TEACHER LEARNING THROUGH THE DIALOGIC SPACE OF A LESSON STUDY CYCLE

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Lesson study is a Japanese practice where teachers conduct a systematic inquiry into their pedagogical practice by closely examining a lesson and its delivery. Lesson study in the U.S. has become a more generalized term for similar collaborative cycles that vary greatly, based on their context. Professional development modalities in the U.S. can be one-dimensional and lack sustainability without ongoing support. There is a need for professional development that nurtures teacher learning, reflection and growth in an ongoing, authentic and supportive environment. This study will explore teacher dialogue and reflection, and any resulting learning and growth, during a lesson study cycle, interpreted from a Japanese lesson study framework.

The study will focus on the dialogue during the lesson debriefs through an analysis of the comments - their depth of reflection, their role in the conversation (i.e., building, providing evidence, questioning, challenging or supporting) and their contribution as a dialogic or supportive move. Participant post-study reflections will also be analyzed for their depth of reflection. Teacher observation notes will be analyzed for observed mathematical practices. An analysis of the data through qualitative and quantitative lenses will attempt to determine if the dialogic space of a community of practice engaged in lesson study can be an effective forum for encouraging and generating teacher reflection and growth. Of particular interest in this study, is how professional dialogue influences each participant's reflective insights on their own practice and contributes to the development of a collective knowledge base.

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Preface

A journey of a thousand miles begins with a single step (Chinese proverb). The dissertation process has been a journey of many single steps towards coming to know and coming to be. I have deep appreciation for those who walked ahead of and beside me throughout the process. May this study be an inspiration to those who will walk behind me with their work.

- My family - for their support and encouragement of my studies and career, and for being patient as I learn how to balance life
- My administrative colleagues, past and present – for seeing something in me and my work, and for encouraging me to pursue Educational Leadership and to achieve the Ed.D.
- My colleagues and "school family" – for embodying a spirit of collaboration and team commitment, and for what they have taught me about effective teaching and learning, meaningful professional development and reflection
- My dissertation committee – for sharing so much of their expertise and insight, guiding my exploration of this topic
- My children and my students – may this be an example of life-long learning and persistence, and may your educational journeys be enhanced as a result

1.0 Introduction

Four kindergarten teachers, seated in tiny student chairs at a hexagon-shaped table, are huddled around a laptop, viewing a YouTube video. A bustle of dialogue and activity ensues, as they brainstorm ideas and select materials, like Unifix cubes, picture books, crayons, and worksheet activities. While it may sound like preparation for a traditional math lesson, it is really a team of teachers engaging in a lesson study cycle[1]. The video and supplies are part of a research lesson designed to introduce students to the concept of decomposing numbers and to engage the teachers in collaboration and reflection focused on teaching and learning.

1.1 Background of the Problem

The current field of education is cluttered with white noise - state and federal mandates, a flood of instructional materials, ever-changing technology, an increase in the basic needs of our students and time constraints. Teachers, who often find themselves teaching in isolation, can be overwhelmed, limiting their capacity to be reflective and effective in their practice. Professional development modalities can be one-dimensional - taking the form of a workshop or consultation, where a perceived expert delivers pre-packaged, scripted training, aloof from the teachers' context,

[1] Lesson study is a process developed in Japan that brings together teachers to collaborate on a research lesson - writing it, teaching it, observing the students, reflecting upon it and revising it, teaching it again, reflecting upon it and revising it again.

and often for the initial part of implementation, without ongoing support. These approaches can lack rich dialogue, in a sustained environment.

1.2 Statement of the Problem

There is a need for professional development that nurtures teacher learning, reflection, and growth in an ongoing, authentic, and supportive environment. This study will explore teacher dialogue and reflection, and any resulting learning and growth, during a lesson study cycle, interpreted from a Japanese lesson study framework. It will attempt to determine if the dialogic space of a community of practice engaged in lesson study can be an effective forum for encouraging and generating teacher reflection and growth.

1.3 Purpose of the Study

This study will explore the experiences of teachers as they engage in a professional development process known as lesson study, in an attempt to determine how, if at all, professional dialogue can deepen teachers' reflections about their own practice. A team of kindergarten teachers will facilitate a lesson study process, presenting in this study as the following steps: (1)

selection of a topic; (2) collaboration to research and write a lesson plan;[2] (3) observation of students while one teacher teaches the lesson; (4 & 5) analysis, reflection, and lesson revision during a team debrief; (6) observation of students while a second teacher teaches the lesson; (7) analysis, reflection and lesson revision during a second team debrief; and (8) a final reflection.

This lesson study cycle will occur within one month during the spring of the school year surrounding a math lesson on decomposing numbers within 10. There are several motives for this focus area. We have recently adopted a new primary text for math instruction - the opportunity to collaborate on the a lesson has the potential to increase the teachers' content knowledge, thoughtful decision-making and reflective action teaching math with the strategies introduced in the new text. In addition, the hands-on, collaborative nature of math problem-solving creates a forum for rich student dialogue and opportunities for utilizing multiple strategies or approaches. The observation and study of the students during a live lesson provides a different lens through which teachers can see their students.

Of particular interest in this study, is how professional dialogue influences each participant's reflective insights on their own practice and contributes to the development of a collective knowledge base. In Pennsylvania, teachers are evaluated with a clinical observation or differentiated supervision - where they choose from the following modes: Professional Learning Community (PLC), action research, peer observation or portfolio. Lesson study is engaged by a Community of Practice (akin to a PLC), naturally involves action research, is an enriched approach to peer observation and can document a process towards an exemplar lesson and deep reflection

[2] In this study, a lesson plan is a document that outlines the learning objectives, aligning PA Core standards, essential questions, student demographics, assessments, instructional sequence, instructional materials, and researched resources.

(in a portfolio format). This creates a dialogic space for lesson study within the greater framework of professional development, supervision, and evaluation.

1.4 Research Questions

The potential lesson study has for positively impacting teacher professional development, with specific emphasis on student observation skills and reflection through dialogue is significant. Context matters. For this potential to be fully realized, the conditions that support lesson study must be considered and a system of sustainable support must be established. This study attempts to address these elements through the exploration of four research questions.

RQ1: What is the story of lesson study: Japanese roots and the movement in the U.S.?

RQ2: How does lesson study support professional development for teachers? What is the incentive for teachers to choose to participate in a lesson study cycle?

RQ3: What happens when a team of teachers engages lesson study?

RQ4: What are the lessons learned from engaging in lesson study?

1.5 My Story

I have encountered lesson study multiple times in my career and it continues to resurface in professional experiences. My first introduction was while reading *The Teaching Gap* by Stigler and Hiebert (1999). I have continued to feed my interest by reading about it in professional journals and guidebooks by practitioners who have translated lesson study experiences for

American teachers.

I experienced professional sharing at Japanese-American teacher exchange meetings during a study abroad trip sponsored by the Japan Memorial Fulbright Program (JMF) in July of 2008. The purpose of the program, funded by the Japanese government, was to connect Japanese teachers and American teachers in a forum for professional exchange. The Japanese education system, from preschool to university, emphasizes continued professional growth and the sharing of effective practices[3], a core part of the JMF program.

My American teacher colleagues and I visited a university, high school, middle school, primary school, and kindergarten. Each school visit involved classroom observations, school tours, interaction with students and an open conversation with teachers from the institution. While lesson study was not a component of the study trip, classroom observations and professional dialogue - key components of lesson study - were significant parts of the school visits. During these professional dialogues, it was evident our Japanese host teachers were just as interested in learning about American approaches to teaching and learning, as we were eager to learn from them. I can vividly picture two lines of tables facing each other. The Japanese educators sat along one side and the American educators sat along the other side, bridged by our translators, who kept busy as we tried to squeeze as many questions and conversations into our short time together. This mindset of continuous growth and development lays a firm foundation for the work of lesson study, where teachers collaborate to learn from their students and from each other.

[3] Lesson study was well-established as a strategy for in-service teacher training by the middle of 1960s (Makinae, 2010).

During my time as an administrator, I have been committed to building a collective knowledge base with my staff and to integrating collaborative learning experiences into our professional development. I see the potential for lesson study to help structure professional collaboration in a way that helps teachers share their expertise and their learning with each other. It can be a vehicle for collaboration, professional growth, and reflection.

1.6 Definition of Lesson Study

Lesson study, as conducted in Japan, follows a widely-accepted process and often fulfills any of three purposes: (1) to solve an educational problem through the development of new curriculum or instructional approaches, (2) to enable individual practitioners to freshly examine their own practice in order to improve it, or (3) to stimulate a shared community of practice amongst teachers within a setting (Ishikawa et al., 2001; Lewis, 2002c). Mathematics educator, Takahashi Nakamura, notes that the purpose of the lesson study shapes the process (Lewis, 2002c). Lesson study in the U.S. is a more generalized term that is loosely used to name interpretations or adaptations of the Japanese approach.

1.6.1 Forms of Lesson Study in Japan

Lesson study is a translation of the Japanese term, "*jugyou kenkyuu*," where "*jugyou*" means "live instruction" and "*kenkyuu*" means "research" or "study" (Isoda, Stephens, Ohara, & Miyakawa, 2007). At its origin, lesson study is a Japanese practice where teachers conduct a

systematic inquiry into their pedagogical practice by closely examining a lesson and its delivery (Fernandez, 2002).

There are multiple forms of lesson study in Japan, each serving different purposes (Fujii, 2016; Lewis, 2000, 2002c, 2016). School- or district-based lesson study ("kounai kenkyuu jugyou") is nearly universal in Japanese schools (NEPRI, 2011). It is conducted by schools 1-3 times a year, is engaged by grade levels or content areas, and often centers on a school-wide research theme (Fernandez & Yoshida, 2004). These studies can take place within a school or involve cross-school teams across a district (Lewis, 2002c). Japanese elementary teachers are generalists who teach all content areas, so lesson studies provide opportunities to deepen their knowledge of a content area and to share their learning with their study group (Murata & Takahashi, 2002). These types of lesson studies contribute to a shared vision of education and to systematic and consistent instructional and learning improvement (Watanabe, 2011).

University-school partnerships serve as forums for the exploration of or implementation of new curriculum and instructional methods (Lewis, 2016). University-affiliated schools often host public research lessons ("koukai kenkyuu jugyou" or "gakushuu kenkyuu happyoukai"), attracting teachers from across the country (Lewis & Tsuchida, 1998). Classrooms become living laboratories where teachers have access to research and support from content-area experts. These lesson studies may be funded by local or national grants for the purpose of researching an identified area (Lewis, 2002c). In this forum, teachers try innovative approaches, informed by research, which often lead to the publication of lessons, articles, books, and textbooks, further disseminating the practice (Lewis & Tsuchida, 1997). It also allows for university-based educators to see how innovations are experiencing success or falling short in schools across Japan (Lewis, 2016).

Independent professional associations also sponsor lesson study, for research and

advancement in their area (Lewis, 2016). National organizations hold research lessons as part of conferences designed to disseminate best practices (Lewis, 2002c). In addition, the teachers' union or a private group of voluntary teachers may convene to conduct lesson studies on areas of personal or organizational interest or current social issues.

1.6.2 Forms of Lesson Study in the United States

When lesson study was originally introduced in American educational discourse in the 1990s, it was called a "research lesson" (Lewis & Tsuchida, 1997). It generated widespread interest with Stigler and Hiebert's (1999) publication of *The Teaching Gap*, which reported the findings of the TIMSS video study[4] comparison of teaching and learning in three countries - Japan, Germany, and the United States. Stigler and Hiebert (1999) credited lesson study for Japan's "structured problem-solving" approach in mathematics, which became a major impetus behind the American exploration of lesson study.

Lesson study has become a generalized term for collaborative cycles in which teachers engage in any combination of the following: study curriculum content and instructional resources; plan instruction; and observe, discuss and reflect upon the instruction, using data collected during observation to determine implications for teaching and learning (Fujii, 2013). The live lesson is at the heart of the lesson study cycle (Lewis, 2016). These practice-based cycles have the potential

[4] The video component of the Third International Mathematics and Science Study (TIMSS) was the first attempt made to collect and analyze videotapes from the classrooms of national probability samples of teachers at work (Stigler & Hiebert, 1997 in Shimizu, 1999).

to impact instruction and four basic inputs to instruction - teachers' knowledge, teachers' beliefs and dispositions, teacher learning community and curriculum.

1.6.3 Stages of Lesson Study

There are some variations on the number of and name of the stages in a lesson study, but they all follow a similar flow in the inquiry cycle. Lewis (2002c) identifies four stages: goal-setting and planning, research lesson, lesson discussion, and consolidation of learning. Fujii (2016) identifies five stages: goal-setting, lesson planning, research lesson, post-lesson discussion, and reflection. Yoshida (1999) identifies eight stages: choose a topic, plan a lesson, teach a lesson, evaluate the lesson and reflect on its effect, revise the lesson, teach the revised lesson, evaluate and reflect, and share the results. While a single lesson is often the medium, lesson study is not just about a single lesson, it is about the teaching of an entire unit or content area and places significant emphasis on the development of students as people and as learners (Lewis, 2002c).

1.6.3.1 Stage 1: Choose a Topic

For the purposes of this study, the lesson study cycle will be identified through eight stages. It begins with a question or topic (Fujii, 2016) to define the problem or identify the goal (Watanabe, 2011). The research theme is developed through consideration of the students' current understanding with relation to their overall learning goals, long-term and short-term (Lewis, 2002c; Lewis & Hurd, 2011; Stepanek, Appel, Leong, Mangan, & Mitchell, 2007). Student work, performance assessments and achievement or growth data is sometimes helpful in narrowing the focus of the lesson study (Lewis & Hurd, 2011). Content goals identify the specific concepts or

understandings that students will develop; process goals identify the skills or habits of mind that students will develop and lesson goals focus on specific student outcomes for the lesson (Stepanek et al., 2007).

This initial step involves "kyouzai kenkyuu," the careful study of academic content and instructional materials (Takahashi, Watanabe, Yoshida, & Wang-Iverson, 2005). Teachers investigate the intended learning trajectory through a review of curriculum standards and research into teaching and learning considerations, including possible misconceptions. They deliberate about approaches, manipulatives and materials that may be used and tasks that may be presented to the students. Lesson study facilitators recommend that teachers study the best lessons available, which allows them to learn how others teach the content (Lewis, 2002b). A review of multiple resources allows comparison and requires teachers to discern which elements support their lesson objectives or student population. Through this process, teachers can deepen their knowledge of the content area and hone their instructional planning skills. Comparing Western and Eastern mindsets, Liping Ma (1999 in Lewis & Hurd, 2011, p .68) observes, "American educators assume that you need to learn content knowledge before you can plan lessons . . . [Japanese] teachers think you learn content knowledge by planning lessons."

1.6.3.2 Stage 2: Plan the Research Lesson

The second stage is to development (Lewis & Hurd, 2011). The lesson plan, developed as a communicative document, captures a shared understanding of teaching and learning intentions - an image of the intended lesson (Wake, Swan, & Foster, 2016). It serves as both a guide for the teacher and the planning team, but also as a reference for observers, giving them context for the teaching and learning process (Watanabe, 2002).

It should be noted that not all Japanese research lessons are prepared collaboratively (Tolle, 2010). Some lessons are prepared by a single teacher, with or without collegial input, to be observed by colleagues for professional feedback. A common Japanese lesson plan template describes the lesson in three columns - tasks, anticipated student responses, and instructional considerations. The plans often include both correct and incorrect student responses - considering how students might response to given tasks. A basic idea underlying lesson study is that the content, wording, and presentation of a problem or activity can affect student learning, illustrating how important intentional language and sequencing of activities is to the effectiveness of the lesson (Lewis & Hurd, 2011; Stepanek et al., 2007).

The plan does not need to be an original plan, but may be (Lewis, 2002c). It is better to teach an existing lesson that is strong, than to teach an original lesson that is not effective. When teachers build upon existing lessons, focusing on continuous improvement, the profession is elevated.

1.6.3.3 Stage 3: Teach the Research Lesson

During the third stage, a teacher teaches the research lesson while the members of the planning team, other colleagues and often, a knowledgeable other, observe and collect data (Lewis, 2002c; Lewis & Hurd, 2011). The observers focus on student comments and actions, rather than on teaching moves, in an effort to gain insight into the students' thinking and learning. Often the observers collect specific data, which can include detailed narrative records - what they said and wrote, how they used the materials, what specific supports encouraged understanding, and what obstacles arose during the lesson (Lewis, Perry, & Hurd, 2004). Observation notes can also address how students solved a problem and how many solved it a particular way, whether or not a

lesson's goal was understood or misunderstood, and how it was understood or misunderstood (Tolle, 2010). These data give deeper insight to the teaching and learning process. The lesson observers do not interfere with teaching or learning during the lesson, they simply collect the anecdotal data. Their interference could cause a distraction from the natural interaction between the students and the teacher and this could also impact the authenticity of the data collected (Takahashi & Yoshida, 2004).

Data collection helps to slow down the flow of instruction to study it (Lewis & Hurd, 2011). A well-designed data collection system during the lesson supports a rich post-lesson discussion. Sometimes observers watch the entire class, noting generalizations. Sometimes observers follow a small group of students through the entire lesson. Both formats have value and are particularly powerful when paired to cross-reference observations and conclusions. Observers may also be assigned specific tasks - to record all questions asked by the students, how frequently specific students respond to teacher questions and prompts, or other questions developed specifically for the research lesson (Stepanek et al., 2007). While tests and student work may offer information on what to improve, lesson study adds the layer of how to improve (Lewis, 2002c).

From the perspective of the teacher teaching the lesson, Takahashi (2001) suggests that teachers carefully develop the lesson activities and then forget the lesson plan and instead, teach the students by looking at their faces. Other facilitators suggest that the teacher not deviate from the research plan, but to be flexible, if necessary (Takahashi, 2006). The individual team must determine which approach to take, based on their objective with the study. When lessons are treated as dynamic and flexible within the framework established by the team, the plan is not a single path to the goal, but more like a map around the topic that helps to reach the destination.

Through the process, teachers begin to apply a new lens to their teaching - the lens of researcher (Fernandez, Cannon, & Chokshi, 2003).

1.6.3.4 Stage 4: First Post-Lesson Discussion

The lesson is debriefed during a comprehensive dialogue in the fourth stage that assesses the lesson and reflects upon its effect (Fujii, 2016; Watanabe, 2011). This post-lesson discussion is the heart of lesson study and the most important part of the deep, constructive process (Tolle, 2010). It is important to consider the public nature of collaboration and to recognize this stage requires vulnerability from the participants to be honest and to focus their conversation on the teaching and learning process and not on specific teachers or students (Lewis & Hurd, 2011). This vulnerability can be eased and the collaboration can be facilitated by assigning roles, like facilitator, note taker, recorder, timekeeper and others, depending upon the culture of the team. A good agenda can assist with safe and productive discussions.

In Japan, the post-lesson discussion is often a formal business affair, comparable to a thesis or conference presentation (Tolle, 2010). The facilitator gives an overview of the presentation, followed by a welcome and introduction of guests by a school administrator. The presenting teacher says a few words about the lesson and what was or was not accomplished. The audience is then encouraged to ask questions for a period of time, followed by time for the audience to make suggestions. The data collected by the observers provide the research foundation on which the discussion proceeds - a level of classroom research not often seen in education. An expert in the field ("koshi") may make some closing comments or address unresolved topics and then the facilitator or administrator concludes the debrief.

Observers share data from the lesson to illuminate student thinking, learning, content,

lesson and unit design and other topics related to teaching and learning (Lewis, 2002c; Lewis & Hurd, 2011). The use of student work helps to make connections and provides evidence of student thinking - a process the Japanese call, "*neriage*," or polishing/kneading (Takahashi, 2006). During this stage, participants can explore what went well and what did not go as planned and consider any unexpected outcomes (Tolle, 2010). The purpose is to discuss the lesson and not to evaluate the teacher (Stepanek et al., 2007). If an administrator is participating in the lesson study, he or she is serving as a participant and not an evaluator.

In Japan, critical feedback is a mark of respect - colleagues offer criticism because they expect that one can improve and because there is something in one's teaching worth improving upon (Lewis & Hurd, 2011). This stage of lesson study attempts to make specific aspects of professional learning explicit and provides time and space for this to occur alongside colleagues (Wake et al., 2016).

1.6.3.5 Stage 5: Revise or Revisit the Lesson

The primary emphasis of the lesson revision is to gain insights into teaching and learning and to inform the design of future lessons, not specifically to revise the lesson plan (Takahashi & McDougal, 2016). However, the goal of improving practice can be realized through a lesson revision and learning how to adjust a lesson is a valuable skill set for teachers (Lewis & Hurd, 2011). One can learn a significant amount from an imperfect lesson, perhaps even more than from a polished lesson (Stepanek et al., 2007). The core purpose of the discussion should focus on how to move students to think more deeply and this requires teachers to share their strategies, spreading knowledge across the profession and developing shared insights (Lewis & Hurd, 2011).

Team members plan and improve the lesson, not as an end in of itself, but as a way to

deepen their own content knowledge or knowledge of student thinking, their understanding of teaching and learning and their commitment to improvement of their own practice and that of their colleagues (Lewis & Hurd, 2011). A hope is that teachers increase instructional coherence across classrooms and their collective sense of efficacy, nurturing a school-wide culture of learning from practice. Revising and re-teaching provide a means for teachers to try out and compare different strategies or approaches (Stepanek et al., 2007).

1.6.3.6 Stage 6: Teach the Lesson a Second Time

Evidence collected and post-lesson discussion reflection informs changes to the lesson for the second teaching (Stepanek et al., 2007). Revisions address problems and student misunderstandings identified in the first teaching presentation. According to Makoto Yoshida, re-teaching the lesson "increases opportunities for teachers to learn from one another and reinforces the valuable skills of lesson observation, discussion, and adaptation that are fundamental to improvements of teaching" (Lewis, 2002c, p. 43).

1.6.3.7 Stage 7: Second Post-Lesson Discussion

The seventh stage involves assessment of and reflection upon the process and recognition of the resulting learning (Fujii, 2016). Reflection helps learners to identify and examine beliefs and values from different perspectives (Brookfield, 1986). It helps learners understand how their beliefs and assumptions shape their experiences and the meaning they create from their experiences (Merriam & Caffarella, 1999 in Stepanek et al., 2007).

1.6.3.8 Stage 8: Final Reflections and/or Research Lesson Report

The cycle can be documented with a report that summarizes the process and projects next steps, further research, or additional professional development needs (Lewis, 2002c; Lewis & Hurd, 2011). The report can include agendas, notes from the meetings, records of the background research, unit plans, drafts of the research lesson, and the final copy of the lesson plan. There is value in documenting the process of observing and debriefing.

The lesson study cycle is not seen as final, but as an ongoing process, that does not necessarily give an answer to the research question, but provides a deeper understanding of the focus area (Fujii, 2014). It is as much about the process, as it is about the lesson, and is most effective when integrated into other ongoing work (Lewis & Hurd, 2011).

2.0 Review of the Literature

This study weaves together several elements through the exploration of an interpretation of lesson study as a framework for professional development. Due to the role lesson study plays in this study, it is important to consider its story - its historical evolution in Japanese education systems, its transfer to the U.S. and the impurities that surface in educational contexts outside of Japan. The specific focus on the post-lesson discussion as a dialogic space, ripe for individual and collective reflection and professional growth, requires an intentional focus on adult learning, communities of practice and attributes of effective professional development. The emphasis lesson study places on watching students closely during the observation and the focus math lessons often receive through lesson study requires a closer look at mathematical teaching and learning processes. This review of literature will journey through these elements.

2.1 The Story of Lesson Study in Japan

2.1.1 A Historical Lens on Japanese Education and Lesson Study

Japanese lesson study (*"jug you kenkyuu"*) began during the Meiji Era when the Education Ministry's Education Order of 1872 established education code (Fernandez & Chokshi, 2002; Nemoto, 1999; Isoda, 2007). Japanese education during this period developed, in part, to institutionalize and perpetuate Japanese cultural identity (White, 1987). The Education Ministry issued additional orders for each school level that, throughout the decade that followed, led to the

establishment of a comprehensive school system - the foundation for the modern education system in Japan (Nemoto, 1999). Lesson study emerged with the founding of the Tokyo Normal School and Elementary School, which were affiliated with the University of Tsukuba, and was instituted top-down, by the government, as an establishment of the school system (Isoda, 2010).

At its inception, lesson study involved the observation of teaching methods in whole classroom teaching, which were introduced in these schools and were progressive, compared with traditional approaches (Isoda, 2010). Teacher's Canon was published by the Normal School in 1873 and articulated the observation etiquette that was expected during lesson study. The first known lesson study guidebook for teachers in Japan, *Reform the Methods of Teaching,* was released in 1883 and focused on Pestalozzian methodology, an approach to teaching through questioning ("hatsumon") to develop students who think by themselves. The changes also involved a shift to an object lesson, modeled after Western approaches (Makinae, 2010). According to Pestalozzian theory, all cognition is based on one's intuition - we recognize things by intuition, then form a concept. Teaching, therefore, should not start from reading books, it should begin with the observation of a familiar object, as this is more natural to development. Throughout history, teachers have made the system their own, learning from each other within their school and across school communities.

2.1.2 The Japanese Educational Landscape

Features of the Japanese educational landscape seem to create supportive conditions for lesson study (Lewis, 2002b). Japanese cultural values, like strong work ethic and the pursuit of perfection, lay a foundation for lesson study. Teachers develop a culture of teaching. Japanese

teachers have a high regard for their professional roles and responsibilities - the academic, social-emotional, physical and mental development of their students - and this regard shapes how they conduct lessons (Okano & Tsuchiya, 1999).

In Japanese schools, teachers' desks are located in a communal workroom, not their classrooms. This arrangement facilitates informal communication, interdependence, and camaraderie amongst teachers (Okano & Tsuchiya, 1999). They value routine informal sharing of their experiences and this serves as an ongoing, embedded vehicle for professional growth. The success of a lesson study group requires the development of a shared professional culture through collective participation (Birman, Desimone, Porter, & Garet, 2000). In Japanese teaching culture, observing one another's lessons is routine, and constructive feedback and reflection are valued (Lewis, 1995). Through providing opportunities to observe and deliberate on teaching and learning, lesson study contributes to a school culture of sharing and collective growth - supporting the classrooms and school as a learning community (Watanabe, 2002).

2.1.2.1 Japanese Curriculum

Japanese teaching and learning are dictated by the National Curriculum and Course of Study, which focuses on academic, social-emotional and ethical development (Lewis, 1995). Emphasis is placed on connections between learning and daily life, and strong consideration is given to how students feel about the content, in addition to what they know about it.

The Education Ministry determines the National Curriculum and authorizes and compiles textbooks for all levels, to ensure a standardized education (Nemoto, 1999). The compilation of textbooks is a lengthy and thoughtful process. Exemplar lessons, refined through research and lesson study processes, comprise the content (Archer, 2016). Japanese teachers use the textbooks

as a starting point and continue to enrich the lessons through their own research.

The Course of Study presents guidelines for each content area. Each school determines its own instructional materials, within these guidelines, while taking into account its own circumstances and community situation. All textbooks must be approved by the Education Ministry or published under the Ministry's copyright, in an effort to ensure equality of opportunity, proper content and improvement of standards nationwide (Nemoto, 1999).

The National Curriculum is frugal - The TIMSS study documents that Japanese 8th grade science textbooks cover eight topics, compared with an average of 65 topics in U.S. 8th grade science textbooks (Schmidt, McKnight, & Raizen, 1997). Teachers have more time to cover less topics in greater detail, so they can devote time to studying the most effective ways to present it.

The Japanese Ministry of Education advises tracking student progress in the National Course of Study in four areas: (1) interest, motives, and attitudes; (2) students' thinking; (3) knowledge and understanding; and (4) skills and procedures (Schmidt et al., 1996 in Corey, Peterson, Lewis, & Bukarau, 2010). There is an intimate relationship between lesson studies, textbooks and the National Course of Study (Lewis, Tsuchida, & Coleman, 2002 in Lewis & Perry, 2003). Advances in one arena tend to reshape the other arenas. New elementary lessons are expected to prove themselves in public research lessons before they are included in textbooks. Teacher-authors of textbooks are typically very active in lesson study, incorporating successful new approaches into textbook revisions.

General stability of Japanese policy may enable educators to concentrate on policy changes that do occur - for example, the National Course of Study is revised on 10-year cycles (Lewis, 2002b). In contrast, U.S. educators are often expected to implement new programs and to show results within just a year of two.

In Japan, a higher percentage of time is focused on instruction, with less time devoted to curriculum alignment and materials selection, due to the frugal, focused curriculum (Lewis, 2002b). U.S. teachers spend a significant amount of time selecting and adapting curricula, aligning curricula with state or district standards and finding or writing lessons to fill in the gaps. The pyramids in Figure 1 show how time is allocated in U.S. and Japanese schools. The U.S. triangle stands precariously on it tip, without a large enough basis of classroom practice, observation, and discussion to support it in a stable fashion.

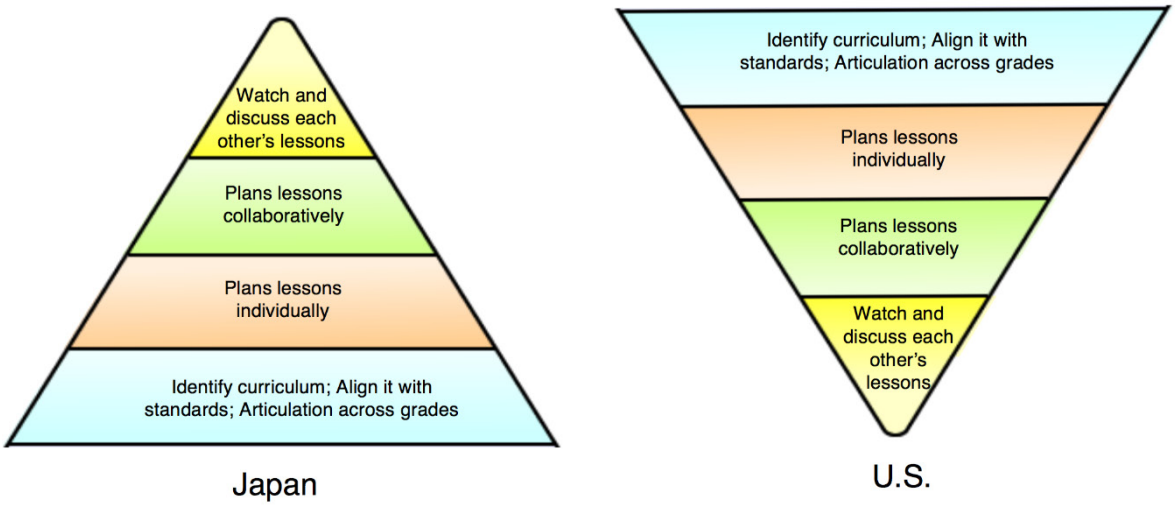

Figure 1. **Teachers' Activities to Improve Instruction**

2.1.2.2 Japanese Classrooms

There is a focus in Japan on supporting the whole child (Lewis, 2002b). Teachers see their job as raising children - promoting social, ethical, emotional, physical, and intellectual development, particularly at the elementary level.

Cooperative learning has a long history in Japan, with the first studies being published in the early 1900s (Lewis, 1995). Cooperative learning is a common strategy in Japanese classrooms, where students work together, interdependently, in small, mixed-ability teams. The Bazu Method, a type of cooperative learning that derives its name from the "buzz" of conversation that accompanies it, suggests an energy about learning. Japanese teachers and students explicitly define and reflect upon the social goals of the group work - helping, friendship, and responsibility. Learning is a social enterprise that involves listening to other ideas, reconciling differences, and problem solving. Discovery learning, where students explore areas of interest or curricular topics on their own terms, is also significant in Japanese pedagogy (White, 1987).

A strong operating force in Japanese classrooms is an emphasis on process (Lewis, 1995). The objective is not limited to obtaining a correct answer, it is also important to be engaged in a wholehearted way, to collaborate and consider others' thinking and to reflect on one's work. *"Hansei"* (self-critical reflection) supports discipline, group formation, and development. To encourage this Japanese teachers carefully plan intentional, purposeful questions, or "hatsumon," to stimulate students' thinking (Dubin, 2009). With thoughtful questions, teachers can guide students to a better understanding of the problem and how it relates to the greater sequence of learning.

2.1.2.3 Japanese Professional Development

Lesson study has been the primary mechanism for professional development for both prospective teachers and practicing teachers since the Japanese public education system started (Lewis & Tsuchida, 1998). The Educational Ministry created a standardized teacher-training curriculum, which is required at all universities (Nemoto, 1999). All newly qualified teachers are

required to participate in a yearlong induction training under the guidance of a master teacher, while simultaneously engaging in teaching and other educational activities at their school. Continuing education, on the job, reflects Japan's cultural commitment to self-improvement (Jones & Jones, 2006; Nemoto, 1999).

Japanese educators consider teaching to be research (Watanabe, 2018). This orientation is different than teacher-as-researcher - in Japan, teachers are researchers. They talk about their research agendas. From this perspective, it is natural for Japanese teachers to engage in lesson study. Individual research occurs in their classrooms, daily, and collaborative research occurs during their lesson study cycles.

There is a strong commitment to learning in Japanese culture (White, 1987). Study, like any activity in Japan worth pursuing, is an opportunity to commit great amounts of effort to a task. The word, "*benkyoo"* (study), connotes the intensity of effort required to learn. Study or work is considered an opportunity to achieve success and teachers are expected to continually improve their professional knowledge to support their students' development and to develop themselves (Okano & Tsuchiya, 1999). Working together is a natural way of being in their school culture. Teachers more regularly engage in voluntary informal study groups outside of working hours. A higher number of professional journals for teachers are produced by teachers, than by university academics (Sato, 1994 in Okano & Tsuchiya, 1999).

Japanese educators have instituted a learning system, "*kounaikenshuu*" - a continuous process of school-based professional development (Stigler & Hiebert, 1999). It consists of a diverse set of activities that contribute to school improvement, which frequently includes lesson study, placing professional growth in the context of the classroom. Lesson study's framework is highly collaborative and grounded in practice - two features of professional development that have

been identified as powerful in supporting change in both teachers and in the academic performance of their students (Darling-Hammond, Chung Wei, Andree, & Richardson, 2009). Through an engaging research process, teachers can develop three critical lenses - as researcher, curriculum developer and student (Clarke et al., 2013). Japanese teachers may spend multiple years investigating a research theme, working to revise and improve each research lesson through several iterations of planning and reflection (Ermeling & Graff-Ermeling, 2014).

Corey, Lemon, Gilbert, and Ninomiya (2016) identify key elements of Japanese professional development that emerged during their collaboration with lesson study teams in Japan: (1) Professional development with actual students adds depth - it is professional learning in real time with a classroom of students. (2) Learning is the goal and mathematical thinking is the key. An analysis of the connections between teacher actions and the mathematical thinking of students seems to be the guide for Japanese teachers in their teaching decisions. (3) Sharing lesson plans increases learning opportunities. Lesson plans contain details that enable teachers to better understand their craft and to adapt the lesson to work with their learners. (4) Collaboration builds a shared knowledge base for teaching and a shared vocabulary for talking about teaching and learning. (5) Professionals work hard to be the best teachers possible. The Japanese colleagues in this study demonstrated a deep love for teaching, a strong desire for success and a refined knowledge of their craft. These principles are embedded into their professional development and their daily classroom practice.

2.2 The Transfer of Lesson Study Outside of Japan

Lesson study was introduced outside of Japan in the late 1990s (Yoshida, 1999) and in the past decade has been explored in the U.S., Australia, Singapore, England, Finland and elsewhere (Robinson & Leikin, 2011). The early discourse was focused more on the process steps, lacking an emphasis on the philosophical underpinnings, and did not account for differences in cultural mindsets surrounding education (Yoshida, 1999). A shortfall of some lesson study endeavors is that they are interpretations in isolation of authentic exposure to or experiences with Japanese lesson study (Takahashi & McDougal, 2016). Some lesson study cycles follow the Japanese steps and some are modified to fit the needs of the individual organization - time, staff, resources, and other variables. As Doig and Groves (2012 in Wake et al., 2016) suggest, there is a need to adapt, rather than adopt, the Japanese model when engaging in lesson study outside of Japan.

Chenoweth (2000) makes a powerful observation that illustrates variation between the educational mindsets: "When a brilliant American teacher retires, almost all of the lesson plans and practices that he or she developed also retire. When a brilliant Japanese teacher retires, he or she has left a legacy to be enhanced by future teachers." Lesson study is a vehicle for preserving and transmitting exemplar teaching and learning.

2.2.1 Early Roots of Lesson Study in the United States

Several teacher-researchers were influential in introducing the U.S. to lesson study. Catherine Lewis' exploration and research of lesson study in Japan began in 1993 followed by the release of the TIMSS results in 1995, which propelled lesson study to an international stage (Lewis,

2002c). Around the same time, Makoto Yoshida, with the guidance of Professor Jim Stigler, conducted an ethnographic study that examined school-based lesson study at a public elementary school in Japan, for his dissertation at the University of Chicago (Watanabe, 2018). The findings of Yoshida's dissertation contributed to the chapter discussing systematic improvement of teaching through lesson study in *The Teaching Gap* by Stigler and Hiebert (1999), which sparked interest in lesson study among U.S. teachers, researchers and educational policymakers (Lewis, 2002b). By 2005, lesson study had spread to at least 125 school districts in 32 U.S. states, an active listserv of more than 900 members exchanged advice and public research lessons were hosted in various regions of the U.S. (Lewis, 2015).

U.S.-based Japanese educators and visiting Japanese educators have served as lesson study facilitators, commentators and consultants (Lewis, 2015). The Japanese Schools of New York-Greenwich and Chicago, regular full-time schools that use Japanese curriculum and cater to Japanese nationals in the U.S., have hosted public research lessons. The Chicago Lesson Study Group launched in 2002 to investigate how to improve the teaching and learning of measurement in the elementary and middle school grades (Takahashi & Yoshida, 2004).

The roots of lesson study at Paterson School #2 in New Jersey date back to the spring of 1997 when the principal, Lynn Liptak, and 8th grade teachers attended a district-sponsored workshop focused on viewing the TIMSS videotapes comparing math lessons in Japan and the U.S. (Lewis, 2002c). Several teachers, on their own initiative, began to orient their lessons to a pattern of instruction observed in the Japanese lessons - pose an interesting word problem and have the students work to solve the problem and present their solution methods. Through this exploration, the Mathematics Study Group, a team of ten volunteer teachers in grades 1-8 and the principal, formed as part of a grassroots initiative (Lewis, 2002c; Takahashi & Yoshida, 2004).

Through a partnership with Makoto Yoshida and Clea Fernandez of Teachers College, Paterson also collaborated with teachers from the Greenwich Japanese School and the original study group grew to 16 teacher participants (Lewis, 2002c; Watanabe, 2018). Lesson study became part of a school-based initiative to provide consistent and coherent math education. Paterson School #2 hosted the first U.S. public research lesson on February 28, 2000.

Lewis also led a team that conducted research on the transfer of lesson study to an American setting in her work with the San Mateo-Foster City School District in San Francisco, California beginning during the 2000-2001 school year (Perry, Lewis, & Akiba, 2002; Watanabe, 2018). Jackie Hurd, a 3rd grade teacher and math coach, experienced lesson study in Japan at an international mathematics conference during the summer of 2000 (Lewis, 2002c). She shared her learning with her three math-coach colleagues, and together, they became the initial team. With district support, through release time and stipends, they generated interest with 28 teachers, representing eight schools. The teams collaborated outside of school hours and were compensated (Perry et al., 2002). This grassroots effort was supported through personal initiative - drawing on videotapes, protocols from the Lesson Study Research Group (2004) and a visit to see research lessons at the Greenwich Japanese School - to inform their practice. At the end of the first year, the original team led a 2-week summer workshop co-designed with the lesson study team at Mills College and other math specialists. Over the course of three years, the lesson study community grew to include 78 participants in smaller teams and involved summer workshops to allow for more collaboration time, professional development, and support. These examples illustrate the variations in how lesson study has been translated in the U.S. (Lewis, 2002c). In November of 2002, the first lesson study conference was held in Connecticut, succeeded by another the following year, with participants attending from across the U.S. (Watanabe, 2018). Even with

these sites for lesson study, the range of Japanese lesson study models available in the U.S. is limited (Perry et al., 2002). Lesson study in each of these forums varies from a standard norm, because it is personalized to the individual context of each situation. Beginning in 2012, a number of U.S. mathematics teachers have participated in the Lesson Study Immersion Program organized by Project IMPULS of Tokyo Gakugei University, observing lesson study in Japan, firsthand, and learning about it at its source (Watanabe, 2018).

2.2.2 Emergence of Lesson Study in Pittsburgh, PA

Lesson study established a presence in the Pittsburgh region in the early 2000s through the work of the Math & Science Collaborative[5], currently housed at the Allegheny Intermediate Unit 3. The Math & Science Collaborative is devoted to strengthening math and science education by coordinating efforts and focusing resources throughout Southwestern Pennsylvania. The organization hosts programming for teachers and students, conducts research, and connects schools with businesses and math-science organizations.

The foundation for the Collaborative's lesson study exploration was laid in 1997 when they developed and facilitated a professional development series with support from the Mid-Atlantic Eisenhower Consortium[6] entitled, "Making Standards and TIMSS Work for the Region" (Bunt,

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[5] Additional information about the Math & Science Collaborative can be found at their website: http://www.aiu3.net/Level2.aspx?id=480

[6] The Mid-Atlantic Eisenhower Consortium for Mathematics and Science Education is a partnership which brings together RBS with other key agencies in the region to improve mathematics and science education for all students. A significant body of their work centers on TIMSS studies, analysis and findings.

2014-2015). The Trends in International Math and Science Studies considered not only achievement test results, but also an analysis of curriculum - both the intended curriculum and the achieved curriculum - through a review of textbooks, teacher surveys and the video study of sample schools in Japan, Germany, and the U.S. (Bunt, 2018). District teams who participated in the TIMSS-focused professional development received a TIMSS toolbox, containing the reports of the TIMSS findings and the videotapes of classroom lessons from the three countries. The teams engaged the content and took their learning back to their district.

The mobilizer of this engagement with the TIMSS results was the Collaborative's Managing Director, Dr. Nancy Bunt. Bunt (2018) had attended a conference about the TIMSS results and met Bill Schmidt, mathematics professor at the University of Michigan, whom she referred to as the "father of TIMSS in the U.S." She identified three tenets of Schmidt's work: (1) curriculum in the U.S. is a mile wide and an inch deep (suggesting curriculum covers too much content and not enough depth); (2) tracking students is a pernicious evil (sorting out opportunities for kids to learn based on initial outcomes); and (3) the nature of instruction matters (going beyond intended curriculum to the role of the teacher in instruction) (Bunt, 2018).

The Collaborative's TIMSS professional development series faced a challenge - a PA exceptionalism, or feeling that the national study results did not have significance for the Region. Bunt (2018) expanded upon this, discussing how teachers have a preconception of how to teach, based upon how they were taught - a cultural script for teaching that is passed on each generation. This receptivity towards changing one's notions of how to teach tends to decrease even more in the upper level coursework in high school and college. This mindset barrier led to the Collaborative's 1999 TIMSS Repeat, a Benchmarking Project for school districts in Southwestern Pennsylvania, which emulated the international study for eighth grade classrooms in the Region

(Bunt, 2014-2015). The results of this study were published in a *Regional Report on Math and Science Education* with the International Educational Study Center at Boston College.

Recognizing the imperative to have a system of support for teachers' exploration of effective practices in teaching and learning, the Math & Science Collaborative created Teacher Leader Academies in elementary math, secondary math, secondary science, middle school math and early learners (Bunt, 2018). These two-year academies brought together teachers in the region and focused on how to make changes in instructional practice through professional development using the TIMSS video studies and other professional development outlets. In an effort to expand the support system within the districts, the Collaborative introduced Lenses on Learning in 2003, a 10-day workshop to engage principals in the work of the academies.

Participants expressed interest in extending the Teacher Leadership Academies and lesson studies became an integral part of the third year, beginning in 2006, when Catherine Lewis facilitated training (Math & Science Collaborative, 2015). To prepare for this endeavor, the Math & Science Collaborative leadership team read Stigler and Hiebert's *The Teaching Gap* (1999), studied the research on lesson study and collaborated with Lewis and other lesson study authorities around the country to learn what approaches were being implemented effectively. The Collaborative defines lesson study as "an ongoing professional learning activity" (Bunt, 2009, p. 4). This became the vehicle for teachers to make the instructional changes they discussed during their prior years in the Teacher Leadership Academies (Bunt. 2018).

In the summer of 2008, more than 150 teachers participated in lesson studies. During the

time the Collaborative engaged lesson study, the Network Connections[7] professional development days featured public lessons, sometimes taught by authorities in lesson study and sometimes taught by local teachers. In 2006, Bill Jackson of the Paterson, N.J. lesson study group taught the public lesson. Each lesson was followed by a debrief, which "sheds light on the most important aspect of Lesson Study - the thinking and learning of the students" (Bunt, 2009, p. 4). [See Appendix A: Math Science Collaborative Lesson Study Events 1997-2010]

In addition to the Teacher Leadership Academy lesson studies and the public lessons featured at the Network Connections, the Math & Science Collaborative hosted Learning Laboratories in the summers beginning in 2007, where participants honed their skills for observing students (Shaneyfelt, 2009). The work of Deborah Ball, Dean of the School of Education at the University of Michigan, inspired the Learning Laboratories (Bunt, 2018). She extended learning for her education majors into the summer through teaching summer classes where her college students could observe, in a fishbowl style, then debrief with her after the lesson to discuss what they observed, explicitly. The Collaborative replicated this approach with a summer school program for 5th grade students who had failed math in a local school district.

These intensive professional development experiences at the Learning Laboratories invited 4th and 5th year Teacher Leaders and Administrators from the *Lenses on Learning* group to observe and gather evidence of one student's thinking and learning during a lesson (Shaneyfelt, 2009). Teachers in higher education were also invited to participate, giving them a lens of learning in the early grades. This model of having secondary and higher education teachers learn from

[7] The Network Connections are bi-annual conferences for district teams that began in 1996 (MSC, 2015).

elementary teachers about instructional strategies, while also serving to mentor the elementary teachers in math-specific content, built a two-way path of respect and increased the pedagogical skills of all participants (Bunt, 2018). As an extension of lesson study, this "fishbowl approach" allowed participants to explore the observation and analysis of student learning on a deeper level (Shaneyfelt, 2009). The lesson was taught by Math & Science Collaborative project directors, while participants observed their designated student, looking for evidence of learning defined by targeted skills: (1) making predictions and pursuing a solution; (2) manipulating materials to solve a problem effectively; (3) providing responses that reflect real, personal thinking; and (4) challenging and questioning each other. The participants also interviewed their designated student at the end of the experience for insight into their learning (Bunt, 2018).

Reflections by the participants illustrated their learning - "Everyone can learn if you can…listen to the student and his/her particular learning style. Learn to watch and listen to how your students learn" (Shaneyfelt, 2009, p. 30). The participants demonstrated a shift in their thinking - "We need to focus on the student and not the task. The only way to see if a student truly understands, can verbalize, can apply knowledge and can thus show us on [assessments] is to listen and watch them in small groups and one-on-one" (Shaneyfelt, 2009, p. 30). The Project Directors highlighted the power of the professional development forum: "Given the opportunity to focus on one student enables one to see the complexity of individual student learning. In the minute-to-minute decision-making process of teaching, it is easier to make decisions based on what is perceived as understanding" (Shaneyfelt, 2009, p. 31).

Although lesson study is not a focal point currently, the Math & Science Collaborative has maintained its focus on learning lessons, through its recent engagement of collaborative learning lessons. Prior to this, much of their emphasis was on facilitating walkthroughs where teacher

participants could learn from colleagues through observing in their classroom and refining their student observation skills. The principles of lesson study remain; however, they present themselves in these other forms of collaborative professional learning.

Bunt (2018) identified an ongoing challenge to the lesson study engagement of the Math & Science Collaborative was the perception teachers had of lesson planning and a narrow focus of the outcome of lesson study limited to the actual lesson plan. In the U.S., teachers often view lesson planning as tasks they are completing daily or weekly within a unit. Lesson study, when viewed through the lens of planning and refining a single lesson, is considered time-intensive, and is overwhelming if teachers have a misconception that it is a process to be applied to every lesson. Bunt (2018) emphasized a lesson study though the lens of "a learning study, more than a lesson study," and called for a shift in mindset to teachers learning about learning. It is a process for learning through one closely studied lesson that can be applied to other lessons. In later years of the Teacher Leader Academies, the Collaborative emphasized growth mindset as a way of fostering a shared learning environment and helping to shape a concept of teacher leaders as lead learners.

2.2.3 Challenges to Translating Lesson Study in the U.S.

Lesson study does not naturally transfer from a Japanese setting to an American setting, but requires some translation and accommodation due to the variations in education systems. Lewis (2002b) cautions that lesson study experiences in the U.S. diverge substantially from the Japanese approach. Lesson study is emerging in schools throughout the country, but it may not be

implemented with fidelity[8] or may lose its influence like other educational innovations. Features of lesson study need to be adapted for the varying educational environment in U.S. schools. Castori (2002) suggests that aligning lesson study with practitioner research would give it more definition. She also believes in the need to find effective ways to adapt it to the schooling routines within our educational system.

Most U.S. teachers engaging in lesson study have not had the opportunity to work with Japanese teachers who can model the process, therefore, many examples of lesson study in the U.S. diverge substantially from the Japanese approach (Lewis, 2002c). This results in lesson study experiences that lack the nuanced understanding that is necessary to use lesson study in the way it was intended (Chokshi & Fernandez, 2004).

Other challenges to implementation include a lack of a shared, frugal curriculum, limited exemplar lesson examples on specific topics, the need for guidelines on how to observe, discuss, and revise lessons and a deficit of shared planning and observation time during the school day. Through her research, Lewis (2002) has found that American schools that have experienced success have several conditions in place - a tradition of collaboration, an interest in teachers' inquiry, a shared curriculum, and administrative support for teacher-led learning.

In many lesson study experiences the foundational step of gaining knowledge and insight into the content area and student thinking is omitted, in an effort to get started with the functional steps of writing the lesson and teaching it (Takahashi et al., 2005). While lesson study in Japan is conducted as part of a school-wide focus that involves the entire staff, lesson study in the U.S. is

[8] Implementation with fidelity to a Japanese model for lesson study

often conducted by enthusiastic volunteers and sometimes is independent of their district professional development activities. A knowledgeable other is a key member of the lesson study team in Japan, but is not always part of the lesson study team in the U.S., leaving a void where an expert could be contributing to the participating teachers' content and pedagogical knowledge growth. Takahashi and McDougal (2016) suggest that certain institutional structures and practices are important for maximizing the impact of lesson study, but are sometimes omitted outside of Japan:

- Participants engage in lesson study to build expertise and learning something new, not to refine a lesson.
- It is part of a highly structured, school-wide or district-wide process.
- Careful study of the academic content and instructional materials is engaged.
- It is done over several weeks, rather than a few hours.
- Knowledgeable others contribute insights during the planning and post-lesson discussion.

The post-lesson discussion - the heart of lesson study, where the deep constructive learning occurs, is also the area of lesson study that has been most neglected and least written about in America (Tolle, 2010). Teacher inquiry through lesson study is not a set of procedures that can simply be replicated. The lesson study process is, at its core, an exercise in reflection and professional collaboration.

Lewis expresses concern about a common misconception that lesson study improves instruction primarily through the improvement of lesson plans (Wang-Iverson & Yoshida, 2005 in Tolle, 2010). While an exemplar lesson plan may be an outcome of lesson study, the main focus is the professional dialogue about teaching and learning that is woven throughout the process. The

goal of American teachers should be to use a lesson study model of professional collaboration to help to create venues of research and discourse to improve teaching and to enhance what we know and understand about student learning (Tolle, 2010).

Lesson study is a set of dispositions, skills and knowledge that are challenged each time a new situation is encountered (Lewis, 2015). This requires an ongoing, embedded culture to sustain lesson study as a system of teacher learning - a collection of practices, habits of mind, knowledge, interpersonal relations, structure, and tools which support teachers as they collaboratively study and improve practice.

Another challenge is that the lesson study process may not be a natural way of learning for teachers who do not regularly collaborate with colleagues, or who have had negative collaborative experiences (Perry et al., 2002). Good collaboration can be challenging and does not occur without effort and an open mind from the participants. This can limit its effectiveness as a professional learning framework for some teachers and teams of teachers.

2.2.4 Difference between Japanese and American Education Systems

The Third International Mathematics and Science Study (TIMSS) video component compared the teaching of 8th grade math in Germany, Japan, and the U.S. (Stigler & Hiebert, 1999). The video study was conducted by videographers who also collected questionnaire responses from the participating teachers and supplemental materials, like copies of the textbook pages and worksheets, to understand the context of the lesson. The research team also included code developers and math teachers. They collaborated to understand how teachers construct and implement lessons and developed a common language for describing and coding the lesson. The

process yielded two kinds of products - impressions or images of teaching in each country and quantified results that indicated how often specific features of teaching occurred.

A finding of the TIMSS video study was that American teachers were highly competent at implementing American teaching methods, but the methods were severely limited. While other countries are continually improving their teaching approaches, the U.S. has no system for improving. [See Appendix B: TIMSS Findings Comparing Japanese & American Approaches]

There are gaps when it comes to improving teaching methodology and these gaps make the transfer of lesson study from Japan to the U.S. difficult (Stigler & Hiebert, 1999). American policymakers and reformers dictate policies or reforms and expect teachers to comply. The teaching profession does not have enough knowledge about what constitutes effective teaching and teachers do not have a means of successfully sharing such knowledge with one another. These are systemic barriers to the implementation of effective lesson study and other professional development vehicles that could help to generate and share knowledge about teaching and learning. Lesson study is oriented to student learning; however, reforms in the U.S. are often tied to particular theories of teaching or to educational trends, instead of to learning outcomes. As a result, success if often measured by the degree to which teachers implement recommended practices.

2.2.5 Continued Lesson Study Research

Lesson study is credited with supporting profound changes in teaching in Japan, but skeptics (Takahashi & McDougal, 2016) caution that its effectiveness in other countries has been inconsistent. Only a few cases have been documented in which there was strong evidence of

impact on teaching and learning. In a review of 643 studies of mathematics professional development using a process modeled on *What Works Clearinghouse* guidelines - some using lesson study and some not - only a study conducted by Lewis and Perry and one other, met scientific criteria and showed an impact on student learning (Gersten, Taylor, Keys, Rolfhus, & Newman-Gonchar, 2014). Takahashi and McDougal (2016) question if there are important aspects of lesson study, as practiced in Japan, that are getting lost in translation or if the shortfalls are due to cultural differences that can't be overcome.

The use of lesson study should be carefully weighed against the challenges of authentically engaging participants in a meaningful experience (Ricks, 2011). Success requires professional development for a foundation in the lesson study process and considerable logistical foresight to plan for collaboration and observation. The process may require additional adaptation from an authentic Japanese lesson study to meet the restrictions of individual organizations or groups. Ebaeguin and Stephens (2015) confirmed this in their investigation of the adaptation and cultural transition of the implementation of lesson study to a non-Japanese context (the Philippines). They concluded it was necessary to consider the existing habits and values teachers have in a particular school and any cultural barriers that could influence their acceptance of lesson study as a mode of professional development. They also advise consideration of the skills and knowledge teachers need to implement lesson study with fidelity.

Adapting lesson study for use in the U.S. presents many challenges, especially in the development of research skills. Fernandez et al. (2003) found that teachers typically have difficulty posing sound questions, conceptualizing a classroom experiment and articulating what artifacts might serve as evidence. More research is needed to understand which adaptations are successful and which are not (Lewis, 2002b). Lewis (2002b, p. 34) calls for U.S. lesson study

pioneers to focus on reinventing lesson study - to recognize that lesson study "can't just be borrowed in toto from an educational system as different as Japan's, but must be thoughtfully adapted to our system."

2.3 Mathematics Teaching and Learning

The literature identifies a variety of characteristics of high-quality mathematics instruction (Robinson & Leikin, 2011) and several studies will be addressed in this review. The following matrix presents the attributes. Both the TIMSS (1999) and PISA[9] (2003) studies highlight the characteristics that surfaced consistently across the countries included in their research population. A meta-analysis by Robinson and Leikin (2011) encompasses findings by other researchers. A study by Corey et al. (2010) identified principles of high-quality math instruction that consistently surfaced through an analysis of conceptions and cultural scripts within conversations between Japanese teachers and student teachers. Their research built upon the conclusions of the TIMSS video study, which proposed that Japanese math lessons tended to be higher quality than their counterparts in the U.S. and Germany (Stigler & Hiebert, 1999). The findings capture important elements of the participating Japanese teachers' conceptions about high-quality

[9] The Program for International Student Assessment (PISA) is an international assessment that measures 15-year-old students' reading, mathematics, and science literacy every three years. PISA also includes measures of general or cross-curricular competencies, such as collaborative problem solving. By design, PISA emphasizes functional skills that students have acquired as they near the end of compulsory schooling. PISA is coordinated by the Organization for Economic Cooperation and Development (OECD), an intergovernmental organization of industrialized countries, and is conducted in the United States by NCES.

mathematics instruction. [See Table 1]

Table 1. Attributes of Effective Math Instruction

	Corey et al., 2010	Sullivan, 2011	Robinson & Leikin, 2011	TIMSS, 1999 & PISA, 2003
Student engagement	Intellectual engagement	Fostering engagement	Asking high-level questions and presenting challenging mathematical tasks	High level of active engagement
Lesson focus	Goals	Articulating goals	Intentionality about the use of strategies and reflection	Balance between practicing rules and algorithms; modeling and argumentation
Lesson coherence	Flow	Promoting fluency and transfer	Encouraging cognitive and meta-cognitive activities	
Curriculum	Unit; sequential framework	Making connections	Opportunities for arguing and making connections	Connections vs. compartmentalization of topics and concepts
Differentiated instruction	Adaptive instruction	Differentiating challenges	Fostering student self-regulation, communication and cooperation by being sensitive to student abilities and needs	
Planning	Preparation; detailed plan	Structuring lessons	Managing lessons clearly and using time effectively	

Research suggests that a key cultural component of the Japanese educational system, fundamental to their ability to craft and implement high-quality math lessons, is a detailed, widely shared conception of what constitutes effective math pedagogy (Jacobs & Morita, 2002). This seems to contribute to the success and sustainability of lesson study as a professional development activity in Japanese educational settings.

2.3.1 Math as a Context for Lesson Study

Lesson study can provide an authentic forum for shaping principles about effective instructional practices. There is a complexity of mathematical knowledge for teaching that encompasses both content knowledge and pedagogical practices (Ball, Thames, & Phelps, 2008 in Clarke et al., 2013). Lesson study's hallmark of observing students during the lesson resonates with the instructional process of Japanese math classes, with an emphasis on problem solving and analyzing the process. The difficulty for some teachers in narrowing a focus on student thinking reflects the complexity of connecting knowledge about students with knowledge about mathematics. These connections involve anticipating students' thinking, potential misconceptions, the motivational effect of different contexts, and the complexity of tasks. Teachers need to be able to act in the moment, integrating these areas to maximize interactions with students (Ball & Bass, 2000).

In Japan, the major reform movement in teaching and learning mathematics occurred during the 1970s and 80s (Takahashi, 2006). The movement resulted in a significant shift from traditional pedagogy that focused on the teacher's instruction to a student-centered classroom that focused on the students' engagement in mathematical activities. Lesson study accompanied this

shift from the traditional approach of "teaching as telling" to a more responsive lens of "teaching for understanding" (Lewis, 2002c).

A lesson study team studied by Moss, Hawes, Naqvi, and Caswell (2015) stated the importance of learning to observe the students' thinking across a variety of contexts and of looking for signs of understanding, not only with words, but also with gestures. Japanese math lessons can be described as "structured problem solving" - a process which involves an emphasis on thinking and discussing alternative solutions to a problem (Shimizu, 1999). The problems are demanding, both procedurally and conceptually - allowing some space to choose from a variety of problem-solving procedures based on how the student conceptualizes the problem (Stigler & Hiebert, 1999). The nature of mathematical learning can be highly collaborative, which has the potential to enhance the process of solving the problem through dialogue and reflection.

Math learning lends itself well to collaboration and social learning. The process of comparing multiple solutions requires active student participation and social interaction, and positions the students as knowledge creators, rather than as passive recipients of knowledge (Hino, 2015; So, Shin, & Son, 2010). Essential to the Japanese approach is a valuing of students' thinking and considering how that will present during the teaching and learning process. While comparing solutions, students need to not only make their thinking visible, they must also listen to ideas and solutions proposed by others, interpret these ideas, challenge different lines of reasoning and give feedback by solving the problem (Hino, 2015). This negotiatory discourse is important in the development of socially emergent cognition, as each student negotiates with the others and forms or transforms his or her experience through the shared project (Powell, 2006 in Hino, 2015). These observations of student interactions can be rich discourse for teacher observers looking for evidence of student thinking during a lesson study.

2.3.2 Lesson Planning Processes

An investigation by Fernandez and Cannon (2005) highlights differences in how Japanese and American teachers think about lesson planning. The participating Japanese teachers' thinking emphasized student discovery of concepts and development of productive dispositions towards learning; whereas, the participating U.S. teachers' thinking tended to focus on students learning specific mathematical content.

The Japanese teachers also considered lesson planning to be a more complex process than did their American counterparts. In Japan, planning itself is regarded as a powerful tool for fostering professional growth - the heart of teaching and the convergence of theory, research and practice (Lewis, 2000). A general Japanese lesson plan format frames the lesson through four columns: (1) Steps of the lesson - the sequence of tasks; (2) Student response - anticipated responses, actions and misconceptions; (3) Teacher response - possible comments, questions or responses to students; and (4) Methods of evaluation - formative and summative. A general format for a lesson plan in the U.S. includes a rationale, objectives, methods and procedures, and an assessment of the students (Fernandez & Chokshi, 2002).

The complexity of thought involved in lesson planning in Japan is evident in the findings of the work of Fujii (2016). Discussions about the task follow two lines of thought: a mathematical perspective, in relation to the scope and sequence of relevant topics, and the appropriateness of the task to the lesson goal. Teachers spend time discussing anticipated student responses, considering first, the class as a whole, then considering outlier students. The conditions or characteristics of the task influence students' thinking processes and solution methods therefore are critical to student success. For example, the numbers used in a task can strongly influence students' ways

of solving the task.

Another distinction that surfaced in Fernandez and Cannon's (2005) investigation was some differences between Japanese and American teachers' goals for themselves and the resulting thinking. U.S. teachers were interested in assessing their students' mathematical performance, whereas, the Japanese teachers were concerned with understanding some aspect of their students' thinking or feelings during the lesson.

Japanese classrooms have unique characteristics, particularly with relation to teachers' intentional guidance of students through the use of multiple solutions of a mathematical task (Funahashi & Hino, 2014). In an analysis of the TIMSS video study, Shimizo (1999 and 1999b) captured the cultural script of a typical Japanese math lesson: (1) "hatsumon" - presentation of the problem; (2) "kikan-shido" - problem solving by the students; (3) "neriage" - whole-class discussion about the methods for solving the problem; (4) "matome" - summing up by the teacher; and (5) additional practice problems or extensions. While the students are working on the problem, the teacher circulates the room to observe conversations and strategies. The teacher may make suggestions or assist students, but is also looking for students who have good ideas to share during the class discussion. Careful consideration of whether the task will elicit the alternative approaches needed for an effective "neriage" is essential.

2.3.3 Math Focus in this Study

Math was the focus for this research study because early years teachers often lack both content knowledge and confidence teaching mathematical concepts (Moss et al., 2015). In contrast, they tend to be more comfortable teaching reading and language-oriented skills (Copley,

2004 in Moss et al., 2015). These orientations are reflective of the participants in the study, who have received explicit, ongoing professional development in reading and several of whom, have reading specialist certifications. At the time of the study, our kindergarten was a half-program, where a considerably higher percentage of the day was devoted to reading instruction and practice, in comparison with math.

These stronger orientations to reading are a barrier to building strong math programs and exemplar math practices. In a formative study, Duncan et al. (2007) showed that mathematics skills measured at kindergarten were strongly predictive of later academic success, above and beyond the variance accounted for by reading, attentional and socioeconomic skills. One factor that can have an impact on math learning in early childhood settings is the teachers' beliefs and knowledge about math, both conceptually and in terms of children's development of mathematic skills (National Research Council, 2009). Wilkins (2008) found that among variables of content knowledge, beliefs, and attitudes, teacher beliefs had the strongest correlation with classroom practice. Beliefs also affect teacher interactions with their students, impacting what they learn. It is not uncommon for early childhood teachers to lack professional preparation and to feel uncomfortable with teaching math (Ginsburg et al., 2006 in Kilday, Kinzie, Mashburn, & Whittaker, 2012).

Professional development related to math teaching and learning for early childhood teachers could contribute to an increase in the capacity of teachers to present mathematical concepts, to understand children's learning trajectories and to assess discrete mathematical skills (Clements & Sarama, 2009 in Kilday et al., 2012). This approach helps teachers to develop adaptive expertise, so they can seize teachable moments and ground their teaching in ideas central to the development of mathematical thinking.

Lesson study has the potential to build teacher capacity and confidence with teaching math by bringing teachers together to share knowledge, coach each other, and support each other's growth. This is demonstrated in a study by Miyakawa and Winslow (2013) that analyzed how the format of an "open lesson"[10] contributes to the construction and diffusion of didactic knowledge in a community of mathematics teachers in Japan. The work of Margolinas, Coulange, and Bessot (2005) explored what a teacher can learn from observing students learning and developed the notion of observational didactical knowledge which "grows from the teacher's observation and reflection upon students' mathematical activity in the classroom" (p. 205).

Miyakawa and Winslow (2013) counter that many teachers work independently to prepare their lessons, teach, and reflect, so consequently, a significant part of their didactical knowledge remains private. Through professional collaboration, in the form of an open lesson or lesson study, they re-position the exploration to what teachers can learn, together, from observing and reflecting upon student learning. Their research suggests that the discussion component of the open lesson provides a space for developing teacher knowledge and supporting communal learning, beyond the individual lesson. This is comparable to the post-lesson discussion in a lesson study.

[10] Open lesson, defined in this study as when "teachers from other schools are invited to observe a class, taught by a teacher of the school, and just after this, to participate in a discussion session with the teacher - and sometimes other invited experts - on the details of the lesson" (p. 186), parallels the commonly-accepted definition of lesson study, void of the collaborative planning pieces and subsequent re-teaching and reflection pieces.

2.3.4 Live Observations of Lessons

When teachers gather to watch a research lesson, they collect kinds of data that cannot be gathered from students' tests, written work or even from video recordings (Lewis, 2002b). Anecdotal notes collected, in-the-moment, can include evidence of students' engagement, persistence, emotional reactions, quality of discussion within small groups, comments, interaction with peers and degree of interest, amongst others. Teachers can observe students' whole demeanor toward learning, the content, and one another. They can, as Japanese educators say, "develop eyes to see the students" (Lewis, 2002b, p. 21).

2.3.4.1 Kidwatching

The team of teacher participants in this study talks a great deal about kidwatching. Termed through the work of Yetta Goodman (1985), kidwatching is a way of intentionally noticing kids within the teaching and learning process - how they learn and what they do to explore their ideas. Teachers have always been observers of their students and teachers interact with students regularly, but the 1930s gave rise to a child-study movement that led to a more intentional focus on student observation (Owocki & Goodman, 2002). It is a seek-to-understand stance that attempts to look at teaching and learning through the children's eyes (Mills, 2005).

Kidwatching is as much a state of mind as a collection of techniques for gathering and reflecting upon data - it is about getting to know students intentionally, through an insider view (Owocki & Goodman, 2002). This is achieved through observing students, gathering a variety of data (checklists, anecdotal notes, transcripts of the kids' comments) and interacting with the kids. It can also involve further prompting - asking questions to discover what children know and why

they think as they do. Careful kidwatching notes help to document children's growth over time and these observations may become strategy lessons or instructional groupings as patterns emerge (Mills, O'Keefe, & Jennings, 2004).

Of particular interest is tuning in to students' comments, questions, and conversations. Oral language is the primary symbol system through which children learn about their world (Owocki & Goodman, 2002). They use talk to facilitate their own thinking and learning and to jointly construct meaning and knowledge with others. Student talk is a window into their thinking and understanding. Social talk also requires the children to listen to each other. Teachers are most responsive when they invite children to construct new insights and to share questions with one another. It is through capturing and interpreting children's talk that teachers gain stronger insight into children's thinking (Lindfors, 1999).

Documenting children's work is a way to make children's thinking visible (Salmon, 2008). Thinking becomes visible when children are aware of it and teachers chart progress by recalling events and evidence of children's thinking. Any system or tool can be used to collect the observation data, as long as it is worth evaluating and reveals the children's knowledge and growth (Owocki & Goodman, 2002). Kidwatching is a way to get to know each child, over time, in as many different contexts as possible (O'Keefe, 1996). The teacher can then make professionally-informed teaching decisions and plan differentiated instruction based on analysis of the data he or she collects, considering how and when students engage in learning.

Most kidwatchers are informed by a developmental, sociocultural perspective on learning (Owocki & Goodman, 2002). This perspective is steeped in the notion that children construct knowledge within their social worlds. Knowledge construction happens as children develop and test an infinite series of hypotheses or ideas. Learning is a process of becoming as internal and

social forces work together to shape their understandings. Teachers who engage in kidwatching view their classrooms as places where they are the learners - learning from their students (Olson, 1990; VanDeWeghe, 1992). These monitoring practices require teachers to reflect on the lesson and to self-reflect on their decisions (Owocki & Goodman, 2002). The aim of kidwatching is not only to become more reflectively aware of how one's students think, but also to become more aware of one's own frames of interpretation.

2.3.4.2 Professional Noticing

Similar attributes to kidwatching have surfaced in the work of Sherin and van Es (2009) and their exploration of professional noticing in mathematics teaching and learning. Professional noticing involves attending to children's thinking strategies, interpreting their understanding and deciding how to respond on the basis of the children's understanding (Jacobs, Lamb, & Philipp, 2010). The learning-to-notice framework developed by Sherin and van Es (2009) includes (1) identifying noteworthy aspects of a classroom situation, (2) using knowledge about the context to reason about the classroom interactions, and (3) making connections between the specific classroom events and broader principles of teaching and learning. Through their work, they determined that teachers can improve their noticing by changing what they notice (i.e., focusing on students' conceptions instead of teachers' actions), and how they reason (i.e., interpretive comments instead of evaluative; synthesizing observations instead of simply reporting details).

Professional noticing of children's mathematical thinking requires attention to children's strategies, along with interpretation of mathematical understandings reflected in those strategies (Jacobs et al., 2010). It is important to recognize that effective professional noticing and kidwatching both require professional development to learn and to practice the skills. Teaching is

a learning profession and teachers need opportunities to learn, with support, throughout their career (Darling-Hammond & Sykes, 1999).

2.4 Adult Learning

Guskey (1986), in proposing a model of teacher change, suggested that when teachers try new approaches to teaching and learning, significant changes in teachers' attitudes and beliefs are more likely to take place only after changes in student learning outcomes are evidenced. Professional growth is enriched when it accompanies a skeptical stance towards oneself and one's classroom - a form of critical curiosity (VanDeWeghe, 1992). Authenticating this, Clarke and Hollingworth (2002) claimed that teacher change is personal and situated, and that the support of teacher development must offer them opportunities to learn in a way that each teacher finds most useful.

Through this situated perspective, teacher learning is "constructed through participation in the discourse and practices of a particular community" (Borko, Jacobs, Eiteljorg, & Pittman, 2008, p. 418). This communal learning is developed through cultural norms, including language, rituals, and symbols (Lave & Wenger, 1991). Participation in a community shapes the identity of members, their future actions, and how they transfer their thinking to other settings.

Reflective of this perspective, there has been a growing consensus towards creating opportunities for teachers to work together to develop their practice, and for these opportunities to be located in the practice of teaching, focused on teachers' everyday work (Higgins & Parsons, 2009). Grierson and Gallagher (2009) advocate that "to enhance potential for change, professional

learning opportunities must be non-threatening, enhance teachers' comfort taking risks with new practices, as well as support their abilities to be honest about the challenges and successes they encounter in doing so" (p. 569). A collaborative network of teachers engaged in a similar focus nourish and sustain one another in vital ways, especially during times of challenge or doubt (VanDeWeghe, 1992). Developing new approaches requires deep thought, inquiry, and collaboration with a collective focus on teaching, rather than on teachers (Stepanek et al., 2007).

2.4.1 Effective Professional Development

Teacher education is not simply about the acquisition of skills; it occurs in complex and fluid contexts (Richardson, 2000 in Marble, 2007). To perform effectively teachers need to be autonomous, reflective decision-makers. Because teacher learning has the potential to be most powerful when it occurs in teams that meet on a regular basis for the purposes of collaborating, problem solving and learning, the National Staff Development Council Standards promote collaboration amongst teachers to design lessons, critique student work and analyze a variety of data (Watanabe, 2011).

In her work studying effective professional development, Darling-Hammond (1999) has found teachers learn best by studying, doing, and reflecting; by collaborating with other teachers; by looking closely at students and their work and by sharing what they see. She suggests an intensive, ongoing model of delivering teacher learning and leadership opportunities - more specifically, a development model that is connected to teaching practices focused on student learning and addresses the teaching of specific curriculum content and skills within the context of school improvement goals, which also builds strong collegial working relationships amongst

teachers (Darling-Hammond et al., 2009). Her research highlights the qualities of effective professional development, as follows (Darling-Hammond, 1999):

- Is experiential, engaging teachers in concrete tasks;
- Is grounded in participants' questions and inquiry, as well as research;
- Mobilizes expertise within and outside of the school;
- Is collaborative, enabling educators to share knowledge;
- Focuses on improving what happens in the classroom, what is taught and how;
- Is sustained, rather than "one-shot";
- Responds to evidence about student learning and development in this setting; and
- Is connected to other aspects of school change

Lesson study embodies these qualities (Lewis, 2002c). It occurs in a real, motivating context - the classroom, and focuses on a problem of significant interest to teachers - their hopes for student learning and growth. The research lesson provides an ongoing method to improve instruction, whereby teachers draw on expertise within and outside of the school. They study exemplar lessons and resources and enhance these through careful observation of their own students and contexts. The process builds collaboration as teachers work on "our" lessons, not "my" lessons.

Through her leadership of lesson study at Paterson School #2 in New Jersey, Principal Lynn Liptak articulated the ways lesson study deviates from traditional professional development (Lewis, 2002c). Lesson study invests time and resources in planning, studying, and refining what actually happens in classrooms, through a system of research and development where teachers advance theory and practice through their study of teaching and learning, testing and improving "best practices." It is an approach that deviates from traditional professional development formats,

as Lewis illustrates in Table 2 (2002c).

Table 2. Comparison of Traditional Professional Development & Lesson Study

Traditional Professional Development	Lesson Study
Begins with an answer	Begins with a question
Driven by the expert	Driven by the participants
Communication from the trainer to the teachers	Communication among teachers
Relationships are hierarchical	Relationships are reciprocal
Research informs practice	Practice is research

2.4.2 How Teacher Beliefs Shape Teaching and Learning

Teachers' beliefs shape how they approach their classroom procedures and practice (Nespor, 1987 in Jacobs, Yoshida, Stigler, & Fenandez, 1997). A commonly accepted definition of beliefs is a mental representation of reality that guides thoughts and behaviors (Pajares, 1992 in Jacobs et al., 1997). Furthermore, beliefs are implicit and must be inferred from what people say, intend or do (Rokeach, 1968 in Jacobs et al., 1997).

Beliefs about what mathematics is seem to differ across Western and Eastern philosophies (Newton, 2007). In Western thinking, mathematics is often described as the most certain branch of human knowledge - which makes right and wrong more distinguishable. A heavy emphasis on truth and correctness contrasts the Eastern view of mathematics. Japanese math teachers emphasize developing conceptual understanding, rather than simply obtaining a correct answer,

and tend to ask more questions about conceptual knowledge and problem-solving strategies than U.S. teachers do. The U.S.'s overemphasis on what is right or wrong makes it difficult for teachers to have authentic conversations with students about mathematics.

In an exploration of how teacher beliefs shape classroom practice across American and Japanese classrooms, Jacobs et al. (1997) facilitated a study where American and Japanese elementary teachers viewed and critiqued video recordings of math lessons in American and Japanese classrooms. The outcomes found the Japanese participants to be more critical in their commentary on the sample lessons. Four areas were targeted – Table 3 shows the distinctions (Jacobs et al., 1997).

Table 3. How Teacher Beliefs Shape Classroom Practice

Topic or Area	Japanese	American
What students should do during the lesson	focused on the depth of the students' understanding of the topic and indications of their intellectual engagement	focused on the students' exhibition of on-task behaviors
How teachers should use language	concerned with when a teacher was talking too much and dominating the lesson	emphasized the clarity of the teachers' language
Pacing and differentiation of instruction	sensitive to the students who needed a slower pace, feeling the lesson should ensure even the slowest learner can keep up	focused on the accelerated students, ensuring they are engaged
Use of instructional materials	felt the chalkboard should depict variety	felt the chalkboard should only show correct answers and feature the work of the teacher and knowledgeable students

Jacobs et al. (1997) make the following conclusions, cautioning the study is based on a small sample size. The Japanese define learning as constructing an understanding of the material presented through student-directed problem solving. The Americans define learning as acquiring skills and procedures, through a teacher-directed, performance- and practice-focused math lesson. A culture-specific epistemology and set of values underlie the social dynamics and the nature of mathematical discourse in Japanese classrooms (Inoue, 2011). It could be argued that these cultural factors could interfere with the success of lesson study in American settings.

Jacobs and Morita (2002) replicated this study with an expanded sample of teachers from both the U.S. and Japan. The commentary on the video lessons was classified into idea units, then sorted into a hierarchy of categories, which were hypothesized as instructional scripts by the researchers. Their findings indicate the American teachers were supportive of both traditional and nontraditional elementary-level math instruction and had different scripts for the two lessons. The Japanese teachers, however, had only one ideal lesson script that was closely tied to traditional Japanese mathematical instruction. These outcomes suggest U.S. teachers may have more culturally-sanctioned options for teaching math, but Japanese teachers may have a more detailed and widely-shared schema about effective teaching practices. Speculation could be made to attribute this commonly shared view to the influence of consensus-building through lesson study.

2.4.3 Communities of Practice

By participating in lesson study, teachers become members of a community of practice that provides a setting for learning (Sowder, 2007 in Robinson & Leikin, 2011). Participation in a community of practice is determined by particular cultural norms, language, special behavior, and

activities. Within a community of practice, members share common actions, procedures, and goals; they have a sense of belonging (Wenger, McDermott, & Snyder, 2002 in Shúilleabháin, 2013). They share a concern or passion about a topic and interact regularly to deepen their knowledge and expertise, through the promotion of group and individual learning. Through their shared experience and purpose, they experience mutual engagement, joint enterprise and a repertoire of negotiable resources that are accumulated over time.

A central role of mentoring within schools is best understood through a lens of situated learning (Lave & Wenger, 1991). Communities of Practice, grounded in a socio-cultural view of learning, emphasize the development of individuals into a group that shares a particular interest, purpose and focus (Cajkler, Wood, Norton, & Pedder, 2014). They are often characterized as sharing ways of interacting and thinking. Mutual engagement is an important concept - a mode of belonging in social learning systems that binds community members together.

Lesson study is intimate and requires vulnerability (Lewis & Hurd, 2011). Group norms help to establish the lesson study team as a learning organization that is committed to supporting each of the members through personal and collective growth. Accountability to colleagues, a focus on student learning and continual efforts to improve are natural and integral parts of this teacher learning community, which creates a foundation for a system that learns. Lesson study demands a different quality and intensity of collaboration than do most other professional development activities.

Although Communities of Practice offer one way of understanding the collaborative nature of the process, they do not make explicit the nuances and complexities involved in the metacognitive aspects of lesson study, assuming that learning is predominantly located in the interactive dimensions of the process (Cajkler et al., 2014). Lesson study should be tested using

other conceptual frameworks to give a multi-layered perspective on what is an inherently complex process.

2.4.4 Characteristics of Collaborative Professional Learning

In their research, Ermeling and Graff-Ermeling (2014) found that a culture of collaboration in a transparent environment is a critical foundation for lesson study. Teaching and learning problems become shared problems and successes are jointly celebrated. The following are characteristics present in collaborative professional learning (Stepanek et al., 2007):

- Common Goals - teachers take on collective responsibility for student learning, sharing a common purpose and criteria for measuring the success of their efforts
- Mutual Trust and Respect - Teachers have a sense of emotional safety that enables them to share their thinking and their practice
- Collective Inquiry - Staff engage in learning new ways to talk about teaching
- Reflective Dialogue - Teachers talk to each other about their practice and their students
- Supportive and Shared Leadership - Teachers have the freedom and authority to make decisions and to explore alternatives and innovations in instruction
- Continuous Learning Opportunities - Professional learning community is not a one-time effort but a way of working together that is embedded into the school culture

2.4.4.1 Lesson Study as a Framework for Professional Development

Lesson study, with its collaborative nature situated within the classroom at the heart of

teaching and learning, can be a powerful vehicle for an authentic approach to professional development. It aligns with a cognitive theory of teacher learning, conceiving learning as changes in an individual's mental schemata, often in response to opportunities to make one's own ideas visible and to mediate one's thinking with that of others in the group (Lewis et al., 2009). Research lessons can be a meaningful, motivating, high fidelity context in which teachers can build their content knowledge (Lewis, 2000).

Lesson study is a constitutive practice that acknowledges that teaching and learning are integrated activities (Crockett, 2007). Productive instructional moves can occur only when teachers observe, listen, and question, gathering evidence of their students' learning as they teach. In child-centered, constitutive practice, these types of formative assessment mediate teaching and learning. This runs counter to a more traditional teacher-centered transmissive approach where teaching and learning are linear - the teaching occurs and the learning happens, followed by the assessment, in a somewhat disconnected fashion.

Japanese teachers use lesson study as the core framework for professional learning, to continually improve the quality of educational experiences they provide their students (Iverson & Yoshida, 2005). Through lesson study, teachers have the opportunity to work collaboratively to seek effective implementation of new ideas, rather than struggle in isolation within their own classroom (Takahashi, 2015). Collaboration can create a profound motivation to improve - individually or collectively - and naturally integrate mentoring of new teachers (Lewis, 1997). Lesson study provides benchmarks against which teachers can measure their own practice and compare it with that of their colleagues. It is not a process that requires a set of skills or capabilities, but it is a context where these skills and capabilities can be developed. It is a way to promote teacher-as-researcher, creating a teacher temperament of inquiry and a disposition toward

investigating one's own practice. Teachers see themselves as developing the profession, as well as themselves (Stigler & Hiebert, 1999).

2.4.4.2 Requirements of Practitioners of Lesson Study

The work of Fernandez et al. (2003), which looked at a U.S.-Japan lesson study collaboration, found that to grow through lesson study, participants needed to learn to apply three critical lenses to their examination of lessons - researcher, curriculum developer, and student. Lesson research differs from typical American research, in that the primary goal is not to generate knowledge for others to apply, but to improve one's own practice, documenting it for others' learning (Lewis & Hurd, 2011).

The second goal is to examine an active improvement effort - not to study variables in isolation, but to consider all the parts together. Knowledge useful to practitioners often differs from typical research knowledge in three ways - it is linked with practice; it is concrete, detailed, and specific; and it is organized and integrated around problems of practice (Hiebert, Gallimore, & Stigler, 2002). Lesson study helps students to see their teachers as learners, modeling an inquiry approach to their work. "If we want our students to be thinkers, researchers, collaborators, readers, writers and evaluators, then they need to see us thinking, researching, collaborating, reading, writing and evaluating" (Routman, 1996 in Stepanek et al., 2007, p. 89).

To adopt a researcher lens for lesson study work, teachers must learn how to generate powerful questions about their practice, skillfully design lessons that can answer their questions and look for concrete evidence in a lesson to shed light on the question (Fernandez et al., 2003). They also need to develop a disposition toward their practice that is grounded in a vision of teaching as a space for learning and of themselves as actively in charge of their ongoing learning

process. Teachers require support to develop skills for critical practice and need to develop a vision of themselves as agents in professional practice (Marble, 2006).

Teachers cannot learn effective lesson study by simply reading about it; they must experience if it firsthand by participating in it on a long-term basis (Takahashi & Yoshida, 2004). It must become a cultural activity, woven into the fabric of teachers' everyday teaching experiences. Lesson study's "product" might be thought of as the development of spaces for learning from practice (Lewis & Hurd, 2011). Teachers have three major spaces for learning within their daily practice - interaction with curriculum, with colleagues and with students. Through a lesson study process, teachers can experience gradual and incremental professional growth and schools can build a bank of valuable resources that can enrich teaching and learning programs.

2.4.4.3 Conditions that Support Lesson Study

Research has shown how the following conditions contribute to successful lesson studies (Stepanek et al., 2007). Teachers must be willing to talk about their beliefs and practices, to collaborate with their colleagues, to learn from each other and their students and to make changes to their teaching. It requires times set aside for teachers to plan, observe and discuss research lessons and a common focus. Support is needed from administrators, facilitators and/or knowledgeable others, who support teachers with resources, such as materials, time and professional development. Other key elements are a high-quality curriculum, positive relationships and group norms, and a nurturing environment. Perry and Lewis (2008) identify five conditions that enable the development of lesson study:

- Build learning opportunities into the design that build upon each other

- Foster positive experiences with professional community
- Create a culture of distributed leadership - authentic and knowledgeable
- Use and develop resources; socialize teachers new to lesson study
- Identify resources - fiscal, human, time and others

There are attributes that contribute to a teacher's readiness to engage in lesson study, as identified by Lewis and Hurd (2011): questioning of subject matter and its teaching, a deep curiosity about student thinking, an urgent sense of responsibility to improve instruction and the willingness to have hard conversations. Participation in a lesson study team requires an abandonment of "my" lesson and an acceptance of "our" lesson.

2.4.4.4 Motivation to Participate in Lesson Study

Participation in a lesson study requires a commitment of time, often outside of the school day, an open mind to new approaches, and a willingness to be vulnerable with colleagues. These elements can be barriers to teachers choosing to participate in a lesson study. In addition to these intrinsic motivations, some conditions can serve as extrinsic motivators to teachers, encouraging them to join in a lesson study. Offering lesson study as an alternative way to meet an existing obligation recognizes that teachers may need to have their load lightened, to take on something new (Lewis, 2002c). When teachers have identified an area of need or interest, there may be more of an openness to engaging lesson study, if it is seen as a vehicle for addressing the need or interest. Teachers in this study volunteered to participate, out of interest in collaborating with each other to share ideas and to learn from each other. In addition, their participation fulfilled a differentiated supervision requirement, where they chose to do peer collaboration and action research as their professional growth modality for that school year.

3.0 Theoretical Framework

Lesson study in the U.S. has lacked a strong research base to support it as an effective professional development method; however, it has been supported by a strong theoretical foundation and aligns with what scholars in teacher professional development are calling for in American education reform (Rock & Wilson, 2005).

3.1 Sociocultural Theory

Analysis of the teaching and learning process and the impact on cognitive development has taken shape through the theoretical perspective often referred to as 'sociocultural,' but sometimes described as 'socio-historical' or 'cultural-historical' (Mercer, 2004). This theoretical perspective emerged from Vygotsky's conception of language as both a cultural and psychological social mode of thinking - a tool for teaching and learning, constructing knowledge, creating joint thinking, and addressing problems collaboratively.

Education is seen as a dialogic process, with teachers and students working in environments that reflect the values and social practices of schools as cultural institutions (Mercer, 2004). Cultural scripts are learned implicitly through observation and participation over time, not by deliberate study (Stigler & Hiebert, 1999). People within a culture share a mental picture of what teaching is and both teachers and students have similar scripts in mind, dictated by core beliefs about the nature of how students learn and the role a teacher should fulfill within the

classroom. Sociocultural research is not a unified field, but authorities within it treat communication, thinking and learning as related processes that are shaped by culture (Mercer, 2004). Lesson study is a culture, not just a professional development activity (Watanabe, 2002).

A sociocultural perspective demonstrates the possibility that educational success and failure may be explained by the quality of educational dialogue, rather than simply in terms of individual student outcomes or teacher skill (Mercer, 2004). It encourages the investigation of the relationship between language and thinking, as well as the relationship of what Vygotsky (1978) called the 'intermental' and the 'intramental' - the social and the psychological - elements of teaching and learning.

When teachers interact and dialogue around a topic or focus, they have the potential to 'interthink' (Mercer, 2000 in Mercer, 2004). Conversations are built on a common knowledge base and lead to the creation of more shared understanding (Mercer, 2004). Professional dialogue is reflexive - participants need to build a contextual foundation for the progress of their talk and talk is also the primary means for building that contextual foundation. Shared knowledge is both invoked and created in dialogue.

In communities of practice, learning involves active, collaborative, reflective activities that facilitate meaning-making for participants (So et al., 2010). These types of exchanges are grounded in the work of Dewey and Vygotsky. Dewey (1938) regarded learning as a process of creating meanings through active reflection and deliberation, not the mere acquisition of knowledge and skills. Learners' experiences are continuously shaped and reshaped through interaction with the environment and with other people. Vygotsky (1978) viewed learning as a social process, where learning is constructed socially.

Social constructivism asserts the social nature of knowledge and the belief that knowledge

is constructed through social interaction and is shared, rather than being isolated by individual experiences. Knowledge is constructed in response to social interactions through negotiation, discourse, reflection, and explanation. Constructivism, as a learning philosophy, situates participants as active agents who construct meaning (Cobb, Yackel, & Wood, 1991 in Inoue, 2011). In this situated perspective, people learn from and with others, exchanging ideas, conceptions, opinions, knowledge, and experiences. The spirit of lesson study embodies collaboration to collectively improve teaching and learning over time (Tolle, 2010).

3.2 Dialogic Theory

Dialogue is an ongoing network of statements, responses, repetitions, and quotations. The Dialogic Theory proposes that our speech is filled with the words of others that carry their own expression, which we assimilate and interpret (Bakhtin, 1986). An expression (word or utterance) is the main unit of meaning formed through a speaker's relation to others (people, expressions, or contexts). These expressions are addressed to someone (addressivity) and responses are anticipated (answerability), thus discourse (chains or strings of expressions) is fundamentally dialogic.

Each thought is shaped through interaction with others' thoughts and is connected to others in a chain of speech communication (Bakhtin, 1986). The "polyphony" of expressions and perspectives interact and have the potential to converge into one learning conversation. A dialogic work constantly engages with and is informed by other expressions and, conversely, informs other expressions. The voices of others become woven into what we say, write, and think (Koschmann,

1999).

In his work with collaborative learning, Koschmann (1999) has explored Bakhtin's influence, particularly with the dialogic nature of all texts for language, knowledge, and learning. Bakhtin's treatment of "voice" and "dialogicality" can serve as a basis for reconceptualizing learning. At its most fundamental level, dialogicality addresses an ontological distinction between self and other (Holquist, 1990). All expressions have an intended audience and this audience contributes to a reciprocal relationship between speaker and listener (Bakhtin, 1986).

Hicks (1996) furthers this exploration of how learning emerges through dialogic, occurring as the co-construction (or reconstruction) of social meanings from within an emergent, socially-negotiated and discursive activity. To embrace this learning, participants must decenter learning from an individual act and position it as a social interaction (Koschmann, 1999). Learning shifts from a discrete, expected event to a more dynamic, process-based and emergent series of events. There is an element of agency to dialogic learning that adds a layer of personal responsibility and social accountability for the construction of knowledge.

Knowledge-building can be analyzed as a property of the teacher-generated texts themselves. Verbal discourse is a social phenomenon (Bakhtin, 1981). The teacher expressions during a dialogue, while they reflect their world view[11], must be viewed within the context of the dialogue, for they can be limited in what they communicate when viewed outside of this dialogic orientation. Bakhtin (1981) speaks to this through "heteroglossia," which considers context over text - a word or comment spoken in that place and at that time will have a different meaning than

[11] World view, in this context, reflects a teacher's perspective of their classroom, students and learning, within the greater educational landscape of their school, state and federal policy.

it would in other conditions. "The word is born in a dialogue . . . [and] is shaped in dialogic interaction" (p. 279). Language can also be limited by jargon - in the case of this study, the teachers' dialogue could be narrowed in meaning by educational jargon or the language of the school organization. This is where the emergence of dialogism is evident - everything has meaning, understood as part of the greater whole, where there is constant interaction between meanings.

3.3 Reflective Practice

Dewey (1933) described reflection as a specialized form of thinking that engages analysis about the reasons for and effects of our actions. Reflection is more relevant and meaningful when grounded in the context of one's practice - and that reflection is amplified when supported by colleagues (York-Barr, Sommers, Ghere, & Montie, 2006). Reflective educators carefully examine, analyze, and reframe learning in terms of specific context variables, previous experiences, and alignment with desired educational goals. They are decision-makers who develop thoughtful plans to move new understandings into action so meaningful improvements result for students (Clarke, 1995). Reflective practitioners draw largely from an experiential or contextual knowledge base in which knowing cannot be separated from doing (Webb, 1995 in York-Barr et al., 2006). They recognize that much of the knowledge about effective practice is tacit, meaning it is learned from experience within the practice context.

Educational change depends on what teachers do and think, therefore individual change is at the heart of organizational change (York-Barr et al., 2006). Organizations learn through their

individual members. Reflection is encouraged when it is implicit in the organization's values, policies, and practices. Every school's goal should be to habituate reflection throughout the organization - individually and collectively. The greatest potential for reflective practice to renew schools lies with the collective thinking, inquiry, understanding, and action that can result from school-wide engagement around a compelling purpose or an inspiring vision. All staff are involved in some type of learning or shared work that relates to school-wide priorities or performance goals and improves professional practice, which influences the continuous improvement of individual, team and organizational practices.

The nature of lesson study has the ingredients to support reflective practice, which involves a rigorous process of reflecting on and reshaping past and current experiences with the intent of improving the quality of professional performance (Kottkamp, 1990). Moon (1999) identifies essential conditions that promote reflection: adequate time and space, a good facilitator, a supportive environment and an emotionally supportive team. In addition, peer sharing experiences promote greater reflection (Hatton & Smith, 1995). These conditions are present in a strong lesson study process, as well.

Through lessons learned during the lesson study engagement by the Math & Science Collaborative, Bunt (2018) advocated that to change one's way of teaching, one must be given professional development, time and ongoing support to develop skills. These elements must be "rooted in reflection, that's how we change behavior" (Bunt, 2018).

3.4 The Dialogic Space of a Lesson Study Cycle

Although the power of a lesson study approach for professional development is acknowledged in a growing number of countries, evidence demonstrating how and what teachers learn through their participation in a lesson study is still scarce. A lesson study, itself, can serve as a context for professional interaction and the immersion in lesson study creates a dialogic space for professional collaboration and peer learning. The teachers' dialogue is an integral part of the lesson study cycle, and serves as a dialogic mechanism for reflection and learning (Warwick, Vrikki, Vermunt, Mercer, & van Halem, 2016).

Through combining their intellectual resources, collaborators are able to address a shared problem and pursue a common goal more effectively than if working alone. The use of language to make joint sense of their experience enables the creation of new understandings that may not have emerged from one person's thinking. This "interthinking" names the intersection of people thinking together and acting together (Littleton & Mercer, 2013). It is a social mode of thinking - a way of constructing knowledge, creating joint understanding, and addressing problems collaboratively.

3.5 Methodological Challenges

Professional dialogue does pose a methodological challenge for analysis because of this reflexivity (Mercer, 2004). Interaction about a topic or focus does involve historical and dynamic aspects - there are historical or cultural components within the institution and there are personal or

social components amongst the people participating in the dialogue. These variables add layers to the dialogue - sometimes intangible in nature.

The dynamic aspect of collective thinking relates to the common knowledge upon which shared understanding is developed and continues to develop through ongoing dialogue. To mediate this reflexivity challenge, sociocultural discourse analysis often involves a combination of both qualitative and quantitative methods and enables the study of the nature and functions of language, thinking, and social interaction (Mercer, 2004). It considers how word choices and cohesive patterning can represent the ways knowledge is being jointly constructed. Dialogue is treated as a forum of intellectual activity, as a social mode of thinking. By combining intellectual resources, members of a group are able to address a shared problem and pursue a common goal more effectively than they could alone (Warwick et al., 2016). This dialogic space allows for teachers to engage with each other to see through another's eyes - a way of thinking through dialogue. While a sociocultural theoretical perspective is more often used to analyze teacher-student or student-student interactions, in the case of this study, it will inform the analysis of teacher-teacher interaction during the post-lesson discussions.

The dialogue that weaves itself together during the lesson debriefs will serve as one research text for the study. As the teacher participants engage in the collaborative lesson study process, they will construct their learning through conversation - a lesson study discourse. Through a qualitative lens, the analysis of this study will focus on detailed consideration of the transcriptions of the professional dialogue. Participant comments will be coded to identify dialogic and supportive moves. Dialogic moves contribute to the construction of knowledge and learning and supportive moves support the development of community and a comfortable space for vulnerability. Participant comments will also be coded by the role they have in the dialogue and

for the level of reflection they engage.

York-Barr et al. (2006) caution that it is not safe to assume that adults who learn well by themselves will also learn well with others. This must be given some consideration when looking at a collaborative process like lesson study. Teamwork is a process and a principle of adult learning and it should not be taken for granted - people need to learn how to work together efficiently (Vella, 1994 in York-Barr et al., 2006).

4.0 Methodology

Japanese researchers share that, despite lesson study's century-old history in Japan, there are no research studies of its effectiveness (Ikeda, 2001 in Perry et al., 2002). Japanese teachers ask how lesson study can be made more effective in their setting, but do not ask if lesson study is effective. There is a need for research that examines the supporting conditions that enable lesson study to succeed at particular sites where it has been effective and that identifies characteristics or results that determine its degree of effectiveness - "existence proof" of the potential effectiveness of lesson study outside of Japan (Lewis, Perry, & Hurd, 2009).

Lesson study research varies in its lenses. There are pockets of literature that look at the challenges of transferring lesson study to non-Japanese contexts, the impact on student learning, the development of instructional methods through lesson study and lesson study for professional development. The literature review for this study focused on research related to lesson study as a professional development framework and the accompanying procedures or protocols to support student learning. There were fewer studies that focused analysis specifically on the dialogue during the debrief, and these select studies tended to be with populations of pre-service teachers, conducted at the university level, although some were with populations of in-service teachers.

Several studies served as mentor studies for this study, specifically for the way they coded dialogue, although, not through replication, because their context was different. As Mercer (2004, p. 140) identifies, "[t]alk which mediates joint intellectual activity poses a considerable methodological challenge for a discourse analyst because of its reflexivity." In response to this challenge, a coding protocol is recommended to scrutinize the data and to analyze the reflective

discourse. The work of Hatton and Smith (1995) identified four levels of reflectivity in teacher candidates' journal writing: (1) non-reflection, pure description; (2) descriptive reflection; (3) dialogic reflection, rationalization; and (4) critical reflection. Perkins (2015) enhanced the definition of these levels with descriptions of action. The four levels seek to capture the depth of reflection and the degree to which reflectivity is expressed.

A study by Warwick et al., (2016) conducted with primary and secondary math teachers in the United Kingdom, categorized teacher contributions to the post-lesson dialogue using five elements: questioning, building on each other's ideas, coming to an agreement, providing evidence or reasoning and challenging each other.

This scrutiny of the data with open coding led to the further classification of the comments as dialogic moves or supportive moves, in the vein of Bakhtin's Dialogic Theory. Dialogic moves are comments that bring the conversation closer to a collaborative learning experience. Supportive moves (affirming comments & agreements) are essential for the creation of a dialogic space where the participants feel supported in expressing their views. Dialogic moves are accepted in groups because they are accompanied by supportive moves, creating a space of reciprocity and collective commitment that supports "the continual (re)negotiation of meaning" (Mercer & Littleton, 2007, p. 25 in Warwick et al., 2016). The interaction of the dialogic moves and the supportive moves are formative in creating a productive learning environment - a dialogic space for teacher learning.

Findings by Warwick's team (2016) suggest that a focus on student outcomes enabled teachers to collaborate more effectively on developing pedagogical intentions to address student needs. They also suggested that particular features of dialogue are evident when teachers move to an agreed perspective on pedagogic change. Evidence of 'supportive moves' in interactions suggest that a form of dialogic space is necessary if all participants in a lesson study group are to

learn from shared understandings about teaching and learning exchanges.

It is important to note the teacher participants in Warwick et al.'s (2016) study were trained in the productive use of dialogue and professional intentions, so their inclination to make contributions to the dialogue in these areas may have been influenced by their awareness of these elements. The researchers found the focus on specific dialogic moves in the group interactions did considerably assist the reflective process.

4.1 Rationale for Study Method and Design

In the places where lesson study has found support and success, teachers find it valuable because it differs from traditional professional development in its relevance to their students and their practice (Murphy, 2012). It attends to teaching in the moment and positions the teacher as researcher and the lesson as the unit to be analyzed and improved. Lesson study is teacher-directed, with teachers determining how to explore their chosen goals and to address student needs through their examination of practice (Chokshi & Fernandez, 2004). Teachers see themselves as professionals, contributing to the profession. Sustained focus on lesson study can help teachers to build a shared language for describing and analyzing classroom teaching.

This study attempted to determine if the dialogic space of the post-lesson discussion stage of an interpretation of lesson study could be effective for encouraging teacher reflection and growth. Special attention was given to the collaborative environment of a community of practice, professional learning, and reflective practice.

The team who participated in this study has taught together for two years. This was their second lesson study together - they had engaged the process together during the previous school year. The pilot lesson study, focused on a STEM[12] lesson, allowed the team to experience a full lesson study cycle. Each member of the team volunteered to participate in the pilot study and expressed sincere interest in doing a second cycle together the following year.

4.1.1 Teacher Incentive

I speculate the structure of a lesson study approach supports teachers as they design a lesson together, teach it, observe students, and evaluate its impact. The collaborative orientation of the activity serves to build mentoring and peer modeling into the professional development. Lessons are researched, instructional decisions are scrutinized, and best practices are forged. Teachers with less experience can learn from working alongside experienced teachers or content area experts. This metacognitive process can then become part of their practice, as they prepare other lessons on their own. Professional development is embedded into the fabric of planning and implementing instruction. Teachers can become active researchers. I believe collaborative lesson study can be more powerful than observing a peer teaching or even conducting an action research project because of how reflective action is woven throughout the process.

A lesson study format can serve as the thread that ties professional development and

[12] STEM stands for Science, Technology, Engineering and Mathematics and is currently emphasized in U.S. schools, in an effort to improve learning in these areas and to increase the number of students pursuing college and careers in STEM fields, as part of a greater effort to maintain the position of the U.S. as a leader in the global economy.

differentiated supervision together to support teacher growth. Regarding this study, the teacher participants had flexible professional development plans, which allowed them to determine their own personal professional development topics and activities. This flexibility allowed for the teachers to identify their professional focus and to count the time spent in lesson study towards required professional development hours, which occur outside of the school day and are compensated. This helped to relieve issues of time commitment and compensation - teachers were completing their differentiated supervision plan and were compensated for their time. These flexible hours were completed after school or on days off, as per the collaborators' schedules - which also allowed for more extended periods of time for planning. For this study, the teachers chose a math lesson and selected action research as their differentiated supervision modality.

There are elements of lesson study that have the potential to neutralize the incentive to participate in it. Lesson study, when engaged authentically, requires more time than traditional professional development activities, requires for teachers to have or to make time to collaborate and requires initiative and personal responsibility for learning from the teacher team. It may not, however, be the best professional development approach for all teachers or school systems.

4.2 Setting and Participants

The kindergarten team who engaged in the study was comprised of four teachers with the following demographics: (1) 6th year teaching kindergarten, 1 year of first grade experience, masters degree in reading; (2) 4th year teaching kindergarten, 1 year of reading support experience, masters degree in reading in progress; (3) 2nd year teaching kindergarten, 8 years of second grade

experience, masters in reading and special education certification; and (4) 2nd year teaching kindergarten, 2 years of second grade experience and special education certification. In addition to the kindergarten team, there were two knowledgeable others who participated in the observations and debriefs, to offer specialized insight. One knowledgeable other is a seasoned learning advisor, with classroom experience in first grade and as a reading specialist – both at this school, and who has extensive experience with early childhood development. I served as a knowledgeable other with experience in K-6 curriculum and pedagogy, in addition to facilitating the overall process. I have a masters degree in school leadership and curriculum and supervision, and have served as a principal for 7 years – all at this school.

The team is highly collaborative – they have worked together to maintain a curricular scope and sequence and pacing guide, regularly share lesson ideas and materials, have created common benchmark assessments and take turns writing the weekly newsletter that is sent home to all kindergarten students. A unique feature of this team is that they share the responsibility for student learning for all students, not just their individual classes. An example of this is how they cross-group[13] their students across the entire grade level during their daily reading intervention period, so students are working on targeted skills in homogenous groups for focused instruction and intervention. This act of shared responsibility, entrusting a colleague with one's students, demonstrates the level of respect and trust this team of teachers has for each other. This dynamic should be acknowledged, as it may not be the case in other schools or with other teams of teachers

[13] In this usage, cross-grouping is when teachers share students across the grade level, so students may work with a teacher other than their classroom teacher for interventions - remediation below benchmark, practice at benchmark or enrichment above benchmark.

where lesson study is engaged. It should also be noted that this team consisted of teachers with multiple years of experience, all of whom had graduate degrees and coursework. These variables likely contributed to their capacity to make insightful student observations, to reflect and to critically analyze teaching and learning processes.

4.2.1 Conditions Supporting the Study

This team teaches in a primary elementary school with 425 students, grades K-2, in a small, suburban school district in Western Pennsylvania. The 40 instructional staff have a history of collaboration and often seek opportunities to work together and to learn from each other. Professional development and faculty meeting activities regularly involve grade levels working together on a task or cross-grade level teams collaborating on an area of interest. Each grade level meets several times a month and teams of teachers regularly work together on curriculum, assessment, and instructional initiatives.

Evidence suggests this group of teachers values learning from each other. A consistently high number of staff members choose to do peer observations for their differentiated supervision modality and it is evident from their supervision reflections that they do use ideas generated during their peer observations in their classroom. This value system indicated that there would be some interest amongst the teachers to participate in a lesson study cycle.

An anticipated barrier was that the time commitment outside of the school day would decrease some interest in participating in a lesson study. While some school time was devoted to the cycle, additional time was required. The teachers had 26 hours of individual professional development hours to complete, on their own time and in areas of personal interest, as per contract.

However, not all teacher learning is best served in a lesson study cycle. These variables weighed into teacher decisions about their interest in participating in a lesson study.

4.2.2 The Process

The teachers selected a math topic as the focus of their research lessons, studied the standards, compared curricula and sample lessons, consulted knowledgeable people and explored strategies appropriate for the lesson. Some teacher work was completed during team meetings and some was completed by individual teachers. Study documents were managed in googledocs, so all team members had access to live documents and could collaborate on the editing. In this study, each teacher who taught one of the lessons developed their own lesson plan. (In a traditional lesson study approach, the team often writes the lesson plan together). The discernment of materials was critical - the rejection of resources that do not advance the goal of the lesson is just as important as the selection of appropriate resources. I was involved as a participant, attending some of the planning meetings, offering ideas during their planning process and participating in the observations and debriefs, in addition to serving as a facilitator for the overall process. My role was not evaluative in any capacity. This is a critical distinction - my role was as a researcher-participant, not as a supervisor or evaluator.

One team member taught their research lesson, while others observed and took detailed notes (Lewis & Hurd, 2011). The teacher-observers focused on the students' thinking and actions as evidence. The data collection plan involved team members observing small groups during the entire lesson and gathering open-ended anecdotal notes and student quotes.

The team engaged in a post-lesson discussion to share their observation insight and to

deliberate about the teaching and learning observed during the lesson. This served to deepen teachers' content knowledge, their awareness of student thinking, their understanding of teaching and learning and their commitment to the improvement of their own practice and that of their colleagues. Enhancements to the second lesson addressed the problems and student misunderstandings identified in the first teaching presentation (Stepanek et al., 2007).

The enhanced lesson was taught by a second teacher in a different classroom, followed by a second reflective discussion (Lewis, 2002b). Reflection is a key component of effective adult learning, helping learners to identify and examine beliefs and values from different perspectives (Brookfield, 1986). It supports teachers as they extract knowledge from their experiences, frame questions about the assumptions that influence their teaching and form new hypotheses (Stepanek et al., 2007). The discussion becomes the reflection (Yoshida, 2006). The process of reflecting is a key step in ensuring that experiences lead to learning and change (Stepanek et al., 2007).

4.3 Ethical Considerations

Although the teacher participants have chosen lesson study as professional development modality within our differentiated supervision model, the analysis prompted by this study was not a condition of their professional evaluation. Teacher responses to differentiated supervision prompts, as part of their evaluation, were separate from the data that was analyzed for the study and their contributions to the study were not factored into or influential of their evaluation rating. Individual teacher reflections, in isolation of each other, do not capture the spirit of this study, which is centered on collaborative learning within a dialogic space.

4.4 Data Collection: Learning as Reconstruction of Experience

Several texts served as data sources. As the lesson was taught, the teacher participants observed the students, noting specifics about what they said and did. For the purposes of this study, this was called "kid-watching." The observation notes they took served as the first text. These reflections-in-action captured and recorded student learning. This is a pivotal component - student thinking and learning drives the teachers' reflective action. These observation notes were transcribed and coded using the Eight Mathematical Practices outlined in the PA Common Core Standards (PDE, 2014). The Mathematical Practices are attributes of effective math learners and serve as a vehicle through which the PA Core Standards are taught. Table 4 outlines the Mathematical Practices and how kindergarten students may exhibit them.

Table 4. PA Core Standards for Mathematical Practice, 2013

Category	The 8 Practices	Skills Kindergarten Students May Exhibit
Habits of Mind of a Productive Math Thinker	1. Makes sense of problems and perseveres in solving them	• Begin to build the understanding that doing mathematics involves solving problems and discussing how they solved them • Explain the meaning of a problem and look for ways to solve it • Use concrete objects or pictures to help to conceptualize and solve problems • Check one's thinking by asking, "Does this make sense?" or try another strategy
	2. Attends to precision	• Develop mathematical communication skills • Use clear and precise language in discussions with others and within one's own reasoning
Reasoning and Explaining	3. Reasons abstractly and quantitatively	• Begin to recognize that a number represents a specific quantity • Connect the quantity to written symbols • Create a representation of a problem while attending to the meanings of the quantities (quantitative reasoning)
	4. Constructs viable arguments and critiques the reasoning of others	• Construct arguments using concrete referents, such as objects, pictures, drawings and actions • Begin to develop mathematical communication skills in mathematical discussions involving questions like, "How did you get that?" and "Why is that true?" • Explain ones thinking to others and respond to others' thinking

Table 4 (continued)

Modeling and Using Tools	5. Models with mathematics	• Experiment with representing problem situations in multiple ways, including numbers, words (mathematical language), drawing pictures, using objects, acting out, making a chart or list, creating equations, etc. • Connect the different representations and explain the connections • Use all of these representations, as needed
	6. Uses appropriate tools strategically	• Begin to consider the available tools (including estimation) when solving a mathematical problem • Decide when certain tools might be helpful • Decide that it might be advantageous to use linking cubes to represent 2 quantities • Compare the two representations side-by-side
Seeing Structure and Generalizing	7. Look for and make use of structure	• Begin to discern a pattern or structure
	8. Look for and express regularity in repeated reasoning	• Notice repetitive actions in counting and computation (ie. patterns or sequences) • Continually check one's work by asking, "Does this make sense?"

The second text was a transcription of the dialogue during the post-lesson debriefs for both the first and second lessons. These reflections-on-action were analyzed for the themes that emerged using the five elements identified in Warwick et al.'s (2016) study and for the role they fulfilled in the professional dialogue, distinguishing between dialogic and supportive moves, as seen in Figure 6. They were also coded by the level of reflection they exemplified, using Hatton and Smith's (1995) four levels, as seen in Figure 7. The transcriptions were coded by a professional development consultant and myself, for inter-rater reliability of the code assignments.

Table 5. The Five Roles of Comments in Conversation

Based on the research of Warwick et al., 2016	
Questioning	requesting information, opinion or clarifications; includes negotiating meaning
Building on each other's ideas	expressing shared ideas for the co-construction of knowledge
Coming to an agreement	expressing shared ideas towards a dialogic resolution
Providing evidence of reasoning	illustration of points or arguments
Challenging each other	challenging or refocusing the talk

The third text was final reflections from the teacher participants on their experience. These reflections characterized reflection-on-action - their overall learning from the lesson study cycle. This allowed them time and space after the lesson study cycle to process their learning and to personalize it to their classroom and students. The participants reflected upon their lesson study experience, guided by four prompts: (1) What do you believe about how kids learn? What role do you play in the learning process? (2) How has your participation in this process changed the ways you think about student learning and about kid-watching as a formative assessment strategy? (3) To what degree was your learning shaped by the contributions of your colleagues? and (4) How has this process impacted your understanding of math and of teaching math? Their anonymous reflections were also coded using Hatton and Smith's (1995) four-level reflective framework, as seen in Table 6.

Table 6. Levels of Reflection

	Hatton & Smith, 1995		Précis: Dr. C. Mike Perkins 8/26/15	
Level 1	Non-reflection / pure description level	which involves mere recall / description	A description of events that occurred or a report of literature. No attempt to provide reasons or justification for events	
Level 2	Descriptive reflection / recall level	which is the lowest level of reflection, involving description / recall as well as an attempt at simple explanation	not only a description of events but some attempt to provide reason justification for events or actions but in a reportive or descriptive way	(a) Reflection based generally on one perspective/factor as rationale (b) Reflection is based on the recognition of multiple factors and perspectives
Level 3	Dialogic reflection / rationalization level	which is a higher level of reflection, involving exploration of alternative explanations from different perspectives	Demonstrates a "stepping back" from the events/actions leading to a different level of mulling about, discourse with self and exploring the experience, events, and actions using qualities of judgments and possible alternatives for explaining and hypothesizing; Such reflection is analytical or/and integrative of factors and perspectives and may recognize inconsistencies in attempting to provide rationales and critique	(a) Reflection based generally on one perspective/factor as rationale (b) Reflection is based on the recognition of multiple factors and perspectives
Level 4	Critical reflection / reflectivity level	which is the highest level of reflection, involving a critical analysis that situates reasoning within a broader historical, social, cultural or political context, with a view to changing or improving in the future	Demonstrates an awareness that actions and events are not only located in, and explicable by, reference to multiple perspectives but are located in, and influenced by multiple historical, and socio-political contexts	

4.5 Data Analysis

The data were analyzed through several lenses, beginning with individual participant contributions to the lesson debriefs. The next view considered the dialogic movement of the comments - how comments fulfilled different roles and naturally resulted in subsequent dialogic moves. The teachers' observations of the lessons were framed by how they represented the eight PA Core Standards for Mathematical Practice. Finally, the final teacher reflections were compared with the collaborative debriefs, with attention to the depth of reflection they engaged.

A mixed-method approach was taken, that looked at teacher reflection and growth both statistically, to look at measurable outcomes, and through transcript excerpts, to give life to the numbers. I opted for this multi-method approach that allowed for participants to tell their story through their words – both during the debriefs and through their reflections – and to give a common currency – coded data and percentages – to compare levels of reflection and dialogic movement across the collaborative debriefs and the individual reflections.

It should be acknowledged that a data set of four participants is limited in its generalization to the greater population of teachers. The small sample allowed more space for participants to be active contributors and a more comfortable environment for intimacy in conversation.

4.5.1 Individual Participant Contributions to the Lesson Debriefs

Table 7. Teacher 2 Lesson Debrief Data

Debrief	# of comments	% of comments	Q	B	A	E	C	D	S	1	2	3	4
1	42	27%	4	18	9	10	1	33	9	15	13	5	0
2	57	34%	4	19	21	12	1	34	23	8	19	7	0

Q – Questioning
B – Building upon
A – Coming to agreement
E – Evidence or reasoning
C – Challenging

D – Dialogic
S – Supportive

Level 1 - Description
Level 2 - Explanation
Level 3 – Alternate explanation with different perspectives
Level 4 – Critical analysis

Teacher 2 contributed the greatest number of comments to both lesson debriefs, with 42 comments (27% of the conversation) during debrief 1 and 57 comments (34% of the conversation) during debrief 2, which was also the lesson she taught. Significant contributions were made to debrief 1, evidenced through the distribution of the roles of her comments - 18 built upon others' ideas, ten provided evidence or reasoning for a proposed idea, four questioned another's comment and one challenged a colleague's idea - all dialogic moves. Nine of her comments were supportive moves, coming to agreement with other participants. The majority of her comments were a reflective level 1 or 2 - 15 and 13, respectively - primarily descriptions or basic explanations of observations. Five comments engaged deeper rationalization and consideration of other perspectives - reflective level 3.

During the discussion about how the students constructed an addition equation from their towers of cubes, she offered the following reflection.

"But, even if we had just switched it, because they do teach that in [the] Eureka [Math approach], that number sentences can be written either way. Like, 7= that may have been a little bit better, because they (students) want to pull from the top first, because that's what they see. And that's just a normal thought, too…. And, then I thought, maybe, what would have helped with writing the number sentence later on was to have them, maybe not do as many on the board, but have them [use] their towers to write the numbers in the number bond, itself, not just leaving the towers there. And, then taking and showing them, ok, now that you have these numbers, let's take it and put it into a number sentence. And, I think if we would have done that throughout the practice, then we would have maybe achieved a better goal of writing that number sentence…. They weren't seeing that those were parts and it was a whole."

She uncovered some insight about the students as learners and as people with kidwatching observations, like the following, where she considers the students' thinking in her brainstorm about how to design the instruction to help the kids see two parts that are added together to get the whole.

"I know you said they wanted to make patterns - but, I find that interesting, you can tell, one kid at my table did black and blue, 5 and 5 - so, she was seeing it as two parts. And then you have the kid that still wants to be like kind of organized, do a pattern. Then you have the kid that just didn't really care what it looked like. And, it kind of shows a little bit into their personality, like who they are…. And, I thought, too - I know Eureka's very intentional about how they teach things and I know it would be cool to have, like you know how they do red and blue all the time - to have 5 of each - they are very intentional about showing that makes 10. And, then I thought, too - to kind of take it to the next level when we're teaching, you (towards teacher who taught the lesson) were always asking, "What's in the jar?" Well, how can we figure out what's in the jar by what's left? Like, what is one less - you know how you had to count 9 of them out? Well, boys and girls, I see one. We know we have 10 - let's think - what is one less than 10? You could check, to get their brains working that way….take 1…to see where their brain is at - you know, because some kids - you know how we teach them there are 5 fingers. Those kids that still struggle with knowing there's 5, can't see that, like you said, 1 is - you're just pulling 1, I don't need to count them

again."

Teacher 2 made similar contributions during debrief 2, however she also had the additional responsibility of teaching this lesson, giving her a different perspective. Of her comments during the second debrief, 19 built upon others' ideas, 12 provided evidence or reasoning for a proposed idea, four questioned another's comment and one challenged a colleague's idea - all dialogic moves. Twenty-one of her comments were supportive moves, coming to agreement with other participants. Her teaching role during this lesson may have influenced the depth of her reflection. During this debrief over half of her comments (19) were a reflective level 2, offering explanations of the observations - both hers and those of the other participants. Eight comments were simply descriptions (level 1) and seven comments engaged deeper rationalization and consideration of other perspectives (level 3). This teacher is a natural and vocal leader on her team. This is consistent with the confidence she demonstrated during the lesson study cycle - teaching one of the lessons and being an active contributor to the conversation during the debriefs.

In her contributions during the debrief, she addresses the vulnerability required to be open to learning within a lesson study approach and alongside colleagues.

"That's what I kind of explained [to the students], I said, 'The grown-ups are coming in and it's a good way for [me] to learn to be a better teacher for you because I'm going to have the grown-ups help me to learn.' Because, it is true, you never know until you actually do the lesson, and then when you have five different eyes on your lesson, you see things you maybe didn't catch….see things differently, through a different lens. Because, I'm looking at it, whole group, trying to figure out who…trying to stay on top of it, but you get to actually sit with the kids, and then come back and say what you saw…. And it is hard, I know it's hard, as a teacher, though to welcome other people, because you sometimes feel like…you're on display; you're being judged. I know you guys don't think that…and you want to do your best, because you want to feel - you want that validation – 'Ok, I can do this!' "

Table 8. Teacher 3 Lesson Debrief Data

Debrief	# of comments	% of comments	Q	B	A	E	C	D	S	1	2	3	4
1	38	25%	1	9	21	4	3	17	21	10	5	1	0
2	40	24%	3	9	21	7	0	17	23	8	8	1	0

Q – Questioning
B – Building upon
A – Coming to agreement
E – Evidence or reasoning
C – Challenging

D – Dialogic
S – Supportive

Level 1 - Description
Level 2 - Explanation
Level 3 – Alternate explanation with different perspectives
Level 4 – Critical analysis

During both debriefs, teacher 3 also contributed a high number of comments - 38 (25% of the conversation) during the first debrief and 40 (24% of the conversation) during the second debrief. Of note, a considerably high number of her comments during both debriefs were supportive, affirming a colleague or coming to agreement with a colleague - 21 comments during each debrief. Her greatest contributions to the debriefs were in building up colleagues, affirming instructional decisions and learning outcomes, and fostering a positive, supportive environment. While a primary goal in lesson study is professional learning, the importance of this positive, supportive culture amongst the participants is essential for creating a space where colleagues feel comfortable being vulnerable with each other - where authentic learning can be fostered. This emotional contribution is also consistent with the positive outlook this teacher exudes, on a daily basis, with her students and colleagues.

She affirmed her colleagues and the process, through comments like, “Yeah, they were just two totally different lessons – in their own way….I thought it was great! It went well today!” She

validated others' comments, "That's the first thing I wrote down! Mmm-hmm." She reinforced observations others shared, which helped to increase the weight of their contributions. When they were discussing the visual layout and color-coding of a number bond, she offered, "Yeah, understanding it's different – or even a different shape."

Teacher 3 did contribute some dialogic moves through her comments. She challenged ideas more than her colleagues did, but did so in a positive, supportive way. "I don't think it matters whether or not you have the equation at the beginning or the end, as long as you keep that consistent." Of her comments during debrief 1, nine built upon others' ideas, four provided evidence or reasoning for a proposed idea, one questioned another's comment and three challenged a colleague's idea. Of her comments during debrief 2, nine built upon others' ideas, seven provided evidence or reasoning for a proposed idea and three questioned another's comment.

The majority of her comments were at a reflective level of 1 or 2 - ten level 1 and five level 2 during debrief 1 and eight at each level (1 and 2) during debrief 2. In each of the debriefs, she contributed one comment at a reflective level 3. An example is her analysis of how lesson content is presented to maximize student thinking and ultimately, learning. "So, if we were to do this again, what if we flip-flopped the exit ticket, or what if we skipped the application piece?"

Table 9. Teacher 1 Lesson Debrief Data

Debrief	# of comments	% of comments	Q	B	A	E	C	D	S	1	2	3	4
1	24	16%	5	4	8	7	0	12	12	7	4	1	0
2	13	8%	2	4	4	3	0	8	5	1	6	1	0

Q – Questioning
B – Building upon
A – Coming to agreement
E – Evidence or reasoning
C – Challenging

D – Dialogic
S – Supportive

Level 1 - Description
Level 2 - Explanation
Level 3 – Alternate explanation with different perspectives
Level 4 – Critical analysis

Teacher 1, who taught the first lesson, contributed 24 comments (16% of the conversation) during debrief 1 and 13 comments (8% of the conversation) during debrief 2. She seemed to be more comfortable expressing ideas about her own teaching or felt more empowered to contribute because she had taught the lesson. (The teacher of the lesson is also the first commenter, to give him/her space to say what he/she would like before colleagues comment). Her distribution of dialogic and supportive moves was more even. Of her comments during debrief 1, four built upon others' ideas, seven provided evidence or reasoning for a proposed idea and five questioned another's comment, in some cases questioning a teaching decision she had made. Half of her comments were dialogic moves and the other half were supportive moves. Seven of her comments were a reflective level 1, four were a reflective level 2, and one reached deeper to a reflective level 3.

Her initial reflection compared her approach during the lesson to her typical instructional strategies in her classroom. This demonstrates a level 3 reflection – analyzing actions in the greater classroom context and applying them to future action.

"The first thing, the cubes, I liked - at first I told [the kids] to take the two apart and then I said, "Let's build our tower of 10." And, afterwards, I thought, we could have put our ten cubes in the number bond, too, but I hadn't really done that. When we do our number bonds, we…switch numbers around. Like today, I wasn't thinking we kept the same number. So, usually, when we do them in class, we'll switch, and we've been doing a lot of team numbers. So, I was thinking that would have been something I could have done - put the 10 there to show 10 and then showed them broken apart, instead of just writing it - for some of the more visual kids.

Of teacher 1's comments during debrief 2, four built upon others' ideas, three provided evidence or reasoning for a proposed idea and two questioned another's comment. She did not challenge any ideas or colleagues during either of the debriefs. Eight of her comments served dialogic purposes and five were supportive moves. Her comments during debrief 2 offered more explanations at a reflective level 2 - six comments - possibly because she had the role of observer and not as teacher for this lesson. She had one comment that was a reflective level 1 and one that was a level 3.

She did share teacher 2's sentiments about the value of observing others in action within a lesson study.

"I agree with [teacher 1], I think it's nice, it's refreshing to go in and see what other teachers are doing….ways they're doing things, because sometimes we're like the kids - set in one way that we do something, because it works for us. You get used to doing it that way all of the time….and changing your perspective a little bit."

Table 10. Teacher 4 Lesson Debrief Data

Debrief	# of comments	% of comments	Q	B	A	E	C	D	S	1	2	3	4
1	12	8%	0	4	4	4	0	8	4	7	1	0	0
2	11	6%	0	5	2	4	0	9	2	6	3	0	0

Q – Questioning
B – Building upon
A – Coming to agreement
E – Evidence or reasoning
C – Challenging

D – Dialogic
S – Supportive

Level 1 - Description
Level 2 - Explanation
Level 3 – Alternate explanation with different perspectives
Level 4 – Critical analysis

Teacher 4 contributed 12 comments (8% of the conversation) during debrief 1 and 11 comments (6% of the conversation) during debrief 2. She contributed the fewest number of comments, but still did contribute to the dialogic moves of the debriefs. Of the four teacher participants, she has the least number of years of experience. This could have factored into her role as more of a listener and learner in the discussion - or to less of a knowledge based for drawing upon. Of her comments during debrief 1, four built upon others' ideas, four provided evidence or reasoning for a proposed idea - dialogic moves - and four were coming to agreement - supportive moves. Of her comments during debrief 2, five built upon others' ideas, four provided evidence or reasoning for a proposed idea - dialogic moves - and two were affirming, supportive comments. She did not make any comments that questioned or challenged people or ideas during either debrief. Her comments were primarily descriptive, at a reflective level 1 - seven in debrief 1 and six in debrief 2. She did contribute reflective level 2 comments - one in debrief 1 and three in debrief 2 - and one level 3 comment in debrief 1.

Teacher 4 made contributions of evidence: "[A student] grabbed more [blocks] - I don't

know if she had more blocks and she changed her part-part - she had 10 and 2 and she had a tower of 10 and 2, but she didn't change that whole. And I don't think she even counted to see how many she had all together. She just had two separate numbers - and didn't really connect that whole to it." She also built upon colleagues' contributions: "With that 10 - when it was 9 in the jar - some of them, you could see, they had to count out 9, but some of them already knew I just take 1 off."

While the four teachers were active contributors to the dialogue during each debrief, none of their comments reached the depth of level 4 or critical reflection. A variety of variables could contribute to this. All of the teachers have less than ten years of experience, so they have not had the degree of experiences that more seasoned teachers may have to bring to the discussion. Their observations and reflections are limited to what they know - both about mathematical content and pedagogy and about the development of young learners. Their capacity for recognizing nuances in teaching and learning and their ability to intuit developmental cues from their kid-watching is still being refined. These variables support the need to involve knowledgeable others in the observation of the lessons and in the debrief. Their content area and pedagogical expertise is valuable in building the capacity and skills of the teacher participants. In this study, the roles of knowledgeable others were fulfilled by an administrator and a learning advisor. While neither is a math content expert, both have had different learning experiences with math curriculum and pedagogy than the teacher participants.

Table 11. Knowledgeable Other 1 Lesson Debrief Data

Debrief	# of comments	% of comments	Q	B	A	E	C	D	S	1	2	3	4
1	23	15%	2	7	8	6	0	15	8	7	6	2	0
2	28	16%	0	11	10	7	0	18	10	2	13	3	0

Q – Questioning
B – Building upon
A – Coming to agreement
E – Evidence or reasoning
C – Challenging

D – Dialogic
S – Supportive

Level 1 - Description
Level 2 - Explanation
Level 3 – Alternate explanation with different perspectives
Level 4 – Critical analysis

Knowledgeable other 1 contributed 23 comments (15% of the conversation) during debrief 1 and 28 comments (16% of the conversation) during debrief 2. The majority of her comments served a dialogic role - seven built upon others' ideas, six provided evidence or reasoning for a proposed idea and five questioned another's comment during debrief 1. Of her comments during debrief 2, eleven built upon others' ideas and seven provided evidence or reasoning for a proposed idea. She also offered supportive comments, affirming people and ideas - eight during debrief 1 and ten during debrief 2. Her comments were within reflective levels 1-3. During debrief 1, seven comments were level 1, six comments were level 2 and two comments were level 3. During debrief 2, two comments were level 1, 13 comments were level 2 and three comments were level 3.

Knowledgeable other 1 made significant contributions that gave insight into developmental thinking which helped to guide the teacher participants to deeper levels of reflection on intentional teaching and the learning that results.

"One of the things with a number bond, I think of the way [the kids] see things. The way you display it is the way they see it. If you could make circles that were just put on the board in different colors,

like you're saying, that would be fine - red, blue and purple, because they all understand that. Then have them be moved - visually move them for them and have them do that a couple of times. This one goes here, this one goes here, this one goes here. Do the circles, first, then add the objects in there. Then leave the objects there with the circles, and underneath that, say "How many are here? How many are here? How many do we have all together?" And then push them back up. And then see if they can pull that number. Like, I would do all of that physical movement for them….You have to physically pull that down in front of them. They would find that engaging, I think. They would be like moving it. So, that might be an easier transition to put it into a number sentence, but tell the story with the number sentence…. I would lay it out the way you use it - completely normally, then have that down here, like this (gestures to where equation should go on board), and then move the circles down there, there and there. Have them do that, moving the circles, even if you wanted them to do it all group, or just a couple kids come up and do that. Then, transition that to, this goes here, this goes here and this goes here…. I think the physical movement would help and the same thing, you could do the number sentence with the kids and they all have to jump over to the equal side. You all have to be here, now - something make it physical for them….and having them physically do it."

"Language is critical….You modeled it. I noticed the 'and' and the + (plus sign) you did it explicitly with. They understood, that's the same. Relating it to story problems, which kids traditionally have lots of difficulty with - they're starting to see a story problem is the same as this - so, I liked that. Because, when you start story problems, kids always see that as different. I like that they can see a story can be a math problem, so it doesn't seem so foreign to them as they start to do them."

"I liked both strategies. I liked the Eureka (math program) strategies and I could see mathematically how helpful they are on a developmental level. It's so much better than just doing rote math. And even just using manipulatives, without a visual - like connecting to those 10s and the part, part, whole. It is, it's like a graphic organizer for math that gives them something to try to get that concept down."

Table 12. Knowledgeable Other 2 Lesson Debrief Data

Debrief	# of comments	% of comments	Q	B	A	E	C	D	S	1	2	3	4
1	14	9%	5	5	0	3	1	13	1	4	7	2	0
2	20	12%	3	6	1	10	0	17	3	1	7	5	4

Q – Questioning
B – Building upon
A – Coming to agreement
E – Evidence or reasoning
C – Challenging

D – Dialogic
S – Supportive

Level 1 - Description
Level 2 - Explanation
Level 3 – Alternate explanation with different perspectives
Level 4 – Critical analysis

Knowledgeable other 2 contributed 14 comments (9% of the conversation) during debrief 1 and 20 comments (12% of the conversation) during debrief 2. The majority of her comments served a dialogic role - five built upon others' ideas, three provided evidence or reasoning for a proposed idea, five questioned another's comment and one challenged an idea during debrief 1. Of her comments during debrief 2, six built upon others' ideas, ten provided evidence or reasoning for a proposed idea and three questioned an idea. She did offer supportive comments, however, it was more of a secondary role - one during debrief 1 and three during debrief 2. Her comments spanned all four reflective levels. During debrief 1, four comments were reflective level 1, seven comments were reflective level 2 and two comments were reflective level 3. During debrief 2, one comment was reflective level 1, seven comments were reflective level 2, five comments were reflective level 3 and four comments pushed participants at a level 4.

It is possible that knowledgeable other 2 was able to reach a level 4 depth of reflection due to her professional experience with curriculum and pedagogy, paired with a more holistic view of the lesson study. The teacher participants tended to focus more on the functional elements of the

teaching and learning process and not as much on the vertical positioning of the lesson in a greater sequence of mathematical development.

"Because if you are talking as you read your story about how many fireflies you have all together - we have two parts, but here's them all together and you're talking about your tens frame - how many of this color and how many of this color and how many all together - That transfers to your number sentence or your equation - the parts go here and that equals how many all together. There's that continuity of math language and you transfer that to: all together means equals…. And that's something, too, when you're thinking about a vertical sequence of math instruction - it's really important. And conceptual understanding, kids can memorize math facts - 3+4=7, but, for them to understand, we're taking 3 and we're adding to that, adding 4 more - that conceptual understanding is really important. So, intentionality in your word choice is important."

The observation component of the lesson study allowed for participants to observe several students throughout the entire lesson. This allows for participants to really tune into student thinking, as knowledgeable other 2 demonstrates below.

"I had [a student] at my table, and he was distracted. The blocks were a bow and arrow, they were binoculars, they were a microphone. He was the last one to do every activity and often it's because he noticed what his peers were doing and realized he needed to be doing it, too. On first observation, he seemed to be completely off-task. He got each one of them correct and he was the only one at the table to get the equation correct without any prompting. So, that was interesting to me. When I asked him, at one point, "what was your direction?" He was able to tell me what it was, but it looked to me like he wasn't paying attention at all. He's a bit of a puzzle - he's listening, even though it absolutely looks like he is not. He is able to do."

Level 4 reflections surfaced during debrief 2, possibly because the second discussion built upon the dialogue and learning during the first debrief. Lesson enhancements were made during

the second lesson based on student observations and teacher conclusions from the first lesson. The lesson was refined through each teaching iteration and each debrief. The progression led naturally towards a deeper level of reflection. The comments that emerged during debrief 2 also brought more of a vertical perspective with regards to math curriculum and pedagogy and functioned as summative reflections on the whole lesson study cycle and experience.

Teacher 1 makes an observation related to the kindergarten math sequencing: "Yeah, I agree. [The concept of part-part-whole] would be better to start with. We could do that at the beginning of the year, then move into the number bond, where it's a little bit more abstract." Knowledgeable other 2 comments on the role of intentional math talk within the vertical math sequence.

"I'm thinking about the word problems. If you look at first and second grade, the application problems are word problems and they spend a lot of time using that modeled problem to practice their strategies. Then they work on other problems, which aren't always word problems. So, that emphasis, when we talk about the language piece and how important it is to be intentional about our words, and help them understand how to take these words and make them into a math problem. This is important. At the kindergarten level, the more exposure to that, the more guidance we give, definitely gives a good foundation for subsequent grades."

4.5.2 Collaborative Implications for Dialogic Moves

A closer analysis of the dialogic moves helps to show the relationship between the comments and how their functions contribute to the dynamic flow of the dialogue and the resulting professional learning and collaborative culture.

Table 13. Dialogic Moves Beginning with Evidence and Reasoning

Introduction of Evidence or Reasoning	Subsequent Dialogic Move	Debrief 1	%	Debrief 2	%
Providing Evidence or Reasoning (E)	Questioning (Q)	4	12%	2	3.5%
	Building on an idea (B)	13	40%	20	47%
	Coming to an agreement (A)	10	30%	16	37%
	Challenging each other (C)	1	3%	0	0
	Providing Evidence or Reasoning (E)	5	15%	5	12.5%
	TOTAL	33		43	

Contributions of evidence and reasoning represented 33 of the comments in debrief 1 and 43 of the comments in debrief 2. In both debriefs, comments that provided evidence or reasoning overwhelmingly led to a dialogic comment that built on that evidence or reasoning (40% and 47%, respectively) or to a supportive comment that agreed with the evidence or reasoning provided (40% and 37%, respectively). These initial comments were met with affirmation or consensus or resulted in the development of an idea through building upon an original idea with additional insight or expertise.

Comments of evidence or reasoning led to additional comments of evidence or reasoning in the first debrief 15% of the time and in the second debrief 12.5% of the time. These comments

were challenged in the first debrief 3% of the time and not at all during the second debrief. The results are fairly consistent across both debriefs. Of greater distinction, comments of evidence or reasoning led to questioning comments 12% of the time in the first debrief and 3.5% of the time in the second debrief. This could be an effect of the first debrief not only reflecting upon the lesson, but also serving as a collaborative forum for enhancing the second lesson - leading to more of a tone of deliberation.

Table 14. Dialogic Moves Beginning with Questioning

Introduction of Questioning	Subsequent Dialogic Move	Debrief 1	%	Debrief 2	%
Questioning (Q)	Questioning (Q)	0	0	1	9%
	Building on an idea (B)	4	24%	2	18%
	Coming to an agreement (A)	6	35%	4	36%
	Challenging each other (C)	1	6%	1	9%
	Providing Evidence or Reasoning (E)	6	35%	3	28%
	TOTAL	17		11	

Contributions that questioned ideas most often led to agreement by the others participants - 35% in debrief 1 and 36% in debrief 2 - or resulted in additional evidence or reasoning in response - 35% in debrief 1 and 28% in debrief 2. Questioning comments also played a role in leading to ideas that built upon each other - 24% in debrief 1 and 18% in debrief 2. A questioning comment

was challenged once during each debrief and was further questioned only once during the second debrief. This suggests that comments that questioned ideas initiated productive conversation that contributed to additional knowledge-building or pedagogical conclusions.

Table 15. Dialogic Moves Beginning with Building Upon Ideas

Introduction of Building Upon Ideas	Subsequent Dialogic Move	Debrief 1	%	Debrief 2	%
Building on an idea (B)	Questioning (Q)	8	17%	6	11%
	Building on an idea (B)	11	23%	16	30%
	Coming to an agreement (A)	22	47%	19	36%
	Challenging each other (C)	2	4%	0	0
	Providing Evidence or Reasoning (E)	4	9%	12	23%
	TOTAL	47		53	

The potential for a lesson study debrief to encourage and support building upon ideas is powerful. This is evidenced in the flow of conversation where the occurrence increased from the groups' first debrief to the second debrief. Ideas that built upon each other continued to build upon each other in subsequent comments - 23% in debrief 1 and 30% in debrief 2. A significant increase is seen in how comments that built upon each other led to conclusions of evidence or reasoning as the group progressed from debrief 1 (9%) to debrief 2 (23%), suggesting either the nature of the conversation naturally led to the increase or the ability of the participants to come to those

conclusion strengthened throughout the lesson study process.

Decreases were seen in building ideas leading to questioning - 17% in debrief 1 and 11% in debrief 2; that resulted in coming to agreement - 47% in debrief 1 and 36% in debrief 2; and that spurred a challenge - 4% in debrief 1 and not at all in debrief 2. This shows a general decrease in building upon ideas through questioning, challenging, or simply agreeing, and an increase in building upon ideas through the provision of evidence or reasoning or additional comments that increased the group's collective knowledge base.

Table 16. Dialogic Moves Beginning with Challenging

Introduction of Challenging	Subsequent Dialogic Move	Debrief 1	%	Debrief 2	%
Challenging each other (C)	Questioning (Q)	0		0	
	Building on an idea (B)	5	100%	0	
	Coming to an agreement (A)	0		0	
	Challenging each other (C)	0		0	
	Providing Evidence or Reasoning (E)	0		1	100%
	TOTAL	5		1	

Comments that challenged ideas served a singular role in each debrief. During debrief 1, all comments that challenged an idea led to additional comments that built upon the original idea.

During debrief 2, all comments that challenged an idea led to the provision of evidence or reasoning in response to the challenge. A secondary purpose of the first debrief was to make enhancements to the second teaching lesson. This could be why challenges were viewed through a lens of building, in an effort to make a decision or to develop the idea. The second debrief was more final and reflective in nature, which may be why challenges were viewed through a lens of providing a response of evidence or reasoning.

Table 17. Dialogic Moves Beginning with Coming to Agreement

Introduction of Coming to Agreement	Subsequent Dialogic Move	Debrief 1	%	Debrief 2	%
Coming to an agreement (A)	Questioning (Q)	5	9%	3	5%
	Building on an idea (B)	14	26%	16	27%
	Coming to an agreement (A)	16	30%	21	35%
	Challenging each other (C)	1	2%	0	0
	Providing Evidence or Reasoning (E)	18	33%	20	33%
	TOTAL	54		60	

Contributions that came to agreement are considered primarily supportive moves within the overall dialogic space. Comments agreeing or affirming another comment led to more agreement 30% of the time in debrief 1 and 35% of the time during debrief 2. They can, however,

serve as dialogic moves in the development of shared understanding and knowledge. Participants' agreement was followed by evidence or reasoning supporting it 33% of the time in each of the debriefs and advancing it by building 26% of the time in debrief 1 and 27% of the time in debrief 2. These affirming comments were challenged 2% of the time and questioned 9% of the time during debrief 1 and were questioned 5% of the time during debrief 2. This could be that the participants had similar philosophies or mindsets about the content of the dialogue or that there was hesitation to introduce conflicting ideas into the conversation.

4.5.3 Collaborative Implications for Depth of Reflection

The development of a reflective disposition can contribute to a teacher's repertoire for responding to teaching and learning in the moment. Reflection enables teachers to construct knowledge through asking questions, critiquing, and evaluating (Lee, 2008). Collaborative reflection requires teachers to take responsibility for learning by sharing ideas and developing insights amongst themselves. Looking at the data through a collective lens is one way to represent to what degree the dialogic space of a lesson study can contribute to the depth of reflection that can be achieved by a collaborative group and process.

Table 18. Five Roles of Comments in Conversation During the Debriefs

	% of comments: Debrief 1	% of comments: Debrief 2
Questioning (Q)	11%	7%
Building on each other's ideas (B)	31%	32%
Coming to an agreement (A)	33%	35%
Providing evidence of reasoning (E)	22%	25.5%
Challenging each other (C)	3%	0.5%

Debrief 1 involved 153 comments and debrief 2 involved 169 comments. There were decreases in the number of comments that questioned an idea (from 11% in debrief 1 to 7% in debrief 2) and in the number of comments that challenged a person or idea (from 3% in debrief 1 to 0.5% in debrief 2). From debrief 1 to debrief 2, there were slight increases in the number of comments that built upon ideas (31% to 32%), that provided evidence or reasoning (22% to 25.5%) and that came to agreement (33% to 35%). These shifts in percentages suggest that, to a small degree, the participants were beginning to shape a collective understanding of teaching strategies and learning outcomes related to this math topic.

Table 19. Dialogic and Supportive Moves During the Debriefs

	% of comments: Debrief 1	% of comments: Debrief 2
Dialogic Moves	64%	61%
Supportive Moves	36%	39%

The percentage of dialogic and supportive moves was relatively comparable across both debriefs. In debrief 1, 64% of the comments served a dialogic role and 36% of the comments served a supportive role. This is compared to 61% dialogic moves and 39% supportive moves during debrief 2.

Table 20. Levels of Reflection During the Debriefs

	% of comments: Debrief 1	% of comments: Debrief 2
Level 1: Non-reflection	52%	25%
Level 2: Descriptive reflection	37%	54%
Level 3: Dialogic reflection	11%	17%
Level 4: Critical reflection	0%	4%

The shifts in reflective levels are more compelling. From debrief 1 to debrief 2, the number of level 1, pure descriptive comments, decreased from 52% to 25%. The number of level 2, descriptive and explanatory comments, increased from 37% to 54%. The number of level 3, alternative perspective comments, increased from 11% to 17%. The number of level 4, critical analysis comments, increased from 0 to 4%. These shifts strongly suggest that collaborative reflection helped to encourage deeper levels of reflection through dialogue and the sharing of ideas and perspectives. The opportunity to discuss specific lessons and to observe students in the same context helped to give participants a common vocabulary for discussing teaching and learning. An increase in the participants' level of comfort being vulnerable with each other may also have been a factor that contributed to the increases in the level of reflection seen in Debrief 2.

4.5.4 Comparison of Individual Reflections and Collaborative Reflection

The individual teacher reflections following the lesson study cycle were anonymous and were guided by four prompts. When these reflective comments were coded using Hatton and Smith's (1995) levels of reflection, they were limited to only level 1 and 2. Teacher A's reflection had 8 of each. Teacher B's reflection had eight level 1 and two level 2 comments. Teacher C's reflection had 23 level 1 and two level 2. Teacher D's reflection had eight level 1 and three level 2 comments.

Table 21. Levels of Reflection During the Post-Study Reflection

	1	2	3	4	TOTAL
Teacher A	8	8	0	0	16
Teacher B	8	2	0	0	10
Teacher C	23	2	0	0	25
Teacher D	8	3	0	0	11

The group reflection during the debriefs allowed for simple observations and ideas to grow, something that is not always realized in an individual, isolated reflection. When teacher 2 shared that, "…the number bond, we're laying it this way. Well, it can be turned…. [a student] had it turned on the side. He was looking at it vertically, instead of looking at it horizontally - and I don't see anything wrong [with that], but we always think that things have to be like…and he was seeing it [a different way]…, knowledgeable other 2 added, "That might make an easier transfer to the equation, too. Set it up with the big circle on the right side, if we're going to have it equal to, or to the left side…to match."

Teachers shared how they enjoyed the process of collaboration.

"Our team did a great job working together to go through this process, we learned from each other and got ideas from each other that might not have gone into the lesson if we were working on our own."

"It's so refreshing to see what other teachers are doing and what's working/what's not working so that I can help my students become more successful during our own classroom learning experiences."

"Often times when we are teaching we do not get the opportunity to get a deeper understanding of what it is the students are thinking because we are also delivering the lesson."

Teachers also shared their learning about math pedagogy.

"After watching this lesson study I learned that some students need more repetition and practice before independently completing a task and I also learned hat some students benefitted from one strategy more than the other, so it's beneficial to use several thinking strategies when introducing a concept."

"This process has given me confirmation that math needs to be taught through meaningful learning experiences. I also believe that we should teach it using the different learning modalities. The children need to experience it through their body (large motor), visually and they need to talk through it and apply it."

For consideration, the outcome of these levels could be attributed to this reflection happening after the lesson study cycle, when teachers' minds are no longer immersed in the rich lesson study cycle and have shifted in focus back to their daily routine. The use of guiding questions could have limited the scope of their reflection and thinking, influencing them to respond a certain way or with specific details they felt were being sought, rather than the dynamic, authentic feelings or thoughts they may have had during the lesson study experience.

The data show deeper levels of reflection were achieved during the collaborative debriefs than within individual teacher reflections. These outcomes also suggest that teachers' reflections were enriched and deepened when in a forum where they could reflect together - building upon one another's ideas, sharing evidence of observations, and questioning and challenging ideas and each other.

Comments in the individual reflections tended to be more generalized. For example, in her reflection, one teacher commented, "For the teacher, it is important to know and understand a student's strengths and weaknesses and try to play up the strengths while building on bettering the areas that may be a weakness for them." Another teacher shared, "Watching over a small group

and actually seeing their learning and thinking process gave me great insight into the way young minds work and think."

The dialogue during the debrief tended to talk about students in more detail, as demonstrated by teacher 3: "I saw that, too….The one little one, he wanted to have - like if the number bond was 7 and 3, he wanted 7 black and 3 green - he was thinking like that." Teacher 2 offered an observation of another student, "…Exactly…[with] 10 there….He didn't understand that when he put them together, cause he did 5 and 5 the first time, but he couldn't, when he put them together and when you asked him to tell what he did, he couldn't remember what he did, or how he [did it]…because it was already together. In his mind, he had to go back and count, there was 5 and 5." Teacher 4 offered another example, "I noticed that [one student] - she was making - I don't know if it was intentional, or not – [sets of] 3. She put 3 in one circle, by itself, then she had a tower of 5 and a tower of 2. So, she kind of made - she was like making 3 groups." Specific examples, like these, allowed for more rich discussion and more meaningful learning.

4.5.5 Teacher Observations of Standards of Mathematical Practice

The use of the PA Core Standards for Mathematical Practice as a lens for kid-watching or student observations gives some insight into the elements of student thinking and problem-solving the teachers were noticing.

Table 22. Standards for Mathematical Practice During Observation 1

Mathematical Practices	T1	T2	T3	T4	KO1	KO2	TOTAL	% of Total
1. Makes sense of problems and perseveres in solving them	NA	0	7	2	5	8	**22**	**27%**
2. Attends to precision	NA	0	1	0	1	2	**4**	**5%**
3. Reasons abstractly and quantitatively	NA	1	3	9	2	2	**17**	**20%**
4. Constructs viable arguments & critiques the reasoning of others	NA	0	1	3	1	6	**11**	**13%**
5. Models with mathematics	NA	4	0	4	6	0	**14**	**17%**
6. Uses appropriate tools strategically	NA	2	0	0	4	0	**6**	**7%**
7. Look for and make use of structure	NA	2	1	0	0	1	**4**	**5%**
8. Look for and express regularity in repeated reasoning	NA	0	1	2	1	1	**5**	**6%**
TOTAL		**9**	**14**	**20**	**20**	**20**	**83**	

Table 23. Standards for Mathematical Practice During Observation 2

Mathematical Practices	T1	T2	T3	T4	KO1	KO2	TOTAL	% of Total
1. Makes sense of problems and perseveres in solving them	3	NA	1	2	5	7	**18**	**32%**
2. Attends to precision	0	NA	1	0	0	2	**3**	**5%**
3. Reasons abstractly and quantitatively	1	NA	4	0	0	5	**10**	**18%**
4. Constructs viable arguments & critiques the reasoning of others	1	NA	0	0	1	1	**3**	**5%**
5. Models with mathematics	0	NA	4	6	0	1	**11**	**19%**
6. Uses appropriate tools strategically	2	NA	0	0	1	1	**4**	**7%**
7. Look for and make use of structure	1	NA	2	0	0	1	**4**	**7%**
8. Look for and express regularity in repeated reasoning	1	NA	2	0	0	1	**4**	**7%**
TOTAL	**9**		**14**	**8**	**7**	**19**	**57**	

During both lessons, the top three practice standards observed were the following: Makes sense of problems and perseveres in solving them (27% and 32%); Reasons abstractly and quantitatively (20% and 18%); and Models with mathematics (17% and 19%). It could be argued these are essential math skills and learning attributes. The lowest four practice standards observed

in both lessons were the following: Attends to precision (5% and 5%); Uses appropriate tools strategically (7% and 7%); Looks for and makes use of structure (5% and 7%); and Looks for and expresses regularity in repeated reasoning (6% and 7%). It could be advocated it is developmentally-appropriate that these skills aren't fully developed, yet and observable with this age group of learners. The most significant difference is seen with the practice standard related to constructing viable arguments and critiques the reasoning of others, which represented 13% of student observations during the first lesson and 5% during the second lesson. This could be related to the changes that were made to the lesson approach and the types of activities that comprised the second lesson, which required the students to talk with each other less than the first lesson.

4.6 Accuracy and Representation

There are limitations that come with the study. Simply stated, we do not know what we do not know. The participants bring a different number of years of teaching experience and different types of experiences to the lesson study. There may have been limitations in what they observed and interpreted during their kidwatching. They may not have been able to make connections between the teaching and learning experiences in their reflections. Their reflections were limited by the scope of their mathematical and pedagogical knowledge.

Teachers who lack a strong background in math or adequate training in the area of teaching mathematics to young children may have misperceptions about math teaching and learning (Rudd, Lambert, Satterwhite, & Zaier, 2008). They may fall back on their own learning and rely heavily on scripted or structured curriculum or lessons, with limited meaningful connections or active

learning in real-world contexts.

Gauging the quality of reflection based on dialogue is not entirely straightforward. Teacher education research literature abounds with definitions of "reflection," making it difficult to hone in on a focused definition. A form of reflection is professional noticing. Mason (1998 in Robinson & Leikin, 2011) identifies the importance of teacher awareness and noticing for learning through teaching. He references the attention and intention in learning about teaching through teaching and suggests that collaboration between teachers intensifies learning from teaching through metacognitive, collaborative growth (Mason, 2010 in Robinson & Leikin, 2011). It takes time and practice to refine this skill set. This team of participants is still in the early stages of learning how to effectively collaborate together to advance teaching and learning.

One notion of reflectivity is that to learn from things done, the learner has to reflect on what has been experienced in practice (Rasmussen, 2016). This can involve individual or collective reflectivity. Teacher reflection contributes to teachers' development by generating knowledge grounded in practice (Ricks, 2011). There are, however, inconsistencies in what reflection means and how teachers engage in it, contributing to it becoming a diluted educational construct. Due to the nature of group dialogue in this study, some ideas or contributions may have gone unspoken. Participants may have had additional reflections that did not surface in the conversation, but that will still influence how they approach teaching and learning in their classroom.

5.0 Lessons Learned

5.1 What is the Story of Lesson Study: Japanese Roots and the Movement in the U.S.?

Lesson study is a powerful vehicle for professional development and curriculum development in Japan and has been an integral part of the fabric of the Japanese educational system for decades. It has been a catalyst for change, a tool for building the capacity of teachers and a forum for documenting best practices and new innovations.

A primary focus of lesson study in Japan is student learning and development, as teachers gather evidence of learning from their observations of students (Lewis, 2002b). Evidence gathered about teacher actions is primarily in the interest of how it relates to student learning and engagement. In the U.S. classroom observation tends to focus on the teacher's behavior and less often on the broad study of the student experience. Liping Ma (1999) has observed that American educators assume that one must learn content knowledge before planning lessons; Japanese teachers think one learns content knowledge by planning lessons.

Lesson study has seen growing international use and has been implemented as a model for improving teacher effectiveness because the framework helps teachers to think deeply about content and student learning (Dubin, 2009). The U.S. has a history of educational faddism and many promising innovations have been discarded before being thoroughly understood or implemented (Lewis & Perry, 2003). To counter this, various tools for lesson study have been developed - including protocols, agendas, handbooks, practitioner-oriented articles, and videos of

sample lesson study processes.

Despite the support of these tools and guides, lesson study continues to fall short of institutionalization within schools and districts in the U.S. and other countries where it has been explored. Lesson study in Japan follows a defined, standardized cycle, which differs from the approach the U.S. and other countries have taken, where the cycle is adapted to fit the context of the individual school.

Professional development activities and schedules can be established to conduct lesson studies, but lesson study work has not been sustainable or become embedded into a school system's way of being outside of Japan because our education systems are structured in ways that interfere with a long-term commitment. Without the guidance of skilled facilitators and systemic supports for lesson study, much of the learning for teacher participants is incidental learning – knowledge gleaned as a by-product of the process (Chokshi & Fernandez, 2004).

Teachers' beliefs also serve to either promote or prevent purposeful learning through lesson study, and the subsequent value that can influence longevity. Japanese teachers view teaching and learning as a constitutive practice, whereas U.S. teachers tend to view teaching and learning as disconnected activities – through the lens of a transmission model (Crockett, 2007). Japanese teachers believe they come to a deeper understanding of the content through doing lesson study, whereas U.S. teachers tend to feel they must become content area experts before teaching (Chokshi & Fernandez, 2004). It is almost as if U.S. teachers feel they learn to teach and Japanese teachers recognize they teach to learn.

Lesson study in Japan is, simply described, a pillar of their education system. It is systemic - not only an expectation dictated by national and district leadership, it is an expectation by teachers – part of how they have learned their profession and how they contribute to their profession.

Lesson study is institutionalized as part of the Japanese education system – district or national research goals become the foci of the lesson studies, partnerships between schools and universities or professional organizations provide knowledgeable others, the culture of Japan promotes collective advancement, peer learning and value for inquiry and research, and lesson studies are scheduled annually in schools throughout the entire country. It is a natural part of what Japanese teachers do (Crockett, 2007).

In the places where lesson study has been engaged outside of Japan, particularly in the U.S., it is more of an add-on – an activity explored by a group of passionate teachers who are motivated by interest or personal drive - and not supported for long-term sustainability through inclusion in a district strategic plan, professional development plan or school schedule. In the U.S., teachers are often expected to implement programs and show results within just a year or two (Lewis, 2002b). In some cases, it is a terminal research intervention, focused on short-term, measurable outcomes, where the researcher is studying teacher learning, and not part of a school improvement plan (Crockett, 2007; Lewis, 2002b). The research suggests that sites where lesson study teams have facilitators who have participated in lesson study cycles in Japan tend to have greater longevity and purpose, but often these facilitators are outside experts and not district personnel, so their involvement is dictated by district initiatives, which often change with frequency as new mandates are delivered by federal, state and local bureaucracies. Lewis (2002b) quotes an American teacher, to help to illustrate the disconnect that interferes with lesson study becoming embedded in professional development in U.S. districts:

> A lot of [American] schools develop mission statements, but we don't do anything with them. The mission statements get put in a drawer and then teachers become cynical because the mission statements don't go anywhere. Lesson study gives guts to a mission

statement – makes it real and brings it to life. (p. 14)

5.2 How Does Lesson Study Support Professional Development for Teachers? What is the Incentive for Teachers to Choose to Participate in a Lesson Study Cycle?

Lesson study is a way for teachers to examine their practice – to investigate issues of pedagogy and content relevant to them (Chokshi & Fernandez, 2004). It should be grounded in the realities of the school and not isolated from the curriculum or everyday experiences of students. It is a forum where all teachers – novice through master – can learn from each other.

In addition to the specific techniques and approaches learned during lesson study, Japanese teachers note the benefits of creating a learning environment amongst teachers in the school (Lewis, 2002b). According to Japanese teachers Lewis worked with, a successful lesson study is not so much what happens in the research lesson, itself – it is what teachers learn while working alongside colleagues. The average Japanese teacher sees about ten research lessons a year (Yoshida, 1999 in Lewis, 2002b), while U.S. teachers have limited opportunities to visit colleagues' classrooms.

Lesson study takes reflection to the next level, making it practical and tangible (Lewis & Hurd, 2011). It requires more than just acquiring new techniques and knowledge; it requires a reexamination and revision of beliefs about learning and teaching. It provides a space to study innovative approaches and to try them in one's own setting, refining and adapting them. It is not about perfecting plans, but about creating a system in which teachers actively learn from each

other, from the curriculum and from student thinking.

With relation to math pedagogy, skilled teachers recognize the value of language that guides conversations to shape students' understanding of mathematical concepts (Rudd et al., 2008). Teachers must be intentional about planning learning experiences that connect new mathematical terms to ideas the children already know (Rubenstein & Thompson, 2002 in Rudd et al., 2008). The specific dialogue between teacher and students links conceptually related linguistic and mathematical knowledge (Moseley, 2005 in Rudd et al., 2008).

5.3 What Happens when a Team of Teachers Engages Lesson Study?

There is a Japanese proverb: "When three people gather, you have a genius" (Lewis & Perry, 2003, p. 246). This illustrates the belief that teaching can be improved through collective effort and that colleagues can help one another to develop professional capacity (Lewis, 2002b). In a mediated lesson study, West-Olatunji et al. (2008) found that reflectivity and professional collaboration were rarely independent of one another. Through their collective journey, the participants grew as reflective practitioners. The study also determined that solidarity and collegiality between the teacher participants increased, as they became more reliant on each other - building trust, and less dependent upon the facilitator to lead the discussions.

A lesson study, itself, can serve as a context for professional interaction and the immersion in lesson study creates a dialogic space for professional collaboration and peer learning. The teachers' dialogue is an integral part of the lesson study cycle, and serves as a dialogic mechanism for reflection and learning (Warwick et al., 2016). Through combining their intellectual resources,

collaborators are able to address a shared problem and pursue a common goal more effectively then if working alone. The use of language to make joint sense of their experience enables the creation of new understandings that may not have emerged from one person's thinking. This aligns with a vision of building a shared community of practice among teachers - "conducted in order to create a consciousness that extends beyond individuals, and [that] is shared throughout the school community," about topics or issues of importance to the group (Lewis, 2002c, p. 23).

Lesson study has the potential to keep teachers in control because it honors and professionalizes their work (Chokshi & Fernandez, 2004). Weeks and Stepanek (2001) advocate that lesson study approaches teaching as an intellectually challenging work, rather than a set of skills to be implemented (in Chokshi & Fernandex, 2004). The attention given to each lesson honors the importance of teaching as a profoundly complex endeavor and acknowledges teachers as professionals who contribute scholarly knowledge to the profession. Once teachers make a commitment to professionalize their teaching experiences, they can invite others to challenge them and to help them achieve their goals for teaching and learning. This sets the tone for professional exchange, reflection, and growth during a lesson study experience.

5.4 What are the Lessons Learned from Engaging in Lesson Study?

Lesson study is more about engaging in the intellectual process that fuels its activities, than it is about the isolated products of these activities (Chokshi & Fernandez, 2004). As demonstrated in this study, the most significant outcomes surfaced during the teachers' collaborative dialogue. While they have the accompanying lesson plans, their greater gains were their insights into student

thinking and their deliberation about instructional strategies and student engagement – perspectives they can integrate into their daily practice and other professional endeavors.

A review of literature by West-Olatunji et al. (2008) summarized that collaboration through lesson study has also been shown to help groups improve their problem-solving abilities, aid teacher-student understanding and rapport building, facilitate conflict resolution and enhance student motivation. Collaboration brings relationships to the foreground and helps teachers regain the personal empowerment needed to address teaching and learning dilemmas effectively.

Through the process of kidwatching, the teacher team revalues the children - noticing and building on what learners can do (Owocki & Goodman, 2002). A teacher who engages in kidwatching can gain a more intimate insight into his or her students, as learners and as people - their identities, experiences, interests, attitudes and learning attributes - and has a system of documenting or recording what the students know and can do. The teacher can use kidwatching to help to reflect on the classroom environment, instruction, student interactions, and child development practices to make future instructional decisions. When teachers interpret the value of data gathered from observations, they are empowered to make better decisions (Mills & O'Keefe, 2011).

There is a strong need for teachers to experience sustained, high-quality professional development in order to improve student learning and teacher instruction (Rock & Wilson, 2005). Lesson study embodies features identified as critical for effective professional development for math teachers, particularly: it is based in teachers practice, focuses on students' learning, is grounded in mathematics, and makes use of teacher collaboration (Smith, 2001 in Watanabe, 2018). It provides a vehicle for engaging teachers in reflection because the structure of the process provides for the stimulation, continuation and application of reflective processes as a lesson is

collaboratively planned, implemented, refined, and retested in classroom practice (Lewis & Tsuchida, 1998 in Ricks, 2011). The cyclical, collaborative approach is conducive to reflective actions (Myers, 2013). The creation and implementation of lesson studies provide opportunities for messy and real-life experiences that facilitate the connection between theory and practice and the integration of new and prior learning - both essential to the reflection process. In the wisdom of John Dewey (1933), "We do not learn from experience, we learn from reflecting on experience" (in Myers, 2013, p. 1).

5.5 Further Research

This study's data show how the dialogic space of a lesson study was an effective forum for this group of teachers to learn from each other and to deepen their reflective skills set. Of importance to note, they had systems of support for the activity: time to plan, administrative support and participation, substitute teacher coverage and collegial support through the knowledgeable others. They also had internal motivation – personal drive, a collaborative spirit, professional incentive to fulfill their differentiated supervision modality and to complete professional hours and past, positive experience with lesson study. These dispositions and conditions are key for a successful lesson study and would need to be replicated, within their context, to help to determine if this type of professional development could have the same results in other settings or with other participants.

Longitudinal studies with a designated group, over time, would help to show if results, like these, would be sustained or changed. As a team grows in vulnerability with each other, practices

the procedures of lesson study together and becomes a more cohesive group, with regards to the relationships between teaching and learning, deeper levels of reflections may become more natural, questioning or challenging comments may increase and more of the overall dialogue could be driven by dialogic moves, as the supportive moves become more embedded in the culture of the group.

In this study, the percentage of the debrief that was encompassed by dialogic and supportive moves was fairly balanced and remained relatively consistent across both debriefs. It would be interesting to see if this consistent balance would be maintained if this group continued to do lesson studies together, or if the dialogic percentage would increase as the culture of the group became more natural, which could potentially lead them to pushing each other more within the dialogic space. I would anticipate the dialogic moves would increase with subsequent cycles together, because the supportive conditions would become more embedded into the culture of their group. This could be studied with groups using a more longitudinal timeline that spanned across multiple lesson studies by the same team of teachers.

Another area where longitudinal research could continue to expand would be the comparison of depths of reflection during the collaborative debrief and the individual post-study reflection. Teachers could potentially develop a capacity for deeper levels of reflection during the post-study reflection through their ongoing participation in a lesson study, where they could grow as a reflective practitioner through their dialogue with colleagues. These peer-supported reflective skills could gradually become more a natural part of their professional practice. Future studies could also provide more professional development to teachers related to strategies for reflection and could leave the post-study reflection open-ended, so as not to limit or persuade specific reflective thoughts by the teachers.

For me, personally, I hope to be able to facilitate lesson study experiences with teams of teachers – in-service or pre-service - throughout my career. If an opportunity were to present itself to introduce lesson study experiences as part of a district's structure for professional development, my plan would involve laying an intentional foundation to address the adaptive challenges of encouraging a collaborative culture, developing communication norms, supporting risk-taking and problem-solving, and fostering reflective strategies. A collaborative process would be engaged to determine a focus to unify the participants in a common effort across the district that would connect with professional development hours/requirements and supervision models/requirements. A thoughtful, strategic schedule and protocol would serve as a blueprint to designate time for collaboration and teacher leaders would be trained to facilitate the process. An approach to documentation and process evaluation would also be established, to record the work of the teachers, to capture their reflections and growth and to determine our next steps.

Appendix A

Table 24. Math Science Collaborative Lesson Study Events 1997-2010

Event	Date	Facilitator	Activity
Network Connections	10/14/1997	Dr. Bill Schmidt	Keynote: Implications of the TIMSS Findings for strengthening math & science instruction
Network Connections	10/08/1998	Dr. Bill Schmidt	Keynote: Implications of the TIMSS Findings for strengthening math & science instruction
			TIMSS Video Study introduction
Network Connections	02/11/1999		Performance Assessment: Experience a 4th & 8th grade tasks from TIMSS
			Making TIMSS Work - learn how teams in the region have planned and implemented professional development
Network Connections	02/09/2006	Catherine Lewis	Lesson Study Introduction - Concepts, Effective Implementation & Benefits
Network Connections	10/24/2006	Bill Jackson - Paterson, NJ	Public lesson: Pre-lesson briefing to prepare for data gathering, Observation of live lesson; Debrief
Network Connections	02/22/2007	Bill Jackson - Paterson, NJ	Public lesson: Pre-lesson briefing to prepare for data gathering, Observation of live lesson; Debrief
		Panel of Administrators	Consider the research noting challenges to authentic implementation of lesson study

Table 24 (continued)

Network Connections	11/29/2007		Collaborative Lesson Design vs. Lesson Study - exploration of purpose and values of each
			TIMSS Video Study introduction
		Local Lesson Study Team	Public Lesson and Debrief Arising from Lesson Study - elementary public lesson conducted by local teachers - Pre-Lesson, Observation & Debrief
		Local Lesson Study Team	Public Lesson and Debrief Arising from Lesson Study - secondary public lesson conducted by local teachers - Pre-Lesson, Observation & Debrief
Network Connections	11/20/2008	Local Lesson Study Team	Math Lesson Study - Public Lesson
		Local Lesson Study Team	Science Lesson Study - Public Lesson
Network Connections	02/12/2009	Local Lesson Study Team	Lesson Study - Public Lesson
Network Connections	11/5/2009		Thinking Through Lesson Protocol - tool for collaborative lesson planning
		Local Lesson Study Team	Mathematics Lesson Study - Public Lesson
Network Connections	02/11/2010	Panel of M&S Collaborative Teachers	What DOES Happen in an MSC Learning Lab?
		Local Lesson Study Team	Science Lesson Study - Public Lesson

Appendix B

Table 25. TIMSS Findings Comparing Japanese and American Approaches

	Japan	America
Lesson content	Content is challenging, both procedurally and conceptually	Content is less advanced and requires much less mathematical reasoning
Teachers' design & presentation of the material	Teachers carefully design and facilitate lesson so students can use procedures that have been developed recently in class - a "structured problem solving" approach	Teachers present definitions of terms and demonstrate procedures for solving specific problems; Students memorize the definitions and practice the procedures - "learning terms and practicing procedures"
Student understanding	Students have richer opportunities to learn the meanings behind the formulas and procedures they are acquiring	Seems to place greater emphasis on definitions of terms and less emphasis on underlying rationale
Lesson coherence	Teachers routinely linked together the parts of the lesson; 96% of Japanese lessons studied contained explicitly statements by the teacher connecting content	Lessons seem to be more fragmented, shifting between topics; Only 40% of lessons studied contained these strong connections
Curriculum	Shared, frugal curriculum - focused content explored deeply	Lessons contained significantly more topics; Curriculum covers more content, less deeply
Ways students engage in mathematics	Students were asked to do more of the mathematical work and calculations; Tasks were student-controlled 40% of the time	Students participated mostly by giving brief responses to the teacher's specific questions; Tasks were student-controlled 9% of the time
Use of visual devices	To provide a record of the problems and solution methods and principles of the lesson; The record builds, left to right, as the lesson proceeds, presenting a cumulative record of the lesson	To focus students' attention; Overhead projectors are used to display information in written or graphic form while it is being described orally
Presentation of the problem	Without demonstrating how to solve it; Allow students to invent their own procedures for solving problems that are challenging; sets the stage for students to work	Demonstrate a procedure for solving problems before assigning them to students; sets the stage for students to practice it

Table 25 (continued)

Lesson Pattern	1) Review the previous lesson - brief teacher lecture, building on previous lesson; 2) Present the problem for the day - a key problem that sets the stage for the lesson; 3) Students work individually or in groups 4) Discuss solution methods - teachers often call on students, specifically, based on the methods they have used during group work; 5) Highlight and summarize the major points; Activities 2-5 can cycle several times	1) Review previous material - through checking homework or doing a warm-up activity; 2) Demonstrate how to solve problems for the day - introduction of new material with step-by-step demonstration; 3) Practice - students complete similar problems 4) Correct seat work and assign homework - more practice problems
Skill emphasis	View math as a set of relationships between concepts, facts and procedures; These relationships are revealed by developing solution methods to problems, studying methods, working toward increasingly efficient methods and talking explicitly about the relationship of interest	Lessons emphasize the skills students should learn and know how to use or transfer
Role of teacher	Teachers choose a challenging focus problem and help students understand and represent the problem so they can solve it; Teachers monitor student work so they can summarize the approaches and solutions during discussion; They encourage students to keep struggling; They lead class discussion, asking questions about the solution methods presented, pointing out important features of students' methods and presenting methods themselves; They keep a visual record and try to connect parts of the lesson	Teachers appear to feel responsible for shaping the task into pieces that are manageable for most students, providing all the information needed to complete the task and assigning plenty of practice; Teachers act as if confusion and frustration are signs they have not done their job; They try to reduce confusion by presenting full information about how to solve problems
One math educator's summary	Lessons deal with the math content and the students; The students engage with the math and the teacher mediates the relationship between the two	There are the students and there is a teacher; The math isn't strongly present - just the interactions between the students and the teachers
Professional development	Teachers see themselves as developing the profession as well as themselves; They view themselves as true professionals, as contributors to the knowledge that defines the profession; It is an integral process of what it means to be a teacher	Teachers go to workshops to learn about new techniques to implement in their classroom - the experts and researchers discover and recommend new teaching practices

Table 25 (continued)

Teacher's manual	10% of statements are devoted to providing a pedagogical rationale; Attention to student thinking accounts for 28% of statements	No statements are devoted to providing a pedagogical rationale; Attention to student thinking accounts for 1% of statements

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