study group learned to function effectively, this facilitated more opportunities for learning and led to increased group learning, and eventually individual learning.

**OTLs Leading to Individual Learning Outcomes**

To identify the specific OTLs in the Lesson Study cycle that led to the individual learning outcomes, I examined the evidence of individual learning identified in my research. In Chapter 6, I described my findings of the outcomes of learning related to the individual teacher categories of learning presented in my conceptual framework: mathematical knowledge, beliefs about teaching and learning, use of resources, and participation in the social practice.

**Mathematical knowledge.** In my research, I found that some teachers perceived increased confidence in their mathematical knowledge after engaging in Lesson Study. The final survey revealed that some teachers also displayed evidence of increased content knowledge. Within the Lesson Study process, the group engaged in activities that offered opportunities to develop this mathematical confidence and knowledge of the content. Most of these activities took place in the investigation phase, followed by the planning phase of Lesson Study, and with some discussion of mathematical content knowledge related to students occurring in the reflection phase.

In the investigation phase of Lesson Study, I saw six specific activities involved in building teachers’ math knowledge: connecting classroom instruction to long-term goals, reflecting on students’ previous math knowledge, exposure to insights from the knowledgeable other about the chosen mathematics topic (solving a system of equations), solving mathematical problems together, discussing the mathematics in the solution
algorithm, and carefully studying how the curriculum materials developed student learning related to linear equations. Engaging in these activities involved exposure to new knowledge and posing questions in the group discussion. The group members had opportunities to build knowledge about mathematics through the sharing of expertise with the knowledgeable other and each other. The in-depth analysis of the systems of equations algorithm provided the group with opportunities to expand specialized content knowledge (SCK) unique to teaching (Ball, Thames, & Phelps, 2008).

In the planning phase of Lesson Study the teachers engaged in an effort to anticipate student solutions to the lesson and identify teacher responses to these various solutions. I identify this activity as an OTL because it led to a rich discussion involving mathematical content knowledge, both linked to students, KCS, and linked to teaching, KCT (Ball, Thames, & Phelps, 2008).

I claim that these extended times discussing anticipated student solutions in the investigation and planning phases, and comparing these to the actual student solutions in the reflection phase, provided the individual teachers with opportunities to learn from the various opinions of others on the topic of mathematical content. The opportunities to participate in discussions on student responses and hearing others’ verbalize their thinking offered opportunities to build knowledge of student learning. Ball, Thames, and Phelps (2008) define this as mathematical knowledge content related to students (KCS). Understanding possible student solutions and knowing how to respond is a type of knowledge needed for effective teaching, or mathematical knowledge content related to teaching (KCT). The members of this Lesson Study group took time to practice anticipating student solutions and teacher responses as a central element for planning a
lesson, offering important OTLs that built mathematical content confidence and knowledge related to students (KCS) and to teaching (KCT) for some members.

In the investigation phase of this Lesson Study the teachers participated in discussions about the mathematical content in the textbook and discussions about the mathematics involved in solving a system of equations. Six OTLs were identified in this phase related to the development of mathematical knowledge. In the planning phase, the members anticipated student solutions and generated teacher responses. Four OTLs were identified in this phase. One OTL was identified, as the group later discussed the actual student responses in the reflection phase. My research findings identified increased confidence and knowledge of mathematics content among the individual teachers in this study. I contend that OTLs within Lesson Study related to mathematical content knowledge, especially in the investigation phase, supported the individual teacher learning in this area. (See Table 7.1 for these identified OTLs linked to Lesson Study activities.)

**Beliefs about teaching and learning.** In my analysis of individual teacher learning I did not find clear evidence showing that this one cycle of Lesson Study had influenced changes in these teachers’ beliefs about teaching and learning. It follows that I cannot assert that the teachers accessed the opportunities to learn in this category since I could not document evidence of individual teacher learning outcomes. However, some teachers did perceive that Lesson Study helped them to reflect on their views in this category. I can identify the activities that *had the potential* to provide the opening to learn about beliefs related to teaching and learning, even though the data in this study did not show clear evidence of these activities leading to individual teacher learning.
As the teachers investigated materials and planned a lesson collaboratively, they had the chance to offer their ideas with a rationale based on their beliefs about teaching and learning. Deliberating about lesson goals, connecting goals to lesson design, and debating about the elements of the lesson with others offered openings for the individuals to articulate beliefs about best practices in mathematics teaching. As the teachers viewed the lesson taught to students, they could reflect on their own beliefs about teaching and learning in relation to the shared reference of the research lesson. Participating in post-lesson reflection offered the opportunity to consider the impact of lesson design on student learning and build an inquiry stance towards the practice of teaching. Interviews provided some evidence that three individual teachers perceived that Lesson Study helped them reflect on their beliefs about teaching and learning and reinforced their inquiry view. I claim that Lesson Study offered OTLs for the individual teachers to think about beliefs and develop beliefs which align with research-based best practices, even if there was not clear evidence that teachers took up these OTLs in this Lesson Study experience.

**Use of resource materials.** In my research, I found that some teachers perceived a change in the use of their resource materials after engaging in Lesson Study. These teachers perceived a change in three areas: use of their classroom textbook, use of alternative textbooks, and use of the blackboard as instructional tool. In the Lesson Study investigation phase the teachers engaged in many activities that offered opportunities to learn how to interact with resource materials in new and deeper ways. There was also one OTL in the planning phase that enriched the teachers’ understanding of a useful classroom resource tool, the blackboard.
In Meetings 1 through 4 the Lesson Study group spent extended time studying their resource materials, thereby supporting individual teacher learning of the curriculum and pedagogy through analysis of the textbook and other materials. Through this analysis, this group had the opportunity to study new knowledge as they explored the pedagogical philosophies presented by the authors. This work provided the group with vertical content knowledge by studying how the mathematics content was built up for students in previous grades (Shulman, 1986). The group had the opportunity to compare how their school textbook presented a topic versus other resources, like the Japanese text, an exposure to a different approach to the development of student learning. They deliberated, through group decision-making, on which problem in the multiple texts best met their goals for this research lesson. The activities involved in studying the curriculum in the investigation phase of this Lesson Study presented important OTLs because of the extended time dedicated to studying the materials, the exposure of new knowledge by studying the previous grade’s texts and alternative texts, and the deciding of the best problem from the resources to meet the lesson goals. This Lesson Study group spent extended time in Meetings 1-4 investigating their resource materials in ways recommended in Lesson Study literature of best practice (Lewis & Hurd, 2011).

Later in Meeting 8 and 9 of the planning phase, the group planned the use of the blackboard in the lesson in reaction to the group’s prediction of student responses. The activity of blackboard planning involved the group discussing how to use the board to document the progression of the students’ responses as they advanced to the solution of the math problem. This was identified as an OTL because the discussions exposed the group to new knowledge about the importance of the board as a teaching tool and led to
perceived individual teacher learning. Extended time was spent discussing the plan for
the board usage. After some debate, the group had to decide how to use the board in this
research lesson.

U.S. teachers typically do not consider planning ahead for board use and do not
focus on the board as a teaching tool for a lesson (Wang-Iverson & Yoshida, 2005).
Having this time in group collaboration was an opportunity for learning how to use the
blackboard as a tool for teaching and learning. I claim that through planning the board
space the group was learning the skill of how to use their resources to be responsive to
student thinking. The careful consideration and the thoughtful debates about the use of
classroom resources were unique learning opportunities, for which teachers often lack
time in their daily practice.

OTLs relating to the use of resource materials help teachers understand and use
their curriculum. I claim that through intensive examination of the materials the
individual teachers had the opportunity to learn more about the use of their resources.
The teachers spent the most time in the four investigation meetings studying their
resource materials. They examined how lessons were built on previous learning within
the curriculum and they compared multiple textbooks. They then built a lesson by
blending resources. The study of the curriculum was linked to the other OTLs in the
investigation phase. As the teachers discussed the mathematical content they used the text
as their main learning resource. They also spent some time planning the blackboard use
in the planning phase. Thus, the opportunity to learn from the curriculum materials in a
broad way was a primary OTL in Lesson Study as it took up the most time and was the
basis for the lesson design. I contend that the investigation phase of Lesson Study
presented multiple and the most significant OTLs for the teachers to consider how their use of resources in lesson design impacts student learning.

**Participation in the social practice.** In my research I found evidence of the influence of Lesson Study on the individual teacher’s social practice. All teachers in this study perceived influence on their learning from the interactions with others. I found two central areas of individual learning: learning to have positive feelings for each other and learning that fellow teachers could also teach and learn from each other. I posit that this change in collegiality influenced teachers’ access to the many activities presented in the collegial work of the Lesson Study cycle. OTLs taken up by the individual teachers led to changes in collegiality and how the teachers learned from each other. Since Lesson Study is about practitioners coming together to participate in the social practice, it follows that all the activities would be OTLs to improve collegiality.

However, I can also point to specific OTLs in three phases of Lesson Study that focused on teachers learning to participate in the social practice. In the investigation phase, the teachers had the OTL group norms and Lesson Study protocols. This OTL continued in the planning phase as the teachers practiced these group norms in their interactions. They also had the OTL the social practice of distributed leadership since the teachers themselves led the planning of this lesson. The activity of debating various elements of the lesson design was an opportunity to build trust among members. Finally, through the reflection phase the teachers had the opportunity to build a culture of sharing ideas about lesson design. I posit that these specific OTLs and the overall participation in the collegial activities of Lesson Study provided teachers with learning related to the social practice.
### Table 7.1: Identified OTLs Linked to Lesson Study Activities and Conceptual Framework

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Lesson Study feature and group activities</th>
<th>Opportunities to learn linked to conceptual framework</th>
</tr>
</thead>
</table>
| **Meeting 1**  
(1 hour) | **Investigation**  
- Collaboratively brainstormed Lesson Study goals. Including: a goal for student content, a goal for student learning, and a goal for teacher learning  
- Created a schedule of meetings |  
- Connecting classroom instruction to long-term goals for teaching (MK-KCT)  
- Reflecting on knowledge of students (MK-KCS)  
- Modeling group norms (PSP)  
- Reflecting on pedagogical values (B-T&L) |
| **Meeting 2**  
(1.5 hours) | **Investigation**  
- Learned about the Lesson Study cycle from ‘knowledgeable other’, Dr. Makoto Yoshida  
- Studied the curriculum materials together  
- Refined goals for this Lesson Study |  
- Building knowledge of Lesson Study norms and protocols (PSP)  
- Fostering knowledge of curriculum and pedagogy through analysis of the textbook (RM)  
- Understanding how lessons were built on previous learning within the curriculum (RM)  
- Creating long-term goals for teaching (MK-KCT) |
| **Meeting 3**  
(1.5 hours) | **Investigation**  
- Learned about mathematical content in the text related to student learning from Dr. Yoshida  
- Reviewed curriculum to determine possible research lesson and focus problem  
- Compared curriculum to other resource materials  
- Discussed the mathematics in the solution algorithm |  
- Building knowledge of mathematics through interactions with others and the knowledgeable other (MK-SCK)  
- Fostering knowledge of curriculum and pedagogy through analysis of the textbook and comparison of textbooks (RM)  
- Studying how lessons were built on previous learning within the curriculum (RM)  
- Building lesson based on existing resources (RM) |
### Meeting 4 (1 hour)  
**Investigation**  
- Reviewed curriculum to determine possible research lesson and focus problem linked to identified goals  
- Compared curriculum to other resource materials  
- Anticipated student solutions  
- Discussed the mathematics in the solution algorithm  
- Fostering knowledge of curriculum and pedagogy through analysis of the textbook and comparison of textbooks (RM)  
- Studying lessons as related to goals for improving teaching and learning (RM, B-T&L)  
- Building knowledge of student thinking by reflecting on anticipating student responses (MK-KCS)  
- Building knowledge of mathematics (MK-SCK)  

### Meeting 5 (1.5 hours)  
**Planning**  
- Created lesson plan template  
- Selected problem for research lesson  
- Solved problem collaboratively  
- Discussed anticipated solutions  
- Discussed lesson plan details: lesson introduction, use of manipulative, presenting student solutions, and partner work  
- Modeling norms for collaborative discussion (PSP)  
- Building knowledge of student thinking by reflecting on teaching strategies on math problem related to anticipating student responses (MK-KCT)  
- Practicing distributed leadership (PSP)  
- Sharing teaching beliefs by creating a lesson plan together (B-T&L)  

### Meeting 6 (2 hours)  
**Planning**  
- Revised lesson plan template  
- Discussed lesson plan details:  
  - teacher questioning  
  - resource materials as tools  
  - choice of words in the problem  
  - time for lesson activities  
  - presenting student solutions  
  - organizing student solutions  
  - important solutions  
  - use of manipulative  
  - partner work  
  - board use  
- Reflecting on elements of a lesson (B-T&L)  
- Debating guided instruction versus a problem-solving approach to math instruction (B-T&L, PSP)  
- Sharing teaching beliefs by creating a lesson plan together (B-T&L)  
- Continuing to debate guided instruction versus a problem-solving approach to math instruction (B-T&L, PSP)  
- Building knowledge of student thinking by reflecting on possible misconceptions and teacher responses (MK-KCS, KCT)  

### Meeting 7 (1 hour)  
**Planning**  
- Updated lesson plan template with anticipated student responses and an introduction  
- Discussed possible student misconceptions  
- Debated use of a table in the introduction  
- Sharing teaching beliefs by creating a lesson plan together (B-T&L)  
- Continuing to debate guided instruction versus a problem-solving approach to math instruction (B-T&L, PSP)  
- Building knowledge of student thinking by reflecting on possible misconceptions and teacher responses (MK-KCS, KCT)
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<th>Meeting 8</th>
<th>Planning</th>
<th>1.5 hours</th>
<th>Reflecting on lesson design by considering typically neglected elements (B-T&amp;L)</th>
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<td>Building knowledge of student thinking by reflecting on responses to possible student solutions (MK-KCT)</td>
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<td>Updated lesson plan template with possible teacher questions</td>
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<td>Developing trust with colleagues (PSP)</td>
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<tr>
<th>Meeting 9</th>
<th>Planning</th>
<th>1 hour</th>
<th>Developing a group identity through the collective desire to present an effective research lesson (PSP)</th>
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<td>Developing trust with colleagues (PSP)</td>
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<td>Building a common understanding of the use of the blackboard as a tool for presenting student solutions (RM)</td>
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<td>Members attended this additional meeting added at the last minute to make final revisions to the lesson plan.</td>
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<td>Watched the short introductory video created to engage students in the problem.</td>
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<td>Discussed the board use as connected to the flow of the lesson and presenting students’ solutions.</td>
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<td>Building a common understanding of the use of the blackboard as a tool for presenting student solutions (RM)</td>
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<tr>
<th>Meeting 10</th>
<th>Research Lesson</th>
<th>1 hour</th>
<th>Reflecting on beliefs of effective instruction through a shared reference, this research lesson (B-T&amp;L)</th>
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<td>Developing knowledge of students’ mathematical thinking through focused discussion on examples of student learning from observation (MK-KCS)</td>
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<td>Building a culture of sharing ideas about lesson design (PSP)</td>
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<td>Forming an understanding of the relationship between lesson design and student learning (B-T&amp;L)</td>
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<td>Building an inquiry stance towards teaching (B-T&amp;L)</td>
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<td>Research lesson was observed by the Lesson Study team, the facilitator, and the knowledgeable other</td>
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<td>Others also joined the team to observe the research lesson, including: other teachers from the district, district administrators, and educators from outside the district</td>
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<td>Observers collected data on the effectiveness of the lesson and student understanding</td>
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<td>Reflection- Post Lesson Discussion</td>
<td>1 hour</td>
<td>Reflecting on beliefs of effective instruction through a shared reference, this research lesson (B-T&amp;L)</td>
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<td>Developing knowledge of students’ mathematical thinking through focused discussion on examples of student learning from observation (MK-KCS)</td>
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<td>Forming an understanding of the relationship between lesson design and student learning (B-T&amp;L)</td>
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<td>Building an inquiry stance towards teaching (B-T&amp;L)</td>
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<td>Discussion immediately followed research lesson</td>
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<td>Began with instructor’s comments on effectiveness of lesson from his perspective</td>
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<td>Shared examples of student understanding and misunderstanding</td>
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<td>Analyzed the students’ solutions as related to the design of the lesson</td>
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<td>Listened to comments by outside guests and final reflections by the knowledgeable other</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Developing knowledge of students’ mathematical thinking through focused discussion on examples of student learning from observation (MK-KCS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Building a culture of sharing ideas about lesson design (PSP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Forming an understanding of the relationship between lesson design and student learning (B-T&amp;L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Building an inquiry stance towards teaching (B-T&amp;L)</td>
</tr>
</tbody>
</table>
Summary of OTLs in this Cycle of Lesson Study

The socio-cultural situated nature of the Lesson Study group made the regular teacher activities visible and available for evaluation by the group, thus creating opportunities for group and individual teacher learning. I believe that the OTLs in Lesson Study taken up by the teachers led to increased group and individual teacher learning. Lesson Study creates the conditions for reflection and rethinking of beliefs and knowledge. The Lesson Study model afforded the group and the individual teachers learning experiences within their situation, their classroom and school. The experiences within Lesson Study were similar and applicable to activities that the teachers do each day. The Lesson Study process involves breaking down the practice of designing a lesson into its smaller parts for the purpose of studying a lesson in detail. Grossman et al. (2009) call this decomposition of practice. The teachers in this study reviewed their resources and planned lessons. Traditionally, teachers do this alone. The study participants got a chance to examine collectively the importance of the often-overlooked details of planning a lesson, such as anticipating student responses and board use. The fast-paced, test-driven daily routine does not often allow teachers to get together and collectively analyze their practice. Through the learning opportunities (OTLs) within this group’s practice of Lesson Study, the teachers got a chance to experience how the details of lesson planning impacted student learning. Others practicing effective Lesson Study are likely to encounter similar OTLs.

In examining the opportunities to learn and the areas of perceived learning by the teachers in this study, I found that more learning was taking place in the investigation phase, followed second by the planning phase of Lesson Study. This conclusion aligns
with situated learning theory since these were the phases that involved more opportunities
to challenge teachers’ beliefs and knowledge (Wenger, 1998). Research has shown that
some U.S. educators are practicing Lesson Study at a less effective level and doing a
modified Lesson Study short cut by eliminating the investigation and planning phases
(Lewis, 2006). They are simply going into someone’s classroom to watch teaching and
then meeting to analyze the lesson. For those who begin to learn about Lesson Study, the
research lesson and reflection phases are the most visible phases. If some U.S. educators
are planning the research lesson together and eliminating the investigation phase they are
missing the intensive study of the resources and the substantial learning coming from that
interaction (Remillard, 2012; Remillard & Geist, 2002). If most of the learning for
teachers is taking place in the investigation phase, then the implication is that those U.S.
practitioners modifying Lesson Study are missing the most impactful teacher learning.

Lesson Study researchers suggest that the teaching activity of studying the
resource materials, called kyozaikenkyu in Japan, fosters knowledge of the curriculum
and links to instructional improvement (Watanabe, Takahashi, & Yoshida, 2008). In
English we do not have a word for the study of resource materials by teachers. The verb
we employ is “use” which does not imply the intensive study that kyozaikenkyu
encompasses. The lack of language is an obstacle to U.S. teachers understanding the
importance of this activity. This highlights the invisible nature of the study of resources
in the investigation phase for U.S. practitioners.

The discussion on OTLs embedded in this Lesson Study provides insight on the
foundation for the identified group learning and individual teacher learning in this study.
My original conceptual framework can then be revised to more clearly illustrate the link
between the activities in Lesson Study and the resulting teacher learning. Through my analysis of the OTLs in Lesson Study, I can connect specific phases of Lesson Study with the specific categories of learning. *Figure 7.1* presents this revised conceptual framework. OTLs that facilitated increased mathematical knowledge can be identified in the investigation, planning, and reflection phases. OTLs linked to learning the use teaching resources took place primarily in the investigation phase, followed by the planning phase. In this study I did not find evidence of changes in beliefs about teaching and learning, therefore I do not show a link to a phase in Lesson Study. A bold arrow now links the collective process of Lesson Study with the resulting group learning outcomes. This arrow points in both directions, to show the interrelationship between the group outcomes and the OTLs presented in the four phases of Lesson Study; as the group learned to function effectively from the Lesson Study experience their opportunities to learn were enriched. Another two-ended bold arrow links group outcomes with individual teacher outcomes. Not only did the socio-cultural nature of the group influence individual teacher learning, the individual teachers influenced the group learning by bringing their knowledge and expertise to the group.
CHAPTER 8: CONCLUSION- IMPLICATIONS FOR THE PRACTICE OF LESSON STUDY IN U.S. SETTINGS

In this study, I found that a group of middle school mathematics teachers were able to access multiple dimensions of teacher learning by practicing a full cycle of Lesson Study. I argue that Lesson Study improved teacher learning by increasing mathematical knowledge and confidence, reflecting on beliefs, building knowledge of resource materials, and strengthening participation in the professional learning community. The case study data revealed that the teachers used the Lesson Study model to uncover group learning and individual teacher learning. Lewis, Perry, and Murata (2006) recommended adding to the knowledge base of U.S. Lesson Study by generating more case studies as “local proof”. This case study adds to that “local proof” of Lesson Study as a vehicle to influence teacher learning. In this chapter, I include the limitations of this study, possible future research, implications for the practice of Lesson Study, and concluding thoughts.

Limitations

This case study on Lesson Study had several limitations, which I should acknowledge here. The first limitation was the focus on only one case of Lesson Study conducted over an eight-month period. This limited data collection to short-term changes in teachers’ knowledge related to the topics studied for this one research lesson, such as knowledge of linear equations, enhancements in use of materials, and participation in the group interactions. Research suggests that changes in knowledge and beliefs are built over-time (Hiebert & Stigler, 2004). Therefore, teachers may need to participate in multiple cycles of Lesson Study to experience changes in beliefs or have a more profound
impact on their use of curriculum materials. This constraint may have impacted obtaining data related to changes in teachers’ beliefs about teaching and learning, since beliefs may take more time to influence. In this study, one participant with a high-level of Lesson Study experience, Claire, expressed this type of cumulative effect of ongoing engagement in Lesson Study. However, since others in this study did not have such background it was unclear if Claire was experiencing the impact of Lesson Study differently than the others.

Another limitation concerns the issue of replication. In this study, I set out to understand how one Lesson Study group practiced Lesson Study and what they learned from this practice. I found that this middle school mathematics team was able to engage in effective Lesson Study that impacted their learning. This may have been accomplished because of support structures particular to this group. This group had the benefit of an experienced facilitator, committed to the philosophy of Lesson Study. He played a role in guiding the group to practice elements of Lesson Study such as early goal setting and the mathematical investigation of the algorithm. To replicate this case study you need the support of school leaders and someone who knows how to articulate all the power of Lesson Study. This group also included a knowledgeable other, who was an international expert on Lesson Study. Dr. Yoshida helped the group to study the mathematics built for students in their classroom textbook, as well as helping the group to compare their text to other textbooks. In addition, this group had one member, Claire, with more-than-typical knowledge and experience in Lesson Study. She internally encouraged the group to practice Lesson Study activities, such as board planning and anticipating student responses. Lesson Study groups may need support from others with Lesson Study experience and extended content knowledge to make sure opportunities for learning arise.
in the group process. Without such supports, a similar case study may not be produce similar results.

**Future Research**

Though Lesson Study may seem simple on the surface, a group of teachers planning and observing a lesson together, there is much more to this professional learning model. I chose to examine the teacher learning related to four categories, but there were others that could have been studied, such as the impact of the facilitator on teacher learning, the transfer of learning gained through Lesson Study on individual classroom practice, and the effect of a multi-year practice of Lesson Study.

There is more to understand about how a knowledgeable Lesson Study facilitator impacts the effectiveness of the practice and influences the teachers’ learning. I did not explore in this research how much the facilitator’s comments or questions impacted the learning of the group. Initially, the facilitator asked many questions to encourage the group to agree on goals and study the materials. Later, the facilitator took on the role as a co-planning member. He did this purposefully to encourage the teachers to be active participants in their own learning and develop an inquiry stance towards their teaching. His beliefs may have helped to facilitate increased learning but this was not researched in this study.

This study did not explore how the Lesson Study experience impacted teaching when the teachers returned to their individual classrooms. The teachers were asked about the influence of Lesson Study on their teaching, but classroom evidence was not collected to confirm these perceptions. Did the opportunity to analyze student learning with others
increase the teachers’ confidence in their own observations of their own students? Did Lesson Study motivate the teachers to go back to their classroom and try new strategies? Did the inquiry stance towards the practice of teaching continue for teachers as they planned and taught classroom lessons? It is unclear if the learning from Lesson Study would have directly translated into classroom practices for all members. Further research could examine if teachers were able to generalize their learning from Lesson Study to other lessons.

Yoshida (1999) explains that for Japanese educators, Lesson Study is practiced every year. It is ongoing and a part of what teachers do there. This study only looked at what the teachers learned through one Lesson Study experience. There were comments from Claire that her learning was more cumulative given her previous Lesson Study experience. The data revealed that this one Lesson Study cycle did not impact all participants in all learning categories. One Lesson Study cycle may not influence a dramatic change in teachers’ practice, knowledge, or beliefs. It is possible that the ongoing participation in lesson research through Lesson Study contributes to changes in the teachers’ learning. A study on multi-year practice of Lesson Study could show if this is true.

**Implications for Practice of Lesson Study**

The findings of this study offer implications for other educational leaders looking to implement Lesson Study in their schools. These include the following critical elements: adequate time to practice Lesson Study, access to rich curriculum materials, support of knowledgeable others, and school support for Lesson Study.
The teachers in this study spent fourteen hours together over eight months to engage in a full cycle of Lesson Study. Schools are often challenged to find time to allow teachers to work together. However, extended time is necessary for teachers to develop as a group and share knowledge. The teachers in this study were able to use contracted after-school PLC time to meet. School leaders must find time for Lesson Study within teachers’ professional workday in order to highlight the importance of Lesson Study as integral to professional growth.

In addition to investing time in Lesson Study, educational leaders must also provide teachers with useful resources to create rich lessons. The findings in this study suggest that Lesson Study provided openings for the teachers to learn from the resource materials, specifically in the investigation phase of the research lesson design. This Lesson Study group benefited from studying the cohesive and well-structured Connected Mathematics Program together. The members learned from each other how the mathematics was built for students through the grades. The shared resource materials helped this group develop vertical curriculum knowledge and added to their understanding of content knowledge related to students.

The teachers in this study were also fortunate to have access to an experienced in-house Lesson Study facilitator and an outside Lesson Study expert, a knowledgeable other. Both experts encouraged the group to practice Lesson Study effectively by attending to important elements. The facilitator guided the group to anticipate student thinking as they designed the research lesson. The knowledgeable other helped the group reflect on their own curriculum materials by comparing it to other resources. School leaders must tap expertise from a range of educators to enrich and expand teacher
Finally, this case study reveals that Lesson Study takes effort and requires commitment from teachers and their school leaders. Educational leaders in this study supported the teachers to effectively conduct a full cycle of Lesson Study. They did this by creating time for the teachers to meet within the school schedule, giving teachers the space to take the lead in their own professional learning, and celebrating the teachers’ efforts. It is a challenge to find support for a long-term professional learning model which progresses through incremental changes to produce deep improvements. This is especially true when school leaders are pressured to quickly raise students’ test scores. School administrators often react to these outside pressures by authoritatively monitoring teachers to use prescribed methods to instruct students. Lesson Study requires school leaders to share their authority in a more collaborative role with teachers as they seek to achieve best practices for teaching in order to improve student learning.

**Conclusion**

Part of my theoretical framework is the socio-*cultural* nature of viewing the Lesson Study learning process. The teaching culture in the U.S. has not always embraced collaboration (Darling-Hammond et al., 2009). The teachers in this study had to work through the traditional isolation to learn how to trust each other, collaborate, and work together to function as a group. This is a process and is ongoing throughout a career. U.S. educators are under criticism for not improving teaching and learning. However, they face obstacles to this improvement. Policies on merit pay and meeting student-growth objectives which are based on students outperforming others’ on standardized
assessments push teachers to not share best-practices and compete with their colleagues in the U.S., especially their closest teaching colleagues in their own department. These obstacles push up against the need to establish close communities of practice for learning to take place.

Another cultural problem in the United States is the disregard for teaching as a profession (Darling-Hammond et al., 2009). Lesson Study highlights the importance of what teachers do and what they need know to help students learn. The teachers in this study experienced the importance of what they do by examining the details that make up an effective lesson. The research lesson developed was worthwhile enough to be examined in such a detailed way and talked about at length by the teachers in this group and outsiders. This cycle of Lesson Study sheds light on all the details that teachers consider when designing a lesson, including examining various resource materials and choosing a useful problem for student learning. Some of these are often neglected in typical lesson planning and in educational research (Cobb et al, 2003).

Hiebert, Gallimore, and Stigler (2002) describe the need for a shared knowledge base to improve teaching and learning for the U.S. teaching profession. Lesson Study as a collaborative model of teacher learning serves as such a vehicle to create this knowledge base. Teachers interact with other teachers to share expertise and discuss concerns. Like the teachers in this study, Lesson Study can facilitate a shared language and knowledge that can support coherence in teaching practices grade-to-grade, thus supporting more consistent student learning. Lesson Study can also support teachers as they develop an inquiry stance towards their practice, since Lesson Study is a model based on practitioner research. If the teachers in this study continue to develop an inquiry mindset they can
build knowledge of new strategies, evaluate those strategies, and improve their teaching.

Stigler and Hiebert (2002) suggest that U.S. educators may need to alter Lesson Study to fit the U.S. culture. However, my study found that a group of U.S. teachers did not need to alter the Japanese Lesson Study cycle to practice it in a U.S. school. This group did need to overcome barriers in the U.S. educational system, but they were able to do so effectively. They found time after-school, learned to function collaboratively, and worked through competing goals from the school and state to engage in a full cycle of Lesson Study. They overcame U.S. cultural norms of isolation to learn to function as a group and access learning opportunities. Working through the barriers, these teachers came together to practice Lesson Study as recommended by Lesson Study experts (Lewis & Hurd, 2011; Perry & Lewis, 2009; Takahashi & Yoshida, 2004). This included recommended activities such as: using a knowledgeable other, deeply studying their resources, planning the board space, and inviting others to observe and comment on their lesson. The U.S. could benefit from learning from Asian educational culture supporting teacher collaborative learning versus teacher competition. Our educational culture in the U.S. may need to be modified to provide more support for teachers who want to learn from collaborative communities such as Lesson Study and work through the cultural barriers.
**APPENDIX 1: MATRIX OF INITIAL INTERVIEW QUESTIONS**

<table>
<thead>
<tr>
<th>Questions about: Background</th>
<th>Questions about: Mathematical Knowledge</th>
<th>Questions about: Beliefs about Teaching and Learning</th>
<th>Questions about: Studying Teaching Resources</th>
<th>Questions about: Collegial Interactions/ Participation in the Social Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many years have you taught math? What grade levels have you taught? What do you teach now?</td>
<td>What education and training have contributed to your knowledge of mathematics?</td>
<td>Think about the math lessons you taught last week. Can you describe one incident that demonstrates your best teaching of math? How does it illustrate your best teaching?</td>
<td>Think about a lesson you taught last week. Describe what teaching resources you used to plan that lesson and how you used them. Is this typical?</td>
<td>Think about your interactions with your colleagues during the previous week in school. Describe these interactions? Is this typical?</td>
</tr>
<tr>
<td>What college degrees have you obtained? What were your majors?</td>
<td>How confident are you with the mathematical content of linear equations in this Lesson Study? (Scale 1-5)</td>
<td>Can you recall a time when things did not go as well when working with students? If so, why do you think it did not go well?</td>
<td>In planning this lesson, what resources materials did you find most helpful? In what way?</td>
<td>In your experience this school year, how did you and your colleagues benefit from interactions?</td>
</tr>
<tr>
<td>Tell me about any previous experience with Lesson Study.</td>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
</tr>
<tr>
<td>Possible follow-up or probing questions during interview</td>
<td>Tell me more about what you learned about mathematical content in __.</td>
<td>Tell me more about that lesson or incident.</td>
<td>Tell me more about how you use __ to plan a lesson.</td>
<td>How frequently does this interaction occur?</td>
</tr>
<tr>
<td>Tell me more about __?</td>
<td>Why did you score yourself at __?</td>
<td>When the lesson well/not well, how did you explain that to yourself?</td>
<td>What parts of __ do you use and how?</td>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX 2: MATRIX OF FINAL INTERVIEW QUESTIONS
(Revised after proposal)

<table>
<thead>
<tr>
<th>Questions about: Overall Lesson Study Experience</th>
<th>Questions about: Mathematical Knowledge</th>
<th>Questions about: Beliefs about Teaching and Learning</th>
<th>Questions about: Studying Teaching Resources</th>
<th>Questions about: Collegial Interactions/Participation in the Social Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you like about this cycle of Lesson Study? What did you dislike?</td>
<td>Did your participation in Lesson Study impact your mathematical knowledge? If so, how?</td>
<td>Did your participation in Lesson Study influence your beliefs about teaching? How?</td>
<td>Think about the planning of the research lesson. Describe how you investigated teaching resource materials?</td>
<td>Think about your interactions with your colleagues during the Lesson Study. How would you describe these interactions?</td>
</tr>
<tr>
<td>Do you think this Lesson Study had an impact on your learning? In what ways?</td>
<td>Following the Lesson Study, how confident are you with the mathematical knowledge of linear equations? (Scale 1-5)</td>
<td>Did you participate in Lesson Study influence how you think about students’ learning? How?</td>
<td>Did your participation in Lesson Study influence how you think about or use your resource materials? If so, how?</td>
<td>Did you learn from your colleagues by engaging in Lesson Study? What did you learn and from whom?</td>
</tr>
<tr>
<td></td>
<td>I noticed ___ during the Lesson Study process. Tell me more about that.</td>
<td>I noticed ___ during the Lesson Study process. Tell me more about that.</td>
<td>I noticed ___ during the Lesson Study process. Tell me more about that.</td>
<td>I noticed ___ during the Lesson Study process. Tell me more about that.</td>
</tr>
<tr>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
<td>Possible follow-up or probing questions during interview</td>
</tr>
<tr>
<td>Do you think your Lesson Study experience will impact your classroom teaching? If so, how?</td>
<td>Why did you score yourself at ___?</td>
<td>Do you think Lesson Study can improve teaching and learning, and if so, how?</td>
<td>Tell me about how you will use teaching resources in the future.</td>
<td></td>
</tr>
<tr>
<td>Will you continue to engage in Lesson Study?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 3: TEACHER’S SURVEY QUESTIONS

Initial and Final – Questions about Mathematical Knowledge
On Lesson Study Topic of Solving Simultaneous (Systems of) Linear Equations

1. Imagine you are teaching solving simultaneous linear equations, otherwise called ‘systems of linear equations’. To make this meaningful for students, sometimes teachers try to come up with a real-world situation or story-problem to show the application of some particular piece of content. Please come up with a problem for your students on this math content. What would you say would be a good story or model for this problem?

2. Melissa and Trevor sell candy bars to raise money for a class field trip. Trevor sells one more than five times as many as Melissa sells. Together they sell 49 candy bars. Find the number of candy bars each student sells.

   a. What are the ways students may try to solve this problem?
   b. What mistakes do you think students may make?
   c. How would you address those mistakes?
   d. What are the goals of asking students to solve this type of problem?
   e. What are the important ideas that you want students to understand about solving systems of equations?

**Question 1 adapted from:** (Ma, 1999, p.55)

**Question 2 source:** (Lappan, Phillips, Fey, & Friel, 2014, p.41)

**Other reference:** (CCSSI, 2010)

- **CCSS.MATH.CONTENT.8.EE.C.8**
  Analyze and solve pairs of simultaneous linear equations.

- **CCSS.MATH.CONTENT.8.EE.C.8.A**
  Understand that solutions to a system of two linear equations in two variables correspond to points of intersection of their graphs, because points of intersection satisfy both equations simultaneously.

- **CCSS.MATH.CONTENT.8.EE.C.8.B**
  Solve systems of two linear equations in two variables algebraically, and estimate solutions by graphing the equations. Solve simple cases by inspection. For ex/, 3x + 2y = 5 and 3x + 2y = 6 have no solution because 3x + 2y cannot simultaneously be 5 and 6.

- **CCSS.MATH.CONTENT.8.EE.C.8.C**
  Solve real-world and mathematical problems leading to two linear equations in two variables. For example, given coordinates for two pairs of points, determine whether the line through the first pair of points intersects the line through the second pair.
“How Many Shots Did She Make?”
Grade 8 Mathematics Lesson Plan

Date: March 28, 2017
Class: Math Grade 8
Number of Students: 17
Planning Team Members: Amy, Brenda, Claire, Dan, Farrah, Gina, and Facilitator
Instructor: Ethan

1. Lesson Title: How many shots did she make?

2. Goals of the Lesson
   A) Introduction to and developing the understanding of a solution to a system of equations.
   B) Student perseverance.
   C) Making mathematical thinking visible.
   D) Provide opportunities for students to recognize the importance of presenting, listening, and discussing solution ideas in order to improve problem solving skills and learning.

3. Instruction of the Lesson—Process of the Lesson

<table>
<thead>
<tr>
<th>Student Activities, Teacher’s Questions and Anticipated Student Reactions</th>
<th>Teacher Support and Things to Remember</th>
<th>Points of Evaluation</th>
</tr>
</thead>
</table>
| 1. Introduction (3 min.)
Basketball highlight video |  | Are there any students confused about basketball’s point system? |
| 2. Posing the problem (5 min.)
In a basketball game, (Brenda) made a total of 10 shots and scored 24 points. How many 2-point shots and how many 3-point shots did she make? Show and explain your mathematical thinking. | Present to students that an important part of the problem is showing their math thinking. | Do the students understand the two given conditions? |

-What does it mean to make 10 shots?
### 3. Solving the Problem (12 min.)

<table>
<thead>
<tr>
<th>Individual work time (4-5 minutes)</th>
<th>Students are asked to first work independently on the problem for 3-5 minutes, then share and work with partner.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Extension</em> disproving other solutions</td>
<td>What methods are they using to solve the problem?</td>
</tr>
<tr>
<td>Share with group of 2 students (4-5 minutes)</td>
<td>Students can present organizational strategy.</td>
</tr>
<tr>
<td></td>
<td>How are they organizing their data?</td>
</tr>
<tr>
<td></td>
<td>-Random guess and check</td>
</tr>
<tr>
<td></td>
<td>-table?</td>
</tr>
<tr>
<td></td>
<td>-systematic guess and check</td>
</tr>
<tr>
<td></td>
<td>-Wrong answer focused on making 24? (Ex: 9 and 2)</td>
</tr>
<tr>
<td></td>
<td>Show one strategy that only works for 24 and another that only works for 10</td>
</tr>
<tr>
<td></td>
<td>What needs to be true about the two values? Is there an algebraic way to represent the pattern in the table? ((x + y = 10) \text{ or } (2x + 3y = 24))</td>
</tr>
<tr>
<td></td>
<td>How is this type of problem different from other problems we have solved before?</td>
</tr>
<tr>
<td></td>
<td>Do students understand that there are now two conditions?</td>
</tr>
<tr>
<td></td>
<td>Make sure students are showing 2 times (x) and 3 times (y) when showing total points</td>
</tr>
<tr>
<td></td>
<td>Do we need two different variables? Why?</td>
</tr>
<tr>
<td></td>
<td>Be sure students clearly define the variables.</td>
</tr>
</tbody>
</table>
4. Student Presentations and Discussions (20 min.) Students share their strategies on the document camera

Anticipated Student Responses for problem solution:

**Random guess and check**
- Student has no organized structure to their mathematical thinking on the solutions they choose.
- Students test very few solutions

**Strategic guess and check**
- Students start with 5 and 5, which yields a result of 2(5) + 3(5) = 10 + 15 = 25. Realizing they need 24 points, they argue that if they increase the two point shots and decrease the three point shot it will be a net zero of negative 1 points resulting in 24 points. So 2(6) + 3 (4) = 12 + 12 = 24.

**A variety of organizational strategies (i.e.: table)**

<table>
<thead>
<tr>
<th>x</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

Anticipated Student Responses for equation writing:

- x + y = 10 only
- 2x + 3y = 24 only
- x = 10 - y
- y = 10 - x
- x + y + 2x + 3y = 24

Correct Answer:  
\[
\begin{align*}
x + y &= 10 \\
2x + 3y &= 24
\end{align*}
\]

Ask students to present their solutions.

Contrast and discuss the methods presented on document camera.

Are the students able to represent the conditions algebraically?

Highlight one strategy that only focuses on finding the solution to the 24 equation and one solution that focuses on the solution to the 10.

Do the students understand the two algebraic equations?

Have students write equations on board after collaborating in groups.

How many solutions are there?

How can we represent the two conditions algebraically?

Do fractions and negative values make sense for solutions in regards to the situation?
5. Summary of the Lesson (5 min.)

Reflectio:n: SIDE 1- Miss O’Halloran made 9 shots and scored 27 points. Could she have made three 2-point shots and seven 3-point shots? Explain or show your mathematical thinking.
SIDE 2- Denise wrote the following system of equations to represent a basketball story:

\[
\begin{align*}
\text{x} + \text{y} &= 7 \\
2\text{x} + 3\text{y} &= 16
\end{align*}
\]

a) Using the algebraic equations above, how many shots were made and how many points were scored?

b) Denise gave a solution of (5 , 2). Is she correct? Show or explain your mathematical thinking.

Homework Problem: At the end of the 2nd quarter she made another 10 shots but this time she scored 29 points, does the solution to the system of equations change? Why?

4. Evaluation of the Lesson:
- Did the students recognize and understand different solutions?
- Did they think deeply and learn from each other through presentations and discussion?
- Was the board space used effectively to present multiple strategies?

5. Example Board Layout

<table>
<thead>
<tr>
<th>Basketball Problem Posed on post-it</th>
<th>Focus on 10 shots</th>
<th>Focus on 10 shots AND 24 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex: 5+5=10</td>
<td></td>
<td>2(6) + 3(4) = 24</td>
</tr>
<tr>
<td>Focus on 25 points Ex: 2(9)+3(2)=24</td>
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</tbody>
</table>

Students will leave reflections on their desks and raise their hand when ready for HW.

Did the students meet the lesson goals?
Lesson Reflection

Side One
During the first quarter of a different game Miss A made 9 shots and scored 27 points. Could she have made three 2-point shots and seven 3-point shots? Explain or show your mathematical thinking.

Side Two
Denise wrote the following equations to represent a basketball story:

\[ x + y = 7 \quad \text{AND} \quad 2x + 3y = 16 \]

a. Referring to the algebraic equations above, how many shots were made and how many points were scored?

b. Denise gave a solution of \( x = 5 \) and \( y = 2 \). Is she correct? Show or explain your mathematical thinking.
Homework Problems

1) Determine if the given values for $x$ and $y$ are a solution of the system of equations. Explain your mathematical thinking to justify each answer.

a. $x + 2y = 6$ AND $x - y = 3$ when $x = 4, \ y = 1$

b. $x - 2y = 4$ AND $3x + y = 6$ when $x = 10, \ y = 3$

c. What does it mean for values of $x$ and $y$ to be a solution to a system of equations?

2) A test has 20 questions worth a total of 100 points. The test consists of True/False questions worth 3 points each and multiple choice questions worth 11 points each. Write a system of equations to represent the situation that could be solved to determine the total number of true/false and multiple choice questions contained on the test. Let $x$ represent the total number of true/false questions and let $y$ represent the total number of multiple choice questions.
BIBLIOGRAPHY


