What do teachers mean when they say student understanding?

Collective conceptual orientations and teacher learning in lesson study

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Abstract:

This study investigated how collective conceptual orientations of lesson study groups guided and created learning experiences for teachers and students. Lesson study meetings and research lesson data were qualitatively analyzed, to identify different collective conceptual orientations of two groups, who otherwise shared many contextual characteristics. The conceptual and procedural orientations toward student understanding guided their instructional investigations, and influenced the ways lessons were planned and taught. The collective conceptual orientations maintained the group cohesiveness, with teachers steering discussion when deviation occurred. The findings suggest that it is not enough for teachers to engage in collaborative PD and discuss student understanding to shift their thinking and classroom practices. Collective conceptual orientations need to be challenged for deep instructional changes to occur.

A considerable body of research supports the effectiveness of teacher professional development (PD) that utilizes collaborative investigation of student understanding (Fennema, Peterson, Chiang, & Loef, 1989; Opfer & Peder, 2011; Wilson & Berne, 1999), yet within this approach, teacher groups vary in their purposes and processes, and what goes on within the groups may be quite unique (e.g., Horn & Little, 2010; Savit, et al., 2012). Each teacher community is nested within a school, and each individual teacher also brings his/her orientation to teaching and learning (Hadar & Brody, 2012). Teachers' learning within each group thus emerges in interactions among context, individual orientations, and collective orientations to learning.

This study investigates how different collective conceptual orientations guide and create learning opportunities for teachers and students in lesson study. Research suggests that a teacher's orientation toward student learning influences his/her decisions, leading to different instructional approaches (Thompson, et al, 1994; Wilson and Goldenberg, 1998). When teachers collaborate, the group's collective orientation affects the instructional decision process, guides teachers' experiences in the collaboration, and ultimately helps create learning opportunities for students. Understanding the role of collective conceptual orientation is essential to our growing knowledge of how to design collaborative PD programs, ensuring it is harnessed in ways that reflect the principles of teacher and student learning that lead to system-level improvement of teaching and student learning (Marrongelle, Sztajn, & Smith, 2013).

In this qualitative study, we investigate collective conceptual orientations of two lesson study groups who share similar professional contexts. After careful analyses of different orientations of the groups, we then examine how their orientations help create different student learning opportunities in research lessons. The findings of this study have important implications on PD design and efforts to ensure that teachers' learning is aligned with broader goals of educational reform in ways that lead to better learning opportunities for students.

Perspectives

Collective Conceptual Orientations

Thompson, Philipp, Thompson, and Boyd (1994) identified individual teacher orientations for teaching in their study of mathematics teachers. When teachers had the *calculational orientation*, they emphasized students' procedural descriptions with numbers in explanations, while *conceptually oriented* teachers supported mathematics discourse that went beyond students' explaining procedural steps. Orientations, in their framing, meant a set of images of teaching and learning, ideas about features of instructional materials and activities that help produce the images, and expectations for student engagement in the images (Thompson, et al, 1994). In other words, a teacher's individual conceptual orientation is his/her core expectations about how mathematics should be taught and learned and specific instructional ideas about making the expectations possible. Wilson and Goldenberg (1998) discuss how teachers' orientations to the subject of mathematics are intimately connected to how they teach, and that ultimately creates different learning contexts and opportunities for students. In their study, a veteran middle-school teacher was successful in modifying some aspects of his teaching, but the deep conceptual orientation about pedagogical authority kept him from fully embracing the reform agenda. Given how individual teachers negotiate their own orientations to make instructional decisions, what might happen when they work together in a teacher group?

Extending this line of work, Bowers and Nickerson (2001) proposed the idea of *collective* conceptual orientation, focusing on the reflexive nature of individuals and group learning (Cobb & Bauersfeld, 1995a; 1995b), and examining how individual orientations and collective conceptual orientation may be intimately connected. Any group (e.g. a classroom of students) over time develops shared orientations, and that in turn guides their collaborative activities. For example, most instructors who have taught two sections of the same course would agree that each class develops its own characteristics and orientations over the course of a semester (Bowers & Nickerson, 2001). While individual actors are clearly important, the shared insight that develops over time is valuable, working to bind different ideas and guide everyone's experiences in the group (Davis & Simmt, 2003). In the current study, we illustrate how collective conceptual orientation works to maintain group members' individual orientations in collaboration, further solidifying social bonds among the members, while guiding instructional decision making.

To ground this research, in the following sections, we will review literature on professional development and teacher learning to set the stage for analyzing teacher learning in group settings.

Professional Development and Teacher Learning

In the last few decades, increased attention to instructional improvement has led many researchers to study the complex processes of teacher learning through PD programs (see, for example, reviews by Wilson & Berne, 1999). As a result, there is general agreement on the characteristics of PD that are effective in helping teachers learn. First, long-term PD settings that allow teachers to develop, discuss, and practice new knowledge is more effective than a short or one-time workshop (Garet, Porter, Desimone, Birman, &

Yoon, 2001). Second, opportunities to actively engage with materials of practices in collaboration with other teachers (instead, for example, passively attending lectures) more likely help teachers rethink their instruction (Borko & Putnam, 1997; Greeno, 1991; Hawley & Valli, 1999; Stein, Silver, & Smith, 1998). Finally, job-embedded professional development more likely helps teachers apply new practices in own classrooms (Hawley & Valli, 1999; Leinhardt, 1988; Wideen, Mayer-Smith, & Moon 1998). Above all, at the core of an effective professional development effort is a community of teachers actively engaged in ongoing, collective inquiry into teaching practice situated within the context of their school.

These characteristics of effective professional development are aligned with learning theories that stress that learning is always active and social (Bransford, Brown, & Cocking, 2001; Cobb, 1994; Vygotsky, 1978; Putnam & Borko, 2000). In identifying teacher professionalism as one of the essential principles of good mathematics classrooms, *Principles to Actions* (National Council of Teachers of Mathematics, 2014) explains "(teachers) have a professional responsibility to collaborate with their colleagues and open their practice to collective observation, study, and improvement" (p.100), and be involved as active partners in own growth. Opening of own practices also helps minimize professional isolation among teachers and provides both reasons and contexts for growth (Birman, et al., 2000; Cordingley et al, 2005; Desimone et al, 2002). In many schools, PLC (professional learning community) is now becoming a norm, but we are also seeing that true communities of practice where teachers actively pose questions, share own practices, and provide feedback on each other's learning (Ball, 1997; Cochran-Smith & Lytle, 1999; McLaughlin & Talbert, 1993; Richardson & Anders, 1994) may not be achieved overnight.

Teachers need to be supported to learn how to productively collaborate with each other and grow professionally together.

One strand of research has investigated how differences among teacher groups influence teacher learning. Savit, et al. (2012) found, in comparing six different professional learning communities, that amount of time spent working with student data was not an indication of teachers' learning, rather, the group's stance on the nature of the inquiry activity was. If teachers analyze student data without making meaningful connections to their teaching, no matter how much time they spend with the data, the activity could simply become busy work. Teachers who take a researchers' stance on their practice, developing their own inquiry questions and using classrooms to investigate student learning, are more likely to benefit from professional development efforts (Fernandez, Cannon, & Chokshi, 2003; Murata, 2011).

Other scholars discuss challenges in predicting teacher learning in different groups because the process evolves within nested "systems within systems." (Stollar, Poth, Curtin, & Cohen, 2006). On an individual-teacher level, each teacher brings his/her own experiences and beliefs about teaching to the group settings (Hadar & Brody, 2012). Research also identifies the critical role of teacher beliefs in their pedagogical decisions (e.g., Richardson, 1996), and how beliefs are hard to change as they are connected to past as well as present (Powell & Birrell, 1992). Additionally, teachers' orientations to learning determine what and how the teacher learns (Opfer & Pedder, 2011). Placing individual actors with different beliefs and experiences together in groups produces unique and different constellations of orientations, and this dynamic must be investigated for effective teacher learning in groups. Furthermore, the broader school context influences collective beliefs and practices about teaching and learning.

Collective conceptual orientations are locally-shared frames of reference, which set the tone for the group's understanding of what is relevant in terms of teaching and learning and directs the group's professional learning trajectory (e.g., Horn, 2005). In a positive light, this collective orientation can help cultivate group bonds and shared commitment to resolve and pursue goals, developing into a collective efficacy (Bandura, 1997). However, it can also be limiting in its scope when new ideas are not aligned with the norm. For example, Coleman (1985, 1987, 1990) described, in his studies, how a group of teachers sanctioned other teacher's practice when it violated the group's teaching beliefs. Collective orientation can thus work to manage group members' thinking and activities and to support or penalize new ideas and improvement processes depending on their alignment to the existing norm. In the process, it further strengthens the relationships among group members as they conform, thus it can become even more difficult to violate the orientation after some period of time. On the other hand, other studies have found that overemphasis on conformity in teacher groups could hinder real professional growth in collaborative groups (Little, 1990), especially when teachers were too quick to agree early on in their investigation without allowing time to understand each other's ideas (Kuusisaari, 2012). Horn and Little (2010) found how the nature and range of external ties (among teachers within schools), which were cultivated over years, were a crucial factor in determining the productive nature of the teacher groups they studied.

In summary, the collective conceptual orientation of a teacher group can enable structure for growth, guiding teachers to what they consider good learning. Thus, when the orientation is skewed away from the conceptual emphasis (towards, for example, a focus on procedures and skills), what teachers learn in collaborative groups can merely reinforce what they already know or believe, help perpetuate the status-quo, and, in fact work to keep teachers from trying new teaching approaches.

Framed within the collective conceptual orientations, the investigational focus (content) of teacher groups determines what they learn in collaborative efforts. In the following section, we will review literature on teacher learning in PD that focus on student understanding of mathematics.

Focus on Student Understanding

Many researchers agree that it is important for teachers to understand student thinking (e.g., Borasi & Fonzi, 2002; Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; van Es, 2011) and use that understanding as the foundation to improve classroom practices. For instance, Cognitively Guided Instruction (CGI) was based on the principle that teacher understanding of student strategy development is critical for both teacher and student learning, and the program has been used for over two decades with notable outcomes (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Jacobs, Franke, Carpenter, Levi, & Battey, 2007). With CGI, based on the principle that all students bring ideas to classrooms, teachers learn about student thinking through analyzing different solution strategies, as indications of students' developing understanding of content. Franke, Carpenter, Levi, and Fennema (2001) found that teachers continued to use student thinking to improve their teaching four years after the CGI training, which helped generate new professional knowledge and efficacy. In another program, Mathematics in the City, Fosnot, et al. (2006), also centers teachers' experiences on students' active engagement in mathematization in workshops within the classrooms. They found that while teachers learned about student learning, they also increased content knowledge of mathematics. In studying teacher noticing, van Es and Sherin (2008) found how teachers learned to interpret students' mathematical thinking in a video club professional development, in which groups of teachers viewed and discussed video clips from their own classrooms. Over time, the teachers increased their attention to students' mathematical thinking, analyzing it in detailed ways (van Es & Sherin, 2008). In many preservice teacher education programs, novice teachers are also taught how to teach mathematics through understanding student learning of the content (e.g., van de Walle, 2013). Taken together, studies point to strong agreement among mathematics teacher educators that student understanding should be central to teachers' learning.

Incorporating student understanding into their teaching practice, however, may not be simple because U.S. mathematics education has traditionally focused on skills and procedures development (Stigler & Hiebert, 1999; Weiss, Pasley, Smith, Banilower, & Heck, 2003). Shifting a focus to student understanding requires redirecting teachers' orientation of what good teaching and learning is, moving away from didactic teaching of correct answers and toward active problem solving and discussions.

Lesson study

In light of the focus on student understanding, lesson study provides an ideal PD structure (NCTM, 2014) in which teachers are guided to examine student learning and their teaching. In particular, lesson study is a teacher-driven approach to professional development, characterized by a focus on student learning, ongoing teacher collaboration, and responsiveness to school needs, all of which are the characteristics closely aligned with the qualities of effective PD (Lewis & Hurd, 2011; Murata, 2011). Lesson study, by default, provides a framework for teachers to hone in on student understanding while increasing the specificity of the targeted learning topic. Starting by setting general goals for the research lesson and followed by examining curricular materials (this step is sometimes accompanied by pre-assessment of student thinking and reading research literature), teachers identify the learning paths between their students' current understanding and lesson goals. From there, teachers plan a lesson to guide their students towards the goals. Teachers identify specific learning that they may see in the lesson, and by designing their lesson, they identify data-collection points in the lesson where they want to better understand student learning. During the research lesson, observing teachers collect data on that specific point and debrief afterwards to share the data and discuss the student learning observed in the lesson. If they so wish, the teachers may then revise the lesson and reteach the lesson to a different group of students later on.

Providing effective PD for teachers is a critical issue in U.S. education, as CCSS-M (2010) introduced the vision with new and ambitious classroom practices (Marrongelle, Sztajin, & Smith, 2013), focusing on student understanding. Schools and districts are in an immediate need to support teachers shift their thinking and classroom practices, and also to scale up instructional improvement at system level (Coburn, 2003; Cohen & Ball, 2007; Elmore, 1996; McLaughlin & Mitra, 2001). In conceptualizing scaling, Coburn (2003) identified four dimensions: depth, sustainability, spread, and shift in reform ownership. In this study, we will investigate the depth of teacher learning as they engage in lesson study, that encompasses many of the effective characteristics based on research discussed above. We will take advantage of this teacher learning process as a research context, while teachers engage in in-depth discussion of student understanding, to study how different lesson study groups' orientations toward student understanding create different teacher and student learning opportunities.

Conceptual Framework and Research Questions

This study is based on the premise that what teachers mean when they talk about student understanding 1) reflects their orientations toward teaching and learning, 2) informs their instructional decisions, 3) determines what they will learn further about student understanding, and 4) helps create student learning opportunities in instruction. As a collaborative group, it is likely that different teachers will bring different orientations about student understanding to the discussions, and the collective orientation of the group will guide and frame their thinking in the process, while simultaneously being reframed by the group members' ideas. In lesson study, the group's collective conceptual orientation will also determine the focus of the research lesson, thus creating different learning opportunities for the students in the lesson.

We considered this process as illustrated in Figure 1.

-- Insert Figure 1 here --

Based on this framework, we asked the following research questions:

- *What are the collective conceptual orientations of two lesson study groups? What do they mean when they talk about student understanding?*
- *How stable are the collective conceptual orientations through the lesson study process? How do the groups shift or maintain the orientations?*

- *What are the learning opportunities for students created in research lessons with different collective orientations? How are their orientations reflected in their teaching?*

By comparing the two groups' processes, we aim to make visible the collective conceptual orientations, and their relationships to the student learning opportunities in the research lessons.

Methods

Participants and Settings

The study was conducted in a school district in the Southeastern region of the United States. In the district, lesson study had been used as a professional development program to support teacher collaboration and learning since early 2000s by a small group of teachers. During the academic year of this study, some of the teachers took the initiative to serve as facilitators and attempted to spread lesson study more widely within the district. The two lead teachers in the study, Bailey and Sam[1] served as lead facilitators in two elementary schools, Pacific Elementary School and Friendship Elementary School, respectively. They were the early initiators of lesson study in the district, sustaining the PD over the years under changing district and school leaderships. We focus our investigation on these two groups because they focused their investigation on student understanding in lesson study meetings and were ideal participants to investigate collective conceptual orientations for student understanding.

Table 1 summarizes the characteristics of the teachers who participated in lesson study in each groups.

[1] All names are pseudonyms.

-- Insert Table 1 here --

As the table shows, teachers in these groups had multiple years of teaching experiences. While three teachers at Pacific Elementary School were new to lesson study, all teachers knew each other in respective groups and were comfortable in sharing their ideas in meetings, which made it possible for us to fully examine their orientations about student understanding.

Each team met at their respective schools for the cycle of lesson study. Table 2 gives an overview of the general agenda and activities for the meetings for the two groups. Each meeting lasted approximately 90 minutes, except the second meeting for each group, which lasted all-day (6 hours). Although the groups followed a similar lesson study process, the facilitator and the teachers in the group determined slight variations in the agenda.

-- Insert Table 2 here --

For research lessons, both Pacific and Friendship Elementary School lesson study groups addressed fraction concepts with upper-elementary grade students. The Pacific Elementary School group taught a lesson on multiplication of fractions, and the Friendship Elementary School group taught a lesson on representing improper fractions (this will be discussed in detail later).

Data Collection

This paper reports findings out of a larger project that investigated effective and scalable models of lesson study as a state-wide professional development. For the original study, various surveys and interviews were conducted to collect data regarding the use of lesson study at the state, district, and school levels, and the findings from these surveys were reported elsewhere (Authors, year; Authors, year). For the current study, in order to focus our analysis on collective conceptual orientation of the groups and teacher learning, we analyzed the videotapes taken during lesson study meetings, research lessons, and research lesson debriefing. All the videos were transcribed for analyses. We also drew information from teacher demographic surveys to understand teachers' experiences with teaching and lesson study. We referred to lesson study reflections (written after each lesson study meeting) as well as interviews conducted at the end of the lesson study to further understand teachers' experiences with the lesson study. We also analyzed teaching and lesson materials from the research lessons (e.g., lesson plans, student worksheet).

Data Analysis

We analyzed lesson study meeting data over several iterations. First, we identified instances in the meeting transcripts where teachers discussed student understanding. We initially looked at places where teachers used certain key terms, such as "understanding," "misunderstanding," "misconception," "error," "knowledge/knowing," and "learning." Because teachers also at times discussed student understanding without using these terms, we then combed through the transcripts again and highlighted places where teachers discussed student understanding in any way. That amounted to 38% of the entire meeting transcript altogether. In counting these instances, in general, one teacher "talk" meant one talk-turn utterance of one teacher. However, at times, one teachers' utterance included more than one related but different ideas about student understanding. In these cases, we coded the utterance as two talks. On the other hand, sometimes more than one utterance composed a talk when a few teachers echoed each other's ideas. In these cases, we coded the group of utterances as one talk, and counted these instances separately as a group talk (this was rare, and only happened 3% of the entire talk coded for this study).

Next, we attempted to categorize teachers' talks about student understanding. We identified how at times teachers talked about student understanding in purely dichotomous manners (e.g., either a student gets it not does not get it), and at other times, as a process of developing concepts. We highlighted these different ways of talks for unique characteristics for each. We identified qualitative differences between the two lesson study groups as one group seemed to focus more on procedural processes and skills development when they discussed student understanding, and the other group focused more on students' thinking processes as conceptual development. This distinction was theoretically important as we attempt to broaden mathematics classroom practices from purely procedural to more conceptual in U.S. classrooms (for example, please see CCSS-M, 2010)

We also noted that there existed different degrees of unpacking of student thinking, related to the focus of the talk. For example, when teachers talked about student understanding as whether or not a student *got it*, there was naturally very little unpacking of the student thinking process. On the other hand, teachers sometimes took a very long time discussing students' thinking processes when they wanted to understand the conceptual development (e.g., where an unanticipated error has occurred). We created a list of characteristics for these different talk categories and attempted to code each teacher talk with the categories.

At this stage, we decided to assign levels to these different categories of talk, from very basic to more conceptual. We describe the levels as follows (see Table 3): Level 1: student understanding as innate ability, Level 2: Student understanding as procedural and skills development, and Level 3: Student understanding as conceptual development. Again, these levels correspond with reform agenda presented in different national documents for mathematics teaching and learning (for example, please see CCSS-M, 2010).

Up to this stage of coding, multiple trained researchers coded the same transcripts to ensure the reliability. As we move onto the next stage of coding, we picked small sections of the meeting transcripts and examined the agreement among raters. We had an appropriate level of agreement at this point (> 80%), and upon discussion, could reach 100% agreement.

Coding each teacher talk into categories was not as straight-forward as we wished, as some talk involved characteristics over several categories (levels). We created a spreadsheet with different smaller sub-characteristics identified and marked each teacher talk for whether or not it had a characteristic (See Appendix for this example). This enabled each talk to have characteristics across multiple levels, and we could code for characteristics without identifying the level at the initial stage of coding. We divided the teacher talks between two researchers at this point for coding. Table 3 lists the characteristics for the three levels.

-- Insert Table 3 here –

After all teacher talks (concerning student understanding of mathematics) were coded in the spreadsheet, we looked at each talk to identify its level. When a talk was marked primarily with characteristics within one level, the talk was identified as that level. When a talk had characteristics spread over several levels, these talks were carefully examined again for subtle nuances by the primary author of this paper. In most cases, identification of levels at this point was not difficult. We compiled the results of the coding into tables and examined the patterns within each group and across groups.

In identifying patterns, we examined the frequencies for each member's talk in each meeting. We identified most-frequent talk for each teacher for each meeting and noted the frequency, then saw the changes over meetings. We compiled those results per group. That suggested each group's collective conceptual orientation.

We then went back to the transcripts and identified places where a teacher's talk violated the group's collective conceptual orientations, to see how the other group members followed up with such talks and how the collective conceptual orientation was sustained through the meetings (or not). For example, while a group is talking about student understanding of mathematics at the conceptual level (Level 3), one teacher may ask a question about students' skills development (Level 2). Focusing on these incidents gave us insights into how the orientations were shifted or maintained.

In analyzing lesson materials, two trained researchers with multiple years of elementary-school mathematics teaching experiences coded the lesson plans and transcripts of the research lessons to identify how certain aspects of collective conceptual orientations toward student understanding (Table 3) are reflected in the lessons. They met multiple times to discuss and identify lesson segments for illustration presented in a latter section.

Findings and Discussions

In this section, we will first describe the different talk paths of two lesson study groups, to identify their collective conceptual orientations about student understanding. Following that, we will discuss how teachers handled different talks in the meetings to see how they maintained particular orientations within the group, with examples of teacher talks. We will then discuss their research lessons and how different learning opportunities were created for students in these lessons.

Collective Conceptual Orientations Reflected in Teachers' Talks

The lesson study groups at Pacific Elementary School and Friendship Elementary School followed a similar lesson study process (Table 2), which was originally introduced to them by the same representative of a shared organization. These schools are also located in the same school district, and each group spent about the same number of hours for lesson study meetings following the agenda. The teachers in both groups all showed their commitment to student learning as well as their professional development by participating in lesson study outside of a school or district expectation.

However, despite such similar circumstances, we found that the lesson study groups had very different talk patterns through their lesson study cycle. The analysis of teacher talks in the meetings revealed that Friendship Elementary School lesson study group had a collective conceptual orientation toward procedural learning, while Pacific Elementary School lesson study group had one toward conceptual learning. We will discuss individual orientation analysis first.

Tables 4 and 5 show the most frequent level of individual teacher talk for each lesson study meeting in two schools. Each column of the table represents a lesson study meeting, while each row shows a teacher and her dominant talk level in each meeting. When the cell is marked as N/A, the teacher either did not talk about student understanding in the meeting or spoke only once for each level. When a teacher talked most frequently at two levels in a meeting, both levels are identified in the cell.

-- Insert Tables 4 and 5 here --

As seen in the tables, teachers talked across more-diverse levels at Friendship Elementary School than Pacific Elementary School. When all teachers consistently talked at Level 3, as the findings show for the Pacific Elementary School, that means that the discussion focused on students' conceptual understanding in the lesson, and detailed unpacking of the student thinking process was a major part of their discussion (Table 3) in meetings. On the other hand, Friendship Elementary School's findings show more diversity and unpredictable movements. While the facilitator, Sam, seemed to stay at the same level (Level 2) throughout, other teachers moved across different levels, and the frequent existence of "N/A" in the table also indicates that some teachers were not necessarily talking about student understanding in some of the meetings (e.g., discussing content or teaching procedures without directly addressing students).

We wanted to also investigate how, as a whole, lesson study discussion patterns progressed in two groups. Figures 2 and 3 illustrate the movements, as well as the percentages of how much each teacher talked in relationship to the whole group's discussion about student thinking in each meeting. For these figures, within each column representing a meeting, we also show different levels (of talk) as sub-columns. Each arrow is a teacher in the lesson study group, and we identify the frequency for each teacher's most dominant talk at each meeting with a dot. Each teacher's talk pattern through the meetings is then illustrated by an arrow across the meetings.

-- Insert Figures 2 and 3 here --

These two figures, first of all, illustrate the strong dominance of facilitators in each meeting in terms of the amount of their contributions (black arrow in each figure is the facilitator). While most teachers talked about 10 – 20% in each meeting (about student understanding), the facilitator dominated the discussion for the average of 30 – 40% of the time, and even talked more than 50% for some meetings. This indicates the strong influence facilitators had in setting the tone and guiding teachers' talks in lesson study.

The figures also illustrate different talk patterns teachers had in respective school. At Pacific (Figure 3), while patterns are evident in terms of talk frequencies of teachers across meetings, most teachers remained at Level 3 for their talk. It is also important to note that three of these teachers, Gina, Wanda, and Glenda were new to lesson study that year (Table 1). This suggests they shared the particular collective conceptual orientation of the group, which might have been shared school-wide. For Friendship (Figure 1), movements are more erratic both in terms of talk frequencies of each teacher as well as the level shifts. Some teachers, such as Sandy and Mickey, seem to change their talk levels from one meeting to the next, with varied frequencies of contribution. Figure 1 (Friendship) overall shows how teachers tend to talk more (higher %) when their talk is at Level 2, which corresponds with Sam's (facilitator) talk, to together frame general focus on the group's talk throughout the lesson study process.

Collective Conceptual Orientations at Work: When a Talk Violates the Norm

While it was important to reveal the foci of discussions by focusing on the different meanings when teachers referred to student understanding of mathematics, the collective conceptual orientations really came into play when a teacher's talk violated the norm in the group discussions. As often seen, a shared cultural norm may go unnoticed until something/someone challenges the idea. In both lesson study groups, the incidents were observed in which a teacher presented a different idea outside of the group's orientation.

In the following section, we will present the examples of such incidents to illustrate how the collective conceptual orientations worked in these instances.

Friendship Elementary School: Moving the Talk Back to Procedural. In the very first planning meeting of Friendship Elementary School lesson study group, the teachers were trying to identify a topic for their research lesson. Sam tried to bring them to a general consensus.

Sam: … Fractions was a big hang-up? OK. So do we all agree that we want to do something with fractions?

Lorena: I know with my kids … in fifth grade, the kids that don't understand adding and subtracting with unlike denominators don't understand that inside of a whole there can be eight 8^{th} or inside a whole there could be five 5^{th}. They don't understand the partitioning of what is actually inside a fraction. And I don't know what grade level teaches that. *[Level 3]*

Sam: We are (4^{th} grade). We did not last year but we do this year. *[Level 2]*

Lorena: OK, so there is the gap right there. So, actually, I think that is where the snafu is happening …actually knowing what a fraction is and how we can change eight 8^{ths} into a whole. *[Level 3]*

Sam: Decomposing fractions? *[Level 2]*

In this short excerpt, Lorena expressed her desire to know more about how students learn partitioning. Both times she spoke, she was starting a new conversation on student's conceptual understanding. Sam's responses, however, were to provide a factual statement ("we are," teaching the concept in the 4^{th} grade) and redirect the conceptual question to a terminology ("decomposing fraction"). This is one example of many talk incidents of this group when the doors were closed for potential conversation toward Level 3.

In another incident during Planning Meeting 4, as teachers discussed details of the lesson, Sandy asked questions about possible student thinking in the lesson.

Sam: Maybe after you do it on the Elmo (document camera), you could say, this is one-third plus one-third plus one-third … do we have five one-thirds?

Lorena: Have the teacher model that.

Sam: Yes, and then you place like a little card that says one-third, one-third, one-third, one-third, and then maybe they will do the same thing as they … after they draw it. Does it make sense?

Sandy: If they don't't' know fractions very well, I think, because we are adding the ones, but not adding the threes, it may be confusing to some? *[Level 3]*

Sam: Well, they better know it by then, for fifth grade, I meant. For fourth grade, you're right. *[Level 2]*

Sandy: They may start saying that's is like 5/15 or something? *[Level 3]*

Sam: Right, but we've already talked about that before this lesson in fourth grade by then. *[Level 2]*

In the example above, in response to Sandy's anticipation of student thinking, Sam was rather dismissive and insisted that students should know it because it was taught in fourth grade. Extending Sandy's questions and asking her to elaborate further would have created a context to further discuss a student thinking process. However, the responses re-problematized the situation away from conceptual.

Over and over again in the Friendship meeting data, we found evidence of teachers' discussions directed away from students' conceptual understanding and toward procedural learning. When teachers' ideas about students' conceptual learning was confirmed or validated, it was often followed by redirection with procedural terms or concrete (procedural) teaching ideas for the concept, not necessarily about student learning of the concept.

It is also important to note that the lesson study group itself carried the shared expectation, and thus they planned the lesson focused on procedures. During Planning Meeting 4, Sandy questions against this direction of the lesson in the following example.

Shelley … they are going to model and then they are going to table talk, and then after the table-talk, after you explain, you show an example that is correct, now you are going to draw …

Sandy Could we give them just free choice … can they just draw it and we see how they drew it? *[Level 3]*

Shelley	But I think it goes back to what (we) said as far as if (students) are stuck, don't know what to figure out. *[Level 2]*
Lorena	Yeah, we're trying to avoid that.
Sam	(Quietly to the teachers who sit close by) I'm not (letting the students) draw …

In the excerpt above, Sandy asks if students could be given an opportunity to draw without specific instruction, so that the teacher could understand their thinking through the drawings. Shelley's response referred back to what they had discussed before, that a student needed to be given precise instruction in order to understand the lesson goals. Sandy's inquiry was quickly turned down by the group, with Sam's final words.

While lesson study as a community builds on the members' interests and backgrounds, and grows by taking in each members' ideas and new information, each group undoubtedly develops ways to negotiate different ideas. The collective conceptual orientation of the group provides a strong foundation for the negotiation, and it directs the group's learning. As evidenced in the data, Friendship Elementary School's lesson study process was guided by their procedural orientation, and the teachers' learning was framed by it as they worked to maintain the orientation.

Next we will turn to illustrate a similar discussion process with the Pacific Elementary School lesson study group.

Pacific Elementary School: Moving the Talk Back to Conceptual. In Planning Meeting 1, the Pacific teachers are discussing different representations to show fractions to students:

Bailey	So this is another representation that I've seen in books. I don't know which one of these three float better for children. Something that we can think about taking a part of a part, multiplying a part times a part.
Mindy	I wonder if like us, it's just depends on the child, which way they see it. *[Level 1]*
Bailey	Yeah, I wonder that, too.

Hanna	And I'm always thinking about which one is abstract versus more concrete. And these are all very abstract, but which one would you consider the most basic way for the child to solve that? *[Level 3]*

As Mindy shared her puzzlement with the attempt to frame representation choices as personal decisions, Bailey validates the sentiment. Before Bailey could continue, Hanna came in to redirect the discussion to focus on the level of abstraction for different representation, to assign reasons for choosing them. This is an example of how different group members steered the discussion to maintain the focus on student conceptual understanding in this group.

Moving farther, in Planning Meeting 3, teachers discussed the problem to be included in the research lesson.

Linda	They need to find out what $1/8^{th}$ was (first), then what $3/8^{th}$ is … to find $1/8^{th}$ of 560, that wouldn't be bad …
Wendy	To me, they should understand that the denominator is 8, so you're putting it into 8 parts, so 560 divided into 8, but they … *[Level 2]*
Bailey	What I am hearing is … because I'm trying to answer this question, 'where in the progression will our unit focus?' It sounds like you're talking about let's focus on multiplying a whole number by a fraction (to situate this topic in student learning progressions). *[Level 3]*

In this example, as Wendy took Linda's idea and framed it in a procedural manner, Bailey placed the problem in the broader student learning progression, redirected the discussion to zoom out, and tied it back to the goal of their research lesson again. In this way, Bailey helped teachers' refocus on student learning at the conceptual level (Level 3). It is often easy for teachers to focus solely on details of instructional decisions and lose sight of the bigger picture of student learning. Bailey demonstrated in a thoughtful way ("what I'm hearing is …") how the goal should be maintained in their planning discussions.

Summary of Teacher Talk Analyses and Collective Conceptual Orientation

The data show that two experienced lesson study groups displayed two different coherent collective conceptual orientations: one group with procedural focus and another with conceptual focus. The orientations were reinforced when deviations occurred, with the facilitators and other teachers redirecting the talks. The orientations were stable over time and facilitators played a major role in maintaining the orientations. These orientations undoubtedly strengthened their teaching beliefs and practices, helped shape their research lessons, and continued to be maintained during the discussion of the student data gathered from the research lesson.

While previous studies examined different group talk patterns (Kuusisaari, 2012; Savit, et al., 2011) and facilitator talk moves (Hmelo-Silver & Barrows, 2008; Zhang, Lundeberg, & Eberhardt, 2011), our findings add to the knowledge on how a group's collective conceptual orientation works to steer teacher discussion in certain ways. It was also not the case that one group (e.g., the group with conceptual focus) facilitated their group's talk very differently from another – in both groups, we identified how group members steered their discussion to remain at its own level, and the steering was accomplished in thoughtful manners.

We will turn now to examine the research lessons. We will illustrate how collective orientations of the two groups may be reflected in students' learning opportunities. The research lesson is the culmination of the teachers' effort in lesson study, in which teachers collect data on student understanding and analyze their lessons based on the data. It is an ideal context to challenge teachers' existing ideas of classroom practices and help generate instructional change. In such a context, we will illustrate how each group's orientation played an important role.

Research Lessons and Opportunities Created for Student Learning

For research lessons, both Pacific and Friendship Elementary School lesson study groups taught lessons on fractions, used relevant contextual problems (will be described below), and engaged students in hands-on activities. The facilitators of the lesson study groups, Bailey and Sam, taught their respective lessons to make the visions of their groups come to life. There were stark differences in terms of how students' ideas were elicited and handled in the lessons, however. In Pacific Elementary School's lesson, students explained their reasoning for solving given problems, while in Friendship Elementary School's lesson, student discussions were narrowly facilitated toward teachers' goals. In the following sections, these characteristics are illustrated with lesson examples.

Pacific Elementary School research lesson: Focus on student reasoning. For the fifth-grade mathematics lesson planned by the Pacific Elementary lesson study group, the instructional goal was "To apply and extend previous understanding of multiplication to multiply a fraction or whole number by a fraction" (CCSS-M.5.NF.4). The lesson started with a scenario for the Fitness Festival that was coming up that weekend. Different lengths for running tracks were given, and students were asked to find the total distance a student would run by completing a certain number of laps around the tracks. After the initial example of finding the total distance with 6 laps around a 1-mile track (6 x 1 = 6 miles), the next problem asked for the distance for 8 laps of a 1/2-mile track. One student, Jan, wrote his solution on his white board as 8 x 1/2 = 8/2 = 4 miles. The teacher asked:

Bailey: Why do we use multiplication in that situation?
Jan: I wrote this equation because, um … they do 8 laps and the track is 1/2 mile. So, it is repeated addition, and with multiplication you can get the answer. I did the multiplication, it is 8/2 and that is 4 miles.
Bailey: [writing the equation as Jan talks]. OK. Does it make sense (to the class)? So, why can we use multiplication in that situation?

Jamie: Because each lap is 1/2, so 1/2 in each lap you have to multiply by 8 …
Bailey: OK, we have 8 equal groups of 1/2, right? So 8 equal groups of 1/2 gives us 4 miles …

Following this, the teacher helped students extend this idea by finding the total distance with 2 laps with a 3/4-mile track, for which students explained their reasoning in two ways as 2 x 3/4 = 6/4 = 1 2/4 of a mile, and 3/4 + 3/4 = 6/4 = 1 2/4 of a mile. The next problem was 1/2 lap with a 1/2-mile track. As students worked individually to solve this problem, the teacher noticed that many students wrote the problem as 1/2 ÷ 1/2. She attempted to address this confusion by presenting a division example with a whole number. When students did not make an immediate connection with the problem situation with multiplication, she decided to take a different approach by presenting the correct expression and having students explain the possible reasoning:

Bailey: … I am going to hold on to this equation [writing 1/2 ÷ 1/2 on the board]. But I want to write another answer I saw in Room B. Tell me what equation this is? [writing 1/2 x 1/2]
Jaime: … 1/2 multiply by 1/2.
Bailey: So, 1/2 of a lap of 1/2 of a mile equals …?
Students: 1/4.
Bailey: 1/4. Talk to your partner how this makes sense in this problem …

Bailey did not dismiss the earlier confusion, but instead presented a different way for students to think about the situation and encouraged students to talk to each other about it. Following this, students used strips of papers to represent this problem situation using fractions, as the teacher wanted them to examine the situation conceptually and concretely. The teacher brought the class back to discussion:

Bailey: OK, good reasoning going on. I am going to ask Sahana and Mateo to please come here and share with us your thinking. Bring your green strips, please, and describe to us your thinking. [placing the strip on the board]
Sahana: … You said that the whole strip would be 1 mile, so if Jorge ran 1/2 of a mile.. well, he didn't.. but, if the track is 1/2 mile, then you have to show 1/2. So, we

	folded the mile in half, so...
Bailey:	Ok, hold on. Can I...? Let me put a label on it [writes on top of the strip on the board]. The whole track was one mile, and which part of this paper is the track? Could you show me?
Sahana:	This part [showing the right half part of the paper]
Bailey:	[to the whole class] Do you agree?
Students:	Yes!
Bailey:	Ok, this part is the track itself [writing on the board]. So, Sahana or Mateo, keep going.
Mateo:	So, after we folded the strip in half, and the track was only 1/2 of that, and then we folded in half again to make 1/2 of the 1/2.

As the examples illustrate, this lesson included aspects of conceptual teaching and learning, and the teacher facilitated student discussion focusing on their reasoning of solution processes. Students were allowed space to discuss their ideas, and the teacher left the ownership of the ideas with students who shared their thinking. It was evidenced when Bailey repeatedly asked students to confirm the representations she was writing on the board, and also asked the whole class whether they agree or disagree with the reasoning. In these ways, students in this lesson were given opportunities to think further about their own mathematical processes as well as to hear and understand their peers' thinking.

Friendship Elementary School research lesson: Focusing on following steps. The Friendship Elementary School research lesson also used a contextual problem, of a teacher entering *Food Network Rice Krispies Challenge*. Students were asked to figure out the amount of cereal needed for a recipe. The goal of the lesson was to "decompose a fraction into a sum of fractions with the same denominator in more than one way, recording each decomposition as an equation, justify decompositions" (CCSS-M.4NF.3b]. In this lesson, compared to the Pacific Elementary School's lesson, many more "how" and "what" questions were asked than "why", and the teacher tightly controlled the flow of the lesson by providing specific directions. Students' answers were also descriptive, showing the procedures used to solve the problems, with few opportunities for argumentation and for deeper reasoning.

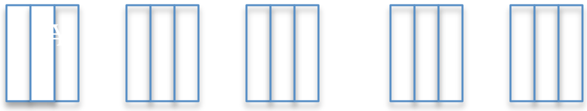
In the lesson, student explanations were typically shallow and procedural. And the teacher followed the answer by a lengthy explanation.

Sam: How would using the 1 cup and the two 1/3 cups be faster to measure her Rice Krispies?
Emily: … because it uses less cups …
Sam: … OK. Let's see if I can draw it. This three 1/3 cups represent one whole cup and the two 1/3 are the remaining part, which is less than another whole cup. So, this amount is more than one cup, but not quite two cups. So, boys and girls, 5/3 is a fraction greater than one. A fraction greater than one has a numerator (that) is more than the denominator. The numerator tells you how many parts you have and the denominator tells you how many parts make up the whole. Recipes are written with mixed numbers, so we will write 1 and 2/3 cups instead of 5/3 cups. A mixed fraction is written with a whole number, which in this case is 1, and the left over fractional amount on the side, in this case is 2/3.

Instead of asking probing questions and encouraging the student to think further, Sam took on the main role to explain the concept to the class. Her explanation also focused on the procedures, although it did accompany visual representations (conceptual tool).

In planning meetings, the Friendship teachers discussed the value of student mistakes and how they could be a window into understanding their thinking process, as well as how teachers could take advantage of mistakes to help students think deeply. In the course of this lesson, Sam attempted to address a student error: when showing 5/3, some students literally followed the name of the fraction, "five third," and drew five boxes, dividing each into thirds:

Sam: I saw a few people doing this, so I want to talk about it. [shows on the document camera]. Who knows what this model is trying to show? Go ahead.



Missy: It is trying to show 15.
Sam: No, I was not trying to show 15. What do you think I was trying to show?
Britt: 5/3.
Sam: I was trying to show 5/3. Tell me why I showed 5/3 that way.
Britt: You have 5 boxes, and you put it in the third.
Sam: So, I have 5 boxes and all are split in 1/3. Anybody see a problem with that?
Andres: One box with the thirds …
Sam: As I do it, you tell me I am doing what you mean, OK? So, are you saying, I am supposed to split this box into thirds and color one, two, three, and it will be 1/3, 1/3, 1/3? Yes? OK, let me do that. So how much would that be?
Andres: 3/3.
Sam: So, that would be three thirds, and that will equal what …?
Andres: One.
Sam: One whole, right? So … how many wholes would it be?
Andres: … 5.
Sam: At first they thought I am going to have 5 boxes, I am going to divide them into thirds, and that will be 5/3. Do you see the thinking in that? And do you see the error?

While this could have opened up a new opportunity for students to deeply think of fraction concepts by carefully analyzing the error process, Sam took the main role in explaining this error, while very narrowly focusing on the correct answer. The Friendship Elementary School's lesson unfortunately accompanied many examples of such missed opportunities for students' conceptual learning. While the teacher attempted to use aspects of student-centered instruction (e.g., contextual problems, visual representations, student errors), the group's strong focus on procedural accuracy kept students from exploring math concepts, and instead drove students to follow teacher directions.

Implications of Collective Conceptual Orientations.

Two lesson study groups' collective conceptual orientations were reflected in how the research lessons were planned and taught, with different learning opportunities for students. There were distinct connections between the ways teachers talked about student understanding in the planning meetings, and the ways the lessons were taught. While this finding may seem obvious, we tend to assume instructional improvement as long as teachers are collaborating and discussing student understanding in job-embedded PD, and this study presents a case of contrasting processes.

Two lesson study groups who shared many similar professional contexts followed different patterns of talk during lesson study and produced lessons with different learning opportunities for their students. These different learning opportunities, however, were closely aligned with the groups' orientations, in such ways that the Friendship group who valued procedural learning produced the lesson that aligned with their orientation, while the Pacific group who emphasized conceptual learning produced their lesson with that emphasis. Thus, even though lesson study, in principle, is considered as an ideal PD to challenge teachers' thinking about classroom practices based on student data, our findings show that both groups of teachers came out of the experiences feeling empowered and reinforced for their existing thinking of classroom practices. We also found that the collective conceptual orientations are not easy to shift when challenged in the group process, rather, they were strengthened and reinforced in the face of the challenges.

In our larger study of lesson study implementation at the state level (Authors, year), we found that lesson study sustained and spread itself at the district and school levels after state funding expired. Different districts and schools created new ways to support teachers' ongoing work with lesson study, therefore developed new levels of ownership (Authors, year). In scaling up an instructional improvement at a system level, Coburn (2003) conceptualizes scale as depth, sustainability, spread, and shift in reform ownership. While our studies together suggest that three of the four dimensions are in general met with lesson study (sustainability, spread, and shift in reform ownership), the depth (defined as "effecting deep and consequential change in classroom practice by altering teachers' beliefs about student learning, nature of subject matter, and effective instruction, norms, of social interactions with students, and pedagogical principles in the enacted curriculum (p4)") may be reached at different levels by different lesson study groups, partially due to differing conceptual collective orientations. We need to investigate further the processes to help lesson study groups reach the ideal depth and identifying key aspects of the processes.

Conclusions

We started this paper by outlining the general agreement in the field about characteristics of effective PD with a focus on student understanding of mathematics. We questioned whether or not that was enough to ensure teacher learning that is aligned with the principles for teacher and student learning that lead to system-level improvement of teaching and student learning. Our findings suggest it is not enough, and guide our attention to the strong role that collective conceptual orientations play in otherwise "research-proven" PD settings, with its enduring influences on teacher and student learning.

Even in lesson study, designed to promote cognitive shift in teacher thinking and practices, the collective conceptual orientations play a dominant role in shaping teachers' and students' opportunities to learn. They strengthen the social ties and group commitment, yet do not necessarily provide the desirable learning setting which leads to improvement in teaching and student learning aligned with reform agenda. The stability of the orientations suggests a possibly enduring gap in teachers' learning opportunities between schools. Our findings suggest that the orientation is not easy to shift, even when different ideas are presented. If the teacher group is left alone with a particular collective orientation that values teacher-directed procedures, the time allowed for teachers to collaboratively investigate classroom practices can become another opportunity to strengthen their traditional beliefs and practices tied to the orientation. If the group's orientation is not in sync with the educational reform effort, it can work against the expectations and help perpetuate the status-quo.

In the case presented in this paper, both facilitators brought different knowledge bases and orientations. Instead of entirely disregarding Sam's contributions, exposure to a different orientation should help her shift her thinking. Dismissing her existing knowledge entirely and demanding her to change would be very similar to her group's orientation to learning by teaching procedures without considering student prior thinking. A PD context for teacher leaders in which experienced teachers come together, share, and challenge each other's ideas based on actual examples from their practices may prove effective in helping shift their own orientations. The examples from this case study can be utilized to generate discussions on different collective conceptual orientations they think their schools have, and use it as a starting point to generate action plans on how to guide their colleagues' learning. By doing so, the teacher leaders will indirectly be challenged about their own orientations and become aware of the importance of their roles in group processes.

It is critical to pay attention to the collective conceptual orientations of teacher learning communities as they shape teachers' learning opportunities. Given the stability of such orientations, identification of factors that could influence the orientations is critical. In future studies, it will also be important to examine school-level orientations and how they influence group orientations. The way in which teachers who were new to lesson study at Pacific Elementary School could readily participate in the group discussions in this study suggests that they had experienced the orientation within the school prior to participating in lesson study. We need to understand the aspects and process of the development of collective conceptual orientations, in order to begin to shift the nature of such orientations, for increased opportunities for teachers and students to learn.

References

Authors (year)

Authors (year)

Ball, D. L. (1997). What do students know? Facing challenges of distance, context, and desire in trying to hear children. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers and teaching* (Vol. 2. Pp769-818). Dordrecht, Netherlands: Kluwer.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. NY: Freeman.

Birman, B. F., Desimone, L., porter, A. C., & Garet, M.S. (2000). Designing professional development that works. *Educational Leadership, 17*, 613-649.

Borasi, R., & Fonzi, J. (2002). *Professional development that supports school mathematics reform* (Vol. 3). Division of Elementary, Secondary, and Informal Education, Directorate for Education and Human Resources, National Science Foundation.

Borko, H. & Putnam, R (1997). Learning to teach. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology*. (pp. 673-708). New York, NY: Macmillan.

Bowers, J. S., & Nickerson, S. D. (2001). Identifying cyclic patterns of interaction to study individual and collective learning. *Mathematical Thinking and Learning, 3*, 1-28.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). How people learn: Brain. *Mind, Experience, and School*, *2*.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C., & Loef, M. (1989). Using knowledge of children's mathematical thinking in classroom teaching: An experimental study. *American Educational Research Journal, 26*. 499-532.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23*(7), 13-20

Cobb, P., & Bauersfeld, H. (1995). *The emergence of mathematical meaning: Interaction in classroom cultures*. Psychology Press.

Cobb, P., & Bauersfeld, H. (1995). Introduction: The coordination of psychological and sociological perspectives in mathematics education.

Coburn, C. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher. 32*(6). 3-12.

Cochran-Smith, M & Lytle, S. L. (1999). Relationships of knowledge and practice: Teacher learning communities. *Review of Research in Education, 24.* 249-305.

Cohen, D. & Ball, D. (2007). Education innovation and the problem of scale. In B. Schneider & S.-K. McDonald (Eds.), *Scale-up in education: Ideas in principle (volume I)* (pp. 19-36). Lanham, MD: Rowman & Littlefield.

Coleman, J. S. (1985). Schools and the communities they serve. *Phi Delta Kappan, 66,* 527-532.

Coleman, J. S., (1987). Norms as social capital. In G. Radnitzky, & P. Bernholz (Eds.), *Economic imperialism: The economic approach applied outside the field of economics*. (pp. 133-155). NY: Paragon.

Coleman, J. S. (1990). *Foundations of social theory.* Cambridge, MA: Harvard University Press.

Common Core Standards. *http://www.corestandards.org/* Accessed 14 July 2013. (Common Core State Standards Initiative web site).

Cordingley, P., Bell, M., Evans, D., & Firth, A. (2005). *The impact of collaborative CPD on classroom teaching and learning review: How do collaborative and sustained CPD and sustained but not collaborative CPD affect teaching and learning?* London: EPPI-Centre.

Davis, B. & Simmt, E. (2003). Understanding learning systems: Mathematics education and complexity science. *Journal for Research in Mathematics Education*, 34, 2. 137-167.

Desimone, l. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24,* 81-112.

Elmore R. F. (1996). Getting to scale with good educational practice. *Harvard Education Review, 66*, 1-26.

Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education, 27*(4), 403-434.

Fernandez, C., Cannon, J., & Chokshi, S. (2003). A US–Japan lesson study collaboration reveals critical lenses for examining practice. *Teaching and teacher education*, *19*(2), 171-185.

Franke, M. L., Carpenter, T. P., Levi, L, & Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Journal. 38*(3). 653-689.

Fosnot, C. T., Dolk, M., Zolkower, B., Hersch, S., & Seignoret, H. (2006). Mathematics in the City: Measuring teacher change in facilitating mathematizing. *NY: Mathematics in the City*.

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

Greeno, J. G. (1991). Number sense as situated knowing in a conceptual domain. *Journal for Research in Mathematics Education, 22*, 170-208.

Hadar, L. L., & Brody, D. L. (2012). The interaction between group processes and personal professional trajectories in a professional development community for teacher educators. *Journal of Teacher Education, 64*(2), 145-161. doi: 10.1177/0022487112466898

Hawley, W. & Valli, L. (1999). The essentials of effective professional development: A few consensus. In G. Sykes, & L. Darling-Hammond. (Eds.), *Teaching as the learning profession: Handbook of policy and practice.* (pp.127-150). San Francisco: Jossey-Bass.

Horn, I. S. (2005). Learning on the job: A situated account of teacher learning in high school mathematics departments. *Cognition and Instruction, 23*(2). 207-236.

Horn, I. S., & Little, J. W. (2010). Attending to problems of practice: Routines and resources for professional learning in teachers' workplace interactions. *American Educational Research Journal, 47* (1). 181-217.

Jacobs, V. R., Franke, M. L., Carpenter, T. P., Levi, L., & Battey, D. (2007). Professional development focused on children's algebraic reasoning in elementary school. *Journal for Research in Mathematics Education, 38*(?), 258-288.

Kuusisaari, H. (2012). Teachers at the zone of proximal development – Collaboration promoting or hindering the development process. *Teaching and Teacher Education, 43*. 46-57.

Leinhardt, G. (1988). Situated knowledge and expertise in teaching. In J. Calderhead (Ed.), *Teachers' professional learning* (pp. 146-168). London, UK: Falmer.

Lewis, C. C., & Hurd, J. (2011). *Lesson study step by step: How teacher learning communities improve instruction*. Heinemann.

Little, J. (1990). The persistence of privacy: Autonomy and initiative in teachers' professional relations. *The Teachers College Record*, *91*(4), 509-536.

Marrongelle, K., Sztajn, P., & Smith, M. (2013). Scaling up professional development in an era of common state standards. *Journal of Teacher Education*, *64*(3), 202-211.

McLaughlin, M. & Talbert, J. (1993). What matters most in teachers' workplace context? In J. W. Little & M. W. McLaughlin (Eds.), *Teachers' work: Individuals, colleagues, and contexts* (pp. 79-103). NY: Teachers' College Press.

McLaughlin, M. & Mitra, D. (2001). Theory-based change and change-based theory: Going deeper and going broader. *Journal of Educational Change, 2*(4). 301-323.

Murata, A. (2011). Conceptual overview of lesson study: Introduction. In L. Hart, A. Alston, & A. Murata (Eds.). *Lesson study research and practice in mathematics education: Learning together*. NY: Springer. pp. 1-12.

National Council of Teachers of Mathematics. (2014). *Principles to Actions: Ensuring Mathematical Success for All*. Reston, VA: National Council of Teachers of Mathematics.

Opfer, V. D. & Peder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research. 81*(3). 376-407.

Powell, R., & Birrell, J. (1992). The influence of prior experiences on pedagogical constructs of traditional and nontraditional preservice teachers. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula (Ed,), *Handbook of research on teacher education* (2nd, ed., pp. 102-119). NY: Macmillan.

Richardson, V. & Anders, P.(1994). The study of teacher change. In V. Richardson (Ed.), *A theory of teacher change and the practice of staff development: A case of reaching instruction* (pp. 159-180). NY: Teachers College Press.

Savit, D., Kennedy, A., Lean, Z., Nelson, T. H. & Deuel, A. (2011, Summer). Support for professional collaboration in middle school mathematics: A complex web. Teacher Education Quarterly, 113-131.

Savit, D., Nelson, T. H., & Deuel, A. (2012). Teacher groups' conceptions and uses of student-learning data. *Journal of Teacher Education 64* (1). 8-21.

Sherin, M. & van Es, E. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education, 60*(1). 20-37.

Stein, M. K., Silver, E. A., & Smith, M. S. (1998). Mathematics reform and teacher development from the community of practice perspective. In J. G. Greeno & S. Goldman (Eds.). *Thinking practices in mathematics and science learning* (pp.) Hillsdale, N. J.: Lawrence Erlbaum Associates

Stigler, J. W., & Hiebert, J. (2009). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. Simon and Schuster.

Stollar, S. A., Poth, R. L., Curtis, M. J., & Cohen, R. M. (2006). Collaborative strategic planning as illustration of the principles of system change. *School Psychology Review, 35*. 181-197.

Thompson, P. W., Philipp, R., & Boyd, B. (1994). Calculational and conceptual orientations in teaching mathematics. In 1994 Yearbook of the NCTM.

van de Walle, J. A., Karp, K. S., & Bay-Williams, J. (2013). Elementary and middle school mathematics: Teaching developmentally. (8th ed). Bloomington, MA: Pearson.

van Es, E. (2011). A framework for learning to notice student thinking. In M. G. Sherin, V. R. Jacobs & R. A. Philipp. (Eds.). *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 134-151). New York: Routledge

van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. A framework for the facilitation of teachers' analysis of video. *Journal of Teacher Education, 65*(4). 340-356.

van Es, E. & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571–596.

van Es, E. & Sherin, M. G., (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education*, *24*, 244–276.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Weiss, I. R., Pasley, J. D., Smith, P. S., Banilower, E. R., & Heck, D. J. (2003). Looking inside the classroom. *Chapel Hill, NC: Horizon Research Inc*.

Wideen, M., Mayer-Smith, J., & Moon, B. (1998). A critical analysis of the research on learning to teach: Making the case for an ecological perspective on inquiry. *Review of Educational Research, 68*, 130-178.

Wilson, M., & Goldenberg, M.P. (1998). Some conceptions are difficult to change: One middle school mathematics teacher's struggle. *Journal of Mathematics Teacher Education*, 1, 269-293.

Wilson, S. M. & Berne, J. (1999). Teacher earning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education, 24*. 173-209.

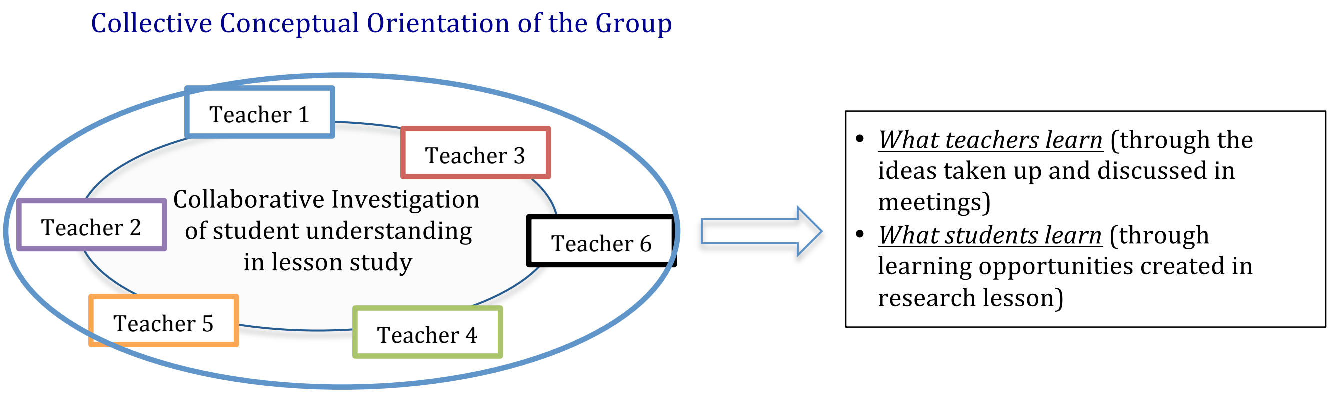


Figure 1. Conceptual Framework

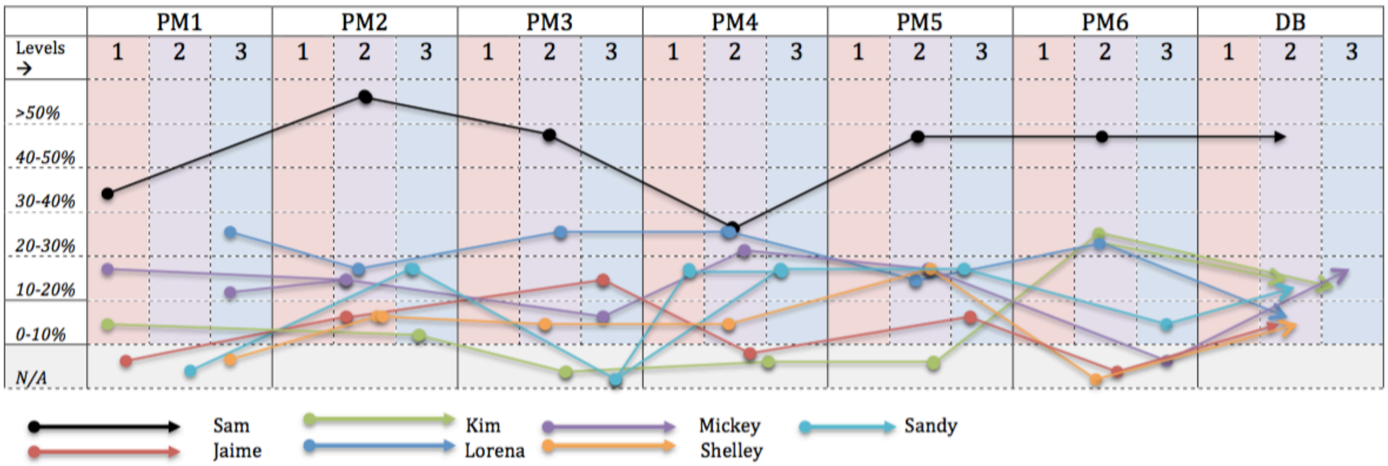


Figure 2. Lesson Study Teacher Discussion Patterns at Friendship Elementary School.

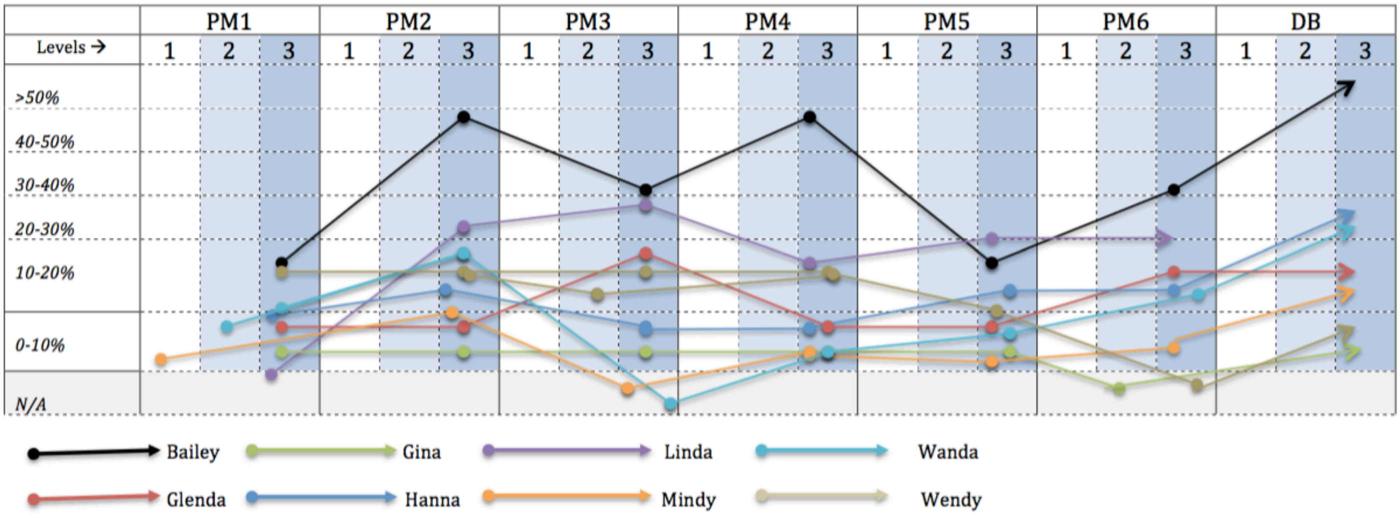


Figure 3. Lesson Study Teacher Discussion Pattterns at Pacific Elementary School.

Table 1. Teacher demographics data

Pacific Elementary School					Friendship Elementary School				
	Names	# of years taught	# of years with LS	Grades taught		Names	# of years taught	# of years with LS	Grades taught
1	Bailey (F)	25	12	3-5	1	Sam (F)	28	7	K-5
2	Linda	22	11	retired	2	Lorena	25	7	2, 3, 5
3	Wendy	24	11	K-1	3	Mickey	11	8	3-5
4	Gina	11	0	3	4	Sandy	19	5	1, 2, 4
5	Wanda	17	0	4-8	5	Kim	34	7	ESL; PK-2
6	Glenda	13	0	K-5	6	Shelly	9	8	1, 3-12
7	Hanna	18	12	K-1	7	Jaime	11	7	K
8	Mindy	14	9	K-5					

Table 2. Lesson study meeting agenda

Pacific Elementary School	Friendship Elementary School
Agenda and main activities	Agenda and main activities
1 Examining resources and mathematics • Discussed resources available for the lesson study process (e.g., Edmodo website, NCTM articles, etc.) • Assigned research articles for teachers to read and report on • Examined three different representations of multiplying fractions, as well as student misconceptions	1 Discussing potential topics for the research lesson. • Brainstormed fraction-related topics that students struggle with • Teachers agreed to review the results of a pending pre-assessment before making the final decision
2 Discussing research and curriculum materials • Each teacher shared thoughts on the assigned research article and led a brief discussion • Examined the standards across K-5 grade levels to identify knowledge and skills related to multiplying fractions • Reviewed the notes from the Knowledgeable Others • Brainstormed problem situations for the RL	2 Examining student data, curriculum materials, and research; initial research lesson planning • Shared the results of the pre-assessment, identifying student learning gaps in modeling fractions greater than 1 • Examined the standards across K-5 grade levels to identify knowledge and skills related to modeling fractions greater than 1 • Shared the research (articles?) on fractions • Brainstormed real-world contexts for the RL task
3 Identifying the goal of the research lesson • Exploring the linear model of multiplying fractions • Discussing the conceptual building blocks of multiplying fractions • Brainstormed real-world contexts for the RL task	3 Planning the research lesson • Re-examined the standards to clarify the grade level for the research lesson • Outlined the sequence of the RL activities • Discussed teacher prompts in the lesson and student responses
4 Planning the research lesson • Discussed an introductory lesson task • Discussed problem situations for the RL • Skyped with the Knowledgeable Other to clarify the problem situation for the RL	4 Planning the research lesson • Reviewed the notes from the Knowledgeable Other • Continued writing and making adjustments to the RL plan, focusing on the sequence of activities • Discussed the logistics of the lesson (e.g., buying needed materials)
5 Planning the research lesson • Discussed teacher prompts in the lesson and student responses • Made adjustments to the lesson tasks • Addressed student misconceptions and discussed how to address them	5 Planning the research lesson • Anticipated student answers and discussed how to address them • Refined the teaching script • Discussed the logistics of the lesson day
6 Finalizing the research lesson plan • Discussed logistics of the lesson day • Anticipated students responses while working with the manipulatives • Fine-tuned the lesson script	6 Finalizing the research lesson plan Rehearsed the RL plan, anticipating student responses and making adjustments to the teaching script
7 Research lesson and debriefing of the lesson	7 Research lesson and debriefing of the lesson

Table 3. Characteristics of Teacher Talk about Student Understanding in Three Levels

Level 1: Student understanding as an innate ability	Level 2: Student understanding as procedural and skills development	Level 3: Student understanding as conceptual development
○ Discussion of student understanding with little or no unpacking of their thinking process. ○ Dichotomous concept of student understanding (whether students get it or not, and very little in-between) ○ Little connection between teaching and learning.	○ Teachers discuss student understanding primarily in terms of procedural accuracy. ○ It may be about students following accurate procedural steps in calculation, using the model given by the teacher, and/or knowing the definitions. ○ Some unpacking of procedural process. ○ Teaching is to “fix” students’ (procedural misunderstanding. Learning can also be instantaneous.	○ Teachers discuss student understanding as a process, as results of certain teaching. ○ Students’ partial understanding and differing developing process are not discussed as something to be fixed, but as a natural happening. ○ Increasing attention to conceptual understanding. ○ Increased unpacking of student thinking process.

Table 4. Individual Teacher Talk Levels Across Lesson Study Meetings at Friendship Elementary School.[2]

	PM1[3]	PM2	PM3	PM4	PM5	PM6	DB
Sam (F)	1	2	2	2	2	2	2
Jaime	N/A	2	3	N/A	3	N/A	3
Kim	1	3	N/A	N/A	N/A	2	2 3
Lorena	3	2	2	2	2	2	2
Mickey	1 3	2	3	2	2	N/A	3
Shelley	N/A	2	2	2	2	N/A	2
Sandy	N/A	3	N/A	1 3	3	3	2

[3] PM means planning meeting, and DB means debriefing.

Table 5. Individual Teacher Talk Levels Across Lesson Study Meetings at Pacific Elementary School.

	PM1	PM2	PM3	PM4	PM5	PM6	DB
Bailey (F)	3	3	3	3	3	3	3
Glenda	3	3	3	3	3	3	3
Gina	3	3	3	3	3	N/A	3
Hanna	3	3	3	3	3	3	3
Linda	3	3	3	3	3	3	3
Mindy	1	3	N/A	3	3	3	3
Wanda	2 3	3	N/A	3	3	3	3
Wendy	3	3 2	3	3	3	N/A	3

Appendix: Coding example

	Level 1			Level 2			Level 3			
Sample Text	Teachers discuss student understanding with (little) or no unpacking of their learning process	Implies students either get it or not, with very little in-between.	*Little connection between teaching and learning.*	Teachers discuss student understanding primarily in terms of procedural accuracy of the answers.	Some unpacking of procedural process	*Teaching is to "fix" students' (procedural) misunderstanding. Learning can also be instantaneous.*	Teachers discuss student conceptual understanding as a sense-making process, as results of certain teaching.	Increasing attention to conceptual understanding.	Increased unpacking of student thinking process	*Teaching is to support learning, by starting where students are currently, and providing experiences*
He can do the math. He doesn't have the people skills to be able to talk with the other people, but he can do the math.	x	x	x							
Every time I asked her something she knew what I was asking her and then with the number sentence, she didn't have any marks or anything. And then I said "Refer to the board" and then she was like, "Oh, I know." She was able to put the plus signs.				x	x	*x*				
We asked them to use the fraction strips and they drew circles. I thought that was interesting. Could a circle be the same? I would like to do a little bit more on the circles and the strips, because I do not think they can represent the same value.					x			x	x	*x*
How do we help them understand that because it's fractions, there is some division going on, but division wasn't the operation?				x	x		x	x	x	*x*