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IMPROVING MATHEMATICS INSTRUCTION IN COMMUNITIES—A CASE STUDY OF TWO TEACHING RESEARCH GROUPS IN A CHINESE ELEMENTARY SCHOOL

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IMPROVING MATHEMATICS INSTRUCTION IN COMMUNITIES---A CASE STUDY OF TWO TEACHING RESEARCH GROUPS IN A CHINESE ELEMENTARY SCHOOL

By

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ABSTRACT

IMPROVING MATHEMATICS INSTRUCTION IN COMMUNITIES----A CASE STUDY OF TWO TEACHING RESEARCH GROUPS IN A CHINESE ELEMENTARY SCHOOL

By

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In this dissertation I adopt an ethnographic approach to examining and understanding what seven Chinese elementary mathematics teachers did in their school-based teaching research groups and related communities, and how what they did influenced their teaching practice. I consider a teaching research group as a community and practice that is a common sub-organization in most Chinese elementary and secondary schools. A teaching research group is located in an institutional context. In this study the participant teachers from two teaching research groups took part in the professional activities offered by intermediate teams that included other math teachers from several schools and by the district. The situative theoretical perspective on teacher learning and professional development allows me to use several key concepts to examine the phenomenon of teachers' professional communities, including joint work, tools as learning resources, collegial relations and a regime of competence. I argue that the teachers' joint work of public lesson contributes to teacher learning and instructional improvement in three ways: enhancing the teachers' math knowledge for teaching and knowledge of instruction; enabling the use of tools as learning resources; and having the teachers realize their

weaknesses of teaching competence. In addition, I find that the dynamics of collegial relations among the teachers is conducive to teacher learning and instructional improvement. Meanwhile, a teacher who acts as a boundary broker across the different communities can bring in learning opportunities for colleagues and expand their visions of teaching and learning. In the end I point out some problems with the teaching research groups and implications for the future.

ACKNOWELDGEMENTS

Five years ago I came across the ocean to pursue my doctoral study at Michigan State University. That was a milestone in my life. Before I left for Michigan, I had never thought about how challenging the doctoral study at Michigan State University could be, and how much I would be reshaped by the academic training. In the first semester at Michigan, I called my family and told them I would not have chosen to go abroad for seeking a doctoral degree if I had known how tough the study life was. The challenge did not come from cultural shocks many foreigners experience when they arrive at a new country. The challenge was from reshaping my way of thinking. Culture and language structure an individual's way of thinking. As a doctoral student, I strived to learn to think critically, independently, rigorously, and creatively. I knew that that would pave my way of becoming an educational researcher. Fortunately, on my journey of finishing the doctoral study, I was guided and supported by my advisor Dr. Lynn Paine. Her research work and well-designed courses sparked my interest in Chinese teachers' learning in communities. Her encouragement, understanding, and enthusiasm for the work of being a researcher and mentor motivated me to complete the five-year long journey. I am grateful to my dissertation committee members who exemplified intellectual excellence and nurtured my thoughts on this study. My dissertation committee members included Chris Wheeler, Jack Schwille, Gary Sykes, and Raven McCrory.

I am indebted also to the principal and teachers at the Tower Elementary School

who opened their doors to welcome me into their world. I could not have finished this study without them being open and friendly. I respect their hard work and love for students. I also thank Prof. Hongyuan Gao who was my professor at Beijing Normal University 15 years ago and helped me gain the entry into the Tower Elementary School. He taught me how supportive a teacher can be for his or her students in their life. Finally, I thank my family whose endless and selfless support gave me courage and confidence along the way of completing my doctoral study. My lovely son, Arthur, whose beautiful smiles and laughs have fueled me to write the dissertation and are fueling me to seek a meaningful and full life. And I am grateful to Hui for his encouragement and support.

PREFACE

That teachers work in communities is a thing I was used to taking for granted. That is the way I used to work when I was a school teacher in China. Though I was not educated to be an English teacher in a secondary school, I accepted a teaching position of teaching English as a second language to seventh graders upon graduation. I did not see it could be a problem that I had no formal training in teaching English to seventh graders. Neither did my school administrators. They and I were all confident with my subject matter knowledge as I minored in English language arts in my undergraduate studies. I guess the school administrators knew that I was going to learn how to teach on the job from my colleagues. So they were not worried about my lack of pedagogical knowledge about teaching English as a second language. I was not worried either because I was so naïve to think that having the subject matter knowledge was enough for me to teach seventh graders. After entering the school I had a mentor who was the head of the English teaching research group. She observed and commented on my lessons many times during the first year. I observed her lessons much more often than she observed mine. She was a nice lady, with more than ten years of teaching experiences. She showed her concern that I could not understand the school and the students so that I would feel frustrated when encountering problems in class. The school was ranked low based on student achievement. Each year few graduates were admitted by selective high schools. The majority of students came from working class families. That environment was very

different from the environment where I grew up. She was so right at this point. Unfortunately, I was too young to understand that by that time.

Teaching is a complicated enterprise that demands more than knowing the subject matter. I shared the same office with the three other English teachers who taught seventh graders. We formed a team to collectively plan lessons. In the first year of my teaching career every Tuesday afternoon I rode a bike to take part in a training session with other new English teachers that was organized by the district. With all the supports from the school and district, I happily started my teaching career. I enjoyed talking and discussing with my lesson planning team colleagues. In the teaching research group meetings I often kept silent to carefully listen to what my senior colleagues said. Observing my colleagues' lessons and reading their lesson plans were what I most wanted to do during the first year. I admired their ease when interacting with their students and always wondered how some of them with less subject matter knowledge than I could teach so well.

Right now, ten years later, I can not remember what exactly I learned from interactions with my colleagues. However, it was true that I became a good teacher after two years. My students achieved well on tests. In fact, my students more often achieved extremely high scores than the students who had other teachers. I felt proud when our teaching research group held a meeting to wrap up the whole semester and share the information about students' performance on tests. At the same time, my mentor was right about the challenge I would face. I shed a lot of tears because it was so hard for some of

my students and their parents and me to understand each other. We had different views on education and the students' future. These parents never expected their kids would live a better life through learning English and receiving more education. For them being able to earn a living as a cook or train driver would be enough for their sons or daughters. My efforts to motivate them to study hard were not appreciated by some parents and students. My colleagues in the lesson planning team helped me adjust my expectations of these students and ways of teaching them as we can not change the reality. Their moral and emotional support accompanied me through the hard times at that school.

That was sad that I had to lower my expectations for some of my students. It was an everlasting dilemma young teachers would always face: enthusiastic young teachers wish education would change their students' life; however, sometimes their students' family education fight against what they did at school, or young teachers lacked effective ways and resources to communicate with parents.

To pursue an advanced degree and a different life, I started my doctoral studies in the US five years ago. What I read and learned in my first year at Michigan State University was overwhelming in terms of promoting my thinking about teacher communities, teacher learning, and teacher work. I was amazed at American researchers' intense interest in Asian models of teachers' professional development such as Japanese lesson study. They tried to connect Asian students' high achievement on international mathematics assessments with their teachers' professional development. That sparked my interest in Chinese teachers' typical form of professional development in the

workplace—participating in teaching research groups and professional activities organized by districts. My teaching experiences tell that teaching research groups play an important part in supporting teachers' learning and instructional improvement. However, there are no empirical studies on teachers' participation in teaching research groups either in China or the US. In China even few researchers use the theoretical concept of community to examine and understand teaching research groups. From there I decided on what I was going to do for the dissertation project. In the following chapters I show the academic journey I made along the way of understanding and examining teachers' participation in teaching research groups.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

The notion of community building is thriving in the scholarly discourse of education. Over the past two decades calls for locating teacher learning in communities or establishing teachers' professional communities have increased in the U.S. The isolated egg-crate working conditions of US teachers were thought to be a barrier to fostering collaborative collegiality among teachers. However, the notion of teachers' community of practice is interpreted and understood in various ways.

Some researchers (Ball & Cohen, 1999; Cochran-Smith & Lytle, 1999; Franke et al, 2005) propose "inquiry communities of teachers" in which teachers hold "inquiry stance on practice," "generate local knowledge, envision and theorize their practice, and interpret and interrogate the theory and research of others" (Cochran-Smith & Lytle, 1999, p. 289). Similar to inquiry communities of teachers, McLaughlin and Talbert (2001) argue for teacher learning communities to "define teachers' joint efforts to generate new knowledge of practice and their mutual support of each others' professional growth" (p.75). Grossman et al (2001) find that a real mature teacher community can be a "teacher intellectual community" where teachers accommodate and benefit from multiple perspectives, take communal responsibility for student learning, have commitment to colleagues' growth while the community focuses on student learning and engaging teachers as students of the subject matters they teach. Despite the different focus on

teachers' communities of practice, those studies converge on a rationale for teachers' communities of practice that professional communities should/can provide an ongoing venue for teacher learning.

Construction of teachers' professional communities is connected with teachers' professional development and teacher learning. On the one hand, some empirical studies point out that effective professional development involves communities of teachers as learners that redefine teaching practice (Garet et al, 2001; Little, 2002; Wilson & Berne, 1999). The studies show that "strong professional development communities are important contributors to instructional improvement and school reform" (Little, 2002, p.936). On the other hand, some researchers (Knight, 2002; Stein et al, 1999) argue for a new theoretical paradigm of professional development that shifts the focus of theories of teacher learning from individual psychology to the social and organizational factors in communities.

Regarding the professional development of mathematics teachers, *Professional Standards for Teaching Mathematics* (1991) issued by the National Council of Teachers of Mathematics (NCTM) states, "As a part of professional development, principals should allocate time for teachers to build collegial links with other faculty" (p.182). Some research projects on improving mathematics instruction try to create collective activities for the participant teachers either through video club, or workshops (e.g., Cognitively Guided Instruction--CGI project) or collective curriculum planning and assessment development sessions (e.g., Quantitative Understanding: Amplifying Student

Achievement and Reasoning—QUASAR project).

In a video club of middle school mathematics teachers (Sherin & Han, 2004) the researchers organized the teachers to watch video excerpts of lessons from two of the four participant teachers and facilitated the group to collaboratively reflect on teaching and student learning. Over the course of the year the teachers gradually shifted the focus of their discussion on pedagogy to student thinking.

CGI, a widely citied mathematics teachers' professional development project, provided regular workshops in which the teachers watched videotapes of an individual child solving word problems, discussed his or her solutions that highlighted distinctions among the problems, and found out how those distinctions were related to the ways that the child thought about and solved the problems (Carpenter, Fennema, & Franke, 1996; Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Franke, Fennema, Ansell, & Behrend, 1998; Franke, Carpenter, Levi, & Fennema, 2001). In the extension program of CGI, researchers (Franke et al, 2005; Kazemi & Franke, 2004) created an ongoing school-based professional development program in which the teachers collaboratively studied their students' written or oral mathematical work and discussed ways to make use of student reasoning.

In a national mathematics educational reform project (QUASAR), a group of middle school teachers took part in varieties of joint activities to learn how to teach an innovative curriculum (Visual Mathematics) that emphasized student mathematical reasoning and communication (Stein, Silver, & Smith, 1998). The researchers found that

the participant teachers highly valued the teacher-teacher interactions around collective curriculum planning and assessment development.

This brief review suggests that in the US context both generic and math-specific discussions of teacher learning give much importance to teacher community. As Borko (2004) points out, however, we still do not know much about exactly what and how teachers learn from professional development and teacher community. Little (2002) argues that few studies go "inside teacher community" to focus closely on the teacher development opportunities and possibilities that reside within teachers' ordinary daily work and what the relationship between teachers' ordinary daily work and their learning in a community looks like. Hill (2004) points out that little is known in literature about the quality and effectiveness of the typical professional development available to most teachers. She notes that a lot of research studies exemplary programs of professional development that are designed and conducted by researchers. Unfortunately, these exemplary programs are atypical in the US professional development system because only a small percent of teachers attend them.

Bearing the literature on teacher community and professional development in the US context in mind, I chose to study a typical form of professional development for the majority of Chinese teachers that locates teacher learning in communities and connects with teachers' daily instructional practice. In China a common form of professional development in the workplace is participating in activities of school-based teaching research groups (Hu, 2005; Li, 2004; Shi, 2002). As Mewborn (2003) notes, in China and

Japan[1] there are prevalent models of continuously improving teaching that engage a community of learners in grappling with significant mathematical ideas and considering how students learn these mathematical ideas. Having teachers collectively work in teaching research groups (TRG) is an important part of the prevalent model of improving teaching on a sustained basis (Hu, 2005; Paine, Fang, & Wilson, 2003; Paine & Ma, 1999; Wang & Paine, 2003).

With years of school teaching experience in China and advanced studies on teacher education in the US, I have been intrigued by the policy and research calls for teacher learning in communities in the US context and the fact that how Chinese teachers improve teaching in communities remains unexamined both in China and the US. In this dissertation study I explore two groups of math teachers' engagement in their communities in a Chinese elementary school. My goal is to understand a common form of professional development available to most Chinese teachers that situates teacher learning in communities and provides teachers sustained and ongoing supports to improve instruction in classrooms. It can contribute to the current literature on teacher community, teacher learning and professional development by revealing what a well-established teacher community can afford for teacher learning on a daily basis, how a common form of professional development engages teachers in improvement of instruction, and how the social and institutional contexts affect teacher learning.

[1] In Japan, the prevalent model is lesson study in which a group of teachers collaboratively refine a lesson by focusing on student learning (Fernandez, 2002; Fernandez, Cannon, & Chokshi, 2003; Fernandez &Yoshida, 2004; Lewis & Tsuchida, 1998; Stigler & Hiebert, 1999).

A teaching research group can be a promising site for studying a teacher community of practice and its relation with instructional improvement. Although in China there is no summative evaluation of teaching research groups, in history and current practice they function as an approach to promoting teacher learning (Li, 2004; Chen, 2007). Ma (1999) asserts that the *profound understanding of fundamental mathematics* (PUMF) possessed by Chinese teachers partly comes from working collaboratively in teaching research groups. PUFM is shared knowledge instead of personal knowledge developed by an individual teacher. Hu (2005) points out that teaching research groups operating as a form of job-embedded professional development provide teachers valuable learning opportunities through engaging them in a range of professional activities. In addition, teaching research groups are wide-spread and well-established sub-school organizations that require all teachers to participate on a regular basis. Thus participation in teaching research groups is an integral part of Chinese teachers' ordinary teaching practice. As a community of practice, a teaching research group is not built on an occasional and voluntary basis, which distinguishes it from the teachers communities established at the request of certain research projects or organized as a temporary community to exist for a short period of time. That makes it possible to offer sustained and ongoing supports that are closely tied to curriculum and instruction.

In general, my study on the two particular mathematics teaching research groups can contribute to the literature in two aspects. First, as a case study of two particular math teaching research groups, the study will enrich our knowledge about what teaching

research groups as communities of practice possibly offer for teacher learning and practice. The current literature shows little about what Chinese teachers learn through participation in teaching research groups and how what they learn affects their teaching practice (Cai, Lin, & Fan, 2004). A teaching research group as a teacher community of practice is theoretically and practically unexamined both in the US and China.

Second, this study will expand the literature on understanding how teachers' communities are situated in institutional settings. Borko (2004) identifies the context in which professional development occurs as one of the elements of a professional development system. But most prior research on teacher communities and teacher learning does not pay attention to the social and institutional contexts (Cobb et al, 2003). Cobb et al (2003) consider a school district as a lived organization that is made up of a configuration of interconnected communities of practice. In this study the two mathematics teaching research groups are housed in the Tower Elementary School, which is a relatively good quality school in the district. The two groups are linked with several math TRGs from different schools and the broader district community. The teachers' opportunities to improve and refine instructional practice are systematically organized in the institutional setting. The intersecting communities of school-based teaching research groups, collaborative teams of math teachers from different schools, and the district communities offer us a chance to explore more fully teacher learning in and across different communities.

In China almost every elementary and secondary school has teaching research groups. For the historical origin of the teaching research group, Hu (2005) describes, "It has evolved from the *kafedra* system introduced from the Soviet Union in the 1950s and is supported by traditional Chinese culture, which encourages collectivism, collaboration, closely knit social and working relations, and shared responsibility for common values and goals" (p.680). A teaching research group can be an administrative organization that manages individual teachers' work. Also it is a community where teachers who teach the same subject matter in a school work and live together (Paine & Ma, 1999). In many schools the teachers in the same teaching research group share an office. A teaching research group holds regular meetings and organizes various activities to engage teachers in discussing and improving instructional practice (Chen, 2007; Li, 2004; Liu, 2000). In the current educational reform, some researchers call for doing more than this in order to make teaching research groups become real learning organizations. They suggest engaging teachers in research (Li, 2006; Liu, 2000) or establishing a partnership with university and college (Zeng, 2003). In this study I do not assume that or evaluate if a teaching research group is a "real" teacher learning community. Instead, following Wenger (1998), I adopt a broader notion of a community of practice to understand teaching research groups where teachers collectively engage in instructional improvement.

Stepping back from the theoretical constructs of teacher professional community that I mention above, I define the teaching research group as a community of practice

where the elementary mathematics teachers collaboratively refine teaching practice through participation in various activities around curriculum and instruction. In the communities of practice they use shared tools and resources, discuss and generate knowledge for teaching mathematics and live with the dynamics of collegial relations.

With a situative perspective, this study on the teachers' learning in two mathematics teaching research groups in an elementary school and the related communities in the district can allow us to consider questions of mathematics teacher learning and teacher professional development more generally in ways that are not investigated either in China or the US. In the next chapter I elaborate on the situaitve perspective and related work, and explain how it shapes my research questions and frames my ways of exploring teacher learning in communities.

CHAPTER TWO

THEORETICAL FRAMEWORK AND RESEARCH METHOD

Introduction

In this chapter I first discuss the theoretical framework I employ in the study. A situative perspective on teaching learning is adopted. In the first part I explain the meaning of the sociocultural perspective on situativity and define the key concepts I use in the study. The key concepts include learning as participation and knowledge in a community of practice. In the second part I describe the ethnographic approach used in the study. At the end I point out the limitations of the study.

Theoretical Framework

In the past decade researchers (Barab & Duffy, 1998; Borko, 2004; Greeno & Collins, 1996; Putnam & Borko, 1997; Putnam & Borko, 2000) have developed a situative perspective to explore teacher learning and professional development. In general, a situative perspective suggests rethinking learning, practice, and identities, and reformulating the complicated relations between learning and contexts. This theoretical perspective has roots in various disciplines, including anthropology, psychology and sociology. Correspondingly, the different disciplinary roots provide multiple conceptual lenses and multiple units of analysis for understanding teacher learning and professional

development (Barab & Duffy, 1998; Borko, 2004; Greeno, 2003).

In research that adopts a situative perspective there are two kinds of conceptual lenses: a psychological perspective of situativity vs. a sociocultural perspective of situativity. In this study I use the sociocultural conceptual lens to understand and interpret how the teaching research groups as communities of practice afforded learning opportunities for the teachers, but I keep the psychological perspective on situativity in the background to understand teacher learning. The sociocultural perspective of situativity allows me to focus on the situated activities and social contexts of teacher learning while the psychological perspective reminds me of the importance of individual teacher's learning in the communities.

A situative perspective on teacher learning

Based on their anthropological work, Lave (1996; 1997), Lave and Wenger (1991), and Wenger (1998) develop a sociocultural perspective of situative learning that considers learning as changing participation in socially organized activities and practices in changing communities. Rather than focusing on the situatedness of individual development, the sociocultural conceptual lens emphasizes influences of a community context, the importance of understanding learning as it emerges in activity, and the meaning of being a part of a community. This perspective leads to a shift in the unit of analysis to the social context in which community members engage in joint activities, interact with one another, with materials, resources, and context.

With respect to teacher learning and professional development, a sociocultural perspective captures the critical aspect of learning to teach on the job, that is to say, learning may occur when teachers participate in activities and practices. Their learning is ongoing, social, situated, and drawing on shared resources, artifacts and tools in communities. Teacher learning "is usefully understood as a process of increasing participation in the practice of teaching, and through this participation, a process of becoming knowledgeable in and about teaching" (Adler, 2000, p.37). However, Sfard (1998) suggests that researchers need to incorporate both metaphors of learning—acquisition vs. participation— to understand human being's learning. The acquisition metaphor conceives of learning as the act of gaining knowledge and constructing meaning by individuals. In this study I mainly draw on the metaphor of learning as participation, as the metaphor allows me to explore teacher learning that is fundamentally social and situated. Meanwhile, some data revealed that the teachers did acquire knowledge for teaching through participation in the professional activities.

With a situative perspective of teacher learning, I try to answer the following research questions in this study:

1. What kinds of joint work did the mathematics teachers engage in within the communities?
2. What did the teachers' participation in the teaching research groups offer for the improvement of their instructional practice?
3. How did the collegial relations among the teachers interweave with their efforts to

improving instructional practice?

Next I discuss in detail how I employ this theoretical perspective to explore the teachers' learning in the communities.

Applying the situative perspective to this study

Learning as participation

Lave and Wenger's (1991) concept of learning deals with knowledge and learning in a way that connects cognition and identity in a sociocultural context. On the one hand, learning is a process of becoming a practicing participant among other community members through access to competence and resources; on the other hand, learning is "a function of learner histories and their changing identities" (Adler, 2000) as learning involves social relations and membership formation within a community of practice. Participation describes "the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises" (Wenger, 1998, p.55).

Broadly, practice in this study refers to the social and cultural conception of particular ways of thinking about teaching and learning school mathematics and teaching school mathematics in cultural contexts. To understand the teachers' practice in their teaching research groups and the related broader communities, I view their learning as a process of participation in the practice of refining instruction, and through participation becoming knowledgeable about teaching and learning. By participation, the teachers

engaged in joint activities, talked about and within practice, and formulated social relations.

The concept of learning as participation directs me to focus on three aspects of the teaching research groups as communities of practice. The three aspects are the teachers' joint activities, the collegial relations that partly constitute the social context of their instructional improvement, and using tools in the communities. The three aspects are compatible with Wenger's (1998) three dimensions of communities of practice that are joint enterprise, mutual engagement and shared repertoire. The mathematics teachers in this study are involved in a broad range of professional activities, including collective lesson planning, preparing and conducting public lessons, observing and reflecting upon lessons, studying and creating curriculum materials, discussing instructional pace, and helping students prepare exams. In Chapter Three I explore the teachers' joint activities of collective lesson planning, preparing final exams and observing lessons.

Although Wenger (1998) points out "participation goes beyond direct engagement in specific activities with specific people" (p.57), he does acknowledge that intense engagement with some activity and with one another is especially significant. Among the joint activities, preparing and conducting public lessons[1] is a specific activity for the teachers of this study that demands their intense engagement with the activity and with their colleagues. That is a process stretching over time and involving many teachers and

[1] Preparing a public lesson is to prepare a lesson "taught by a teacher to a class of pupils, with observers in attendance. Typically, an open [public] lesson involves a public debriefing or discussion following the lesson" (Britton, Paine, Pimm, & Raizen, 2003, p.377). The preparation process is from several days long to several months long.

resources. It is also a process of talking about and within practice as the teachers go through cycles of revising and rehearsing, and discussions and reflections. Thus in Chapter 4 I choose to focus on this specific activity in order to understand how it functions as a mechanism through which the teachers learned to improve instruction.

The sociocultural perspective of situative learning considers participants' roles, identities, and mutual relations as integral part of their learning trajectory (Lave & Wenger, 1991; Rogoff, 1995; Wenger, 1998). Regarding the collegial relations among teachers, Little (1990) distinguishes four types of collegiality from extreme independence to joint work. Joint work indicates interdependence among teachers, collective actions and shared responsibility for teaching. Lord (1994) proposes critical collegiality in teachers' communities that promotes collaborative reflection upon teaching practice and enhances teacher learning. According to Hargreaves's (1990; 1992) definition of collegiality, the collegiality within teaching research groups is "contrived collegiality" [2] instead of collaborative collegiality. But Wang and Paine (2003) argue that the contrived collaborative collegiality within teaching research groups helps teachers learn and create a professional culture. In this study I attend to the collegial relations among the teachers. What are the relationships that characterize the teachers' membership in the teaching research groups? How do the relations contribute to their learning? In Chapter Five I particularly focus on the fourth grade TRG teachers' collegial relations and illustrate the

[2] Hargreaves (1990; 1992) coined the term "contrived collegiality" that is characterized by a set of formal, specific bureaucratic procedures to increase the attention being given to joint teacher planning and consultation. He argues that contrived collegiality does not guarantee a teaching community which works effectively, openly and supportively.

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influences of a teacher's broker role on the group's learning. I discuss the concept of boundary broker below.

The third aspect the concept of learning as participation brings to my attention is using tools in the communities of practice. One of the key ideas of a situative perspective is that cognition and learning are not solely a property of the minds of individuals (Putnam & Borko, 1997). Cognition and learning are stretched over and mediated between individuals and the sociocultural contexts with cultural tools and artifacts (Gauvain, 2001; Wertsch, 1991). This point highlights the important role that tools play in teachers' participation in communities of practice. Ball and Cohen (1999) argue for incorporating tools and artifacts into teachers' meaningful professional education. When mapping out a landscape of this kind of professional education that was in and around practice across time and over topics, they propose that one of the key components was using suitable tools to investigate practice in communities. In order to ground teachers' professional learning in tasks, questions and problems of practice, they suggest that concrete records and artifacts of teaching and learning should be collected and drawn on for professional inquiry. When trying to answer the question how Chinese elementary mathematics teachers obtained profound understanding of fundamental mathematics, Ma (1999) claimed that one of the plausible reasons was that they intensively studied teaching materials as tools individually and with their colleagues in teaching research groups. This leads to a sub research question: how are tools used as part of the communities of practice? In this study, I pay attention to both material tools and symbolic

tools (Gauvain, 2001) used in the teachers' communities. Symbolic tools mainly refer to language and concepts that mediate teachers' action in communities. Materials tools refer to kinds of artifacts like textbooks, teaching guidance books[3], curriculum standards, other curriculum materials, student tests, and forms of technology. In Chapter Four I explore the use of tools in the joint work of preparing the public lessons.

Knowledge, a regime of competence, and a community of practice

Much research has been done about teacher knowledge, knowledge for teaching, or the relations of knowledge and teaching practice (Cochran-Smith & Lytle, 1999). According to different epistemologies, Cochran-Smith and Lytle (1999) reveal three kinds of conceptions about the knowledge teachers need to teach well, including knowledge for practice, knowledge in practice and knowledge of practice. Knowledge for practice stresses the hegemony of formal knowledge generated by researchers while knowledge in practice assumes a notion of practical knowledge that teachers invent and acquire in action through deliberation and reflection. Knowledge of practice adopts inquiry as stance toward knowledge and its relationship to practice, which emphasizes that teachers work together within inquiry communities to generate local knowledge, theorize their practice and interrogate the theory and research of others.

A comprehensive literature review (Wilson & Berne, 1999) on contemporary

[3] In China each textbook for different grade and semester is accompanied by a teaching guidance book for teachers. Sometimes it is called guides for teachers' instruction.

professional development finds that teachers acquire professional knowledge through interacting with other teachers in communities; however, the researchers contend that the location of the knowledge is unclear. As communities develop a shared knowledge that transcends and shapes individual participants' knowledge, it is hard to capture group knowledge versus an individual's knowledge.

Different from most of teacher communities discussed in the US literature, teaching research groups are deeply-rooted in the teaching culture, well-established communities of practice with a long history, which makes teaching research groups "a regime of competence" (Wenger, 1998). A community establishes what it is to be a competent participant. In others words, it sets up goals for individuals' knowledge and learning. In this regard, Wenger considers that a community of practice acts as a regime of competence. He argues that interactions between an individual's experience and the regime of competence lead to acquisition or creation of knowledge in a community of practice. Although he avoids using the word "knowledge", Wenger states that knowledge is a matter of competence for an enterprise. In this study I consider the teaching research groups and the related communities a regime of competence, which means that the teachers are acculturated into the communities and expected to acquire knowledge for becoming competent participants in the teaching practice and possibly generate knowledge through collectively refining the competence embedded in the communities.

The assertion that teaching research groups and the related teacher communities act as a regime of competence has the following implications for this study. First,

knowledge of practice moves around in communities through teachers' social interactions. By observing, discussing, reflecting, and trying out, teachers gain the competences expected by teachers' communities. The competences are collective and shared knowledge that is created and accumulated and developed over time. Second, in a regime of competence learning is an important function of collaboration. Teachers collaboratively refining practice in communities results in their learning. When teachers collaborate with each other, they learn how to be a competent member, thereby increasing their knowledge and augmenting the overall knowledge of communities.

Regarding knowledge for mathematics teaching, some researchers (Ball & Bass, 2000, 2003; Ball, Hill, & Bass, 2005) propose the concept of mathematical knowledge for teaching that is "a kind of professional knowledge of mathematics different from that demanded by other mathematically intensive occupations" (Ball, Hill, & Bass, 2005, p.17). They define two elements of mathematical knowledge for teaching: common mathematical knowledge and specialized mathematical knowledge that only teachers need to know. The specialized mathematical knowledge for teaching interweaves math content and pedagogy. Compared to the concept of pedagogical content knowledge, mathematical knowledge for teaching attends to "the dynamic interplay of content with pedagogy in teachers' real-time problem solving" (Ball & Bass, 2000, p.88). In this study, I identify two kinds of knowledge discussed in the teaching research groups, including mathematical knowledge for teaching and knowledge of instruction. Knowledge of instruction, I define, refers to knowledge of general pedagogy about managing student

learning in math class, such as engaging students in discussion, motivating students to learn, and wording questions raised to students, etc.

To answer the research questions, I choose the teaching research group as the unit of analysis. Figure 2.1 shows the social and institutional context in which the teaching research group was situated. Within the teaching research groups the teachers interacted with each other around content and students. The content was reified in the tools the teachers used and students occurred in their interactions. When the teachers went about the activities, they kept the interactions between students and content and between students and teachers in mind. As the teaching research groups are situated in the institutional setting of school and district, I also pay attention to how the teaching research groups are connected with communities outside the school.

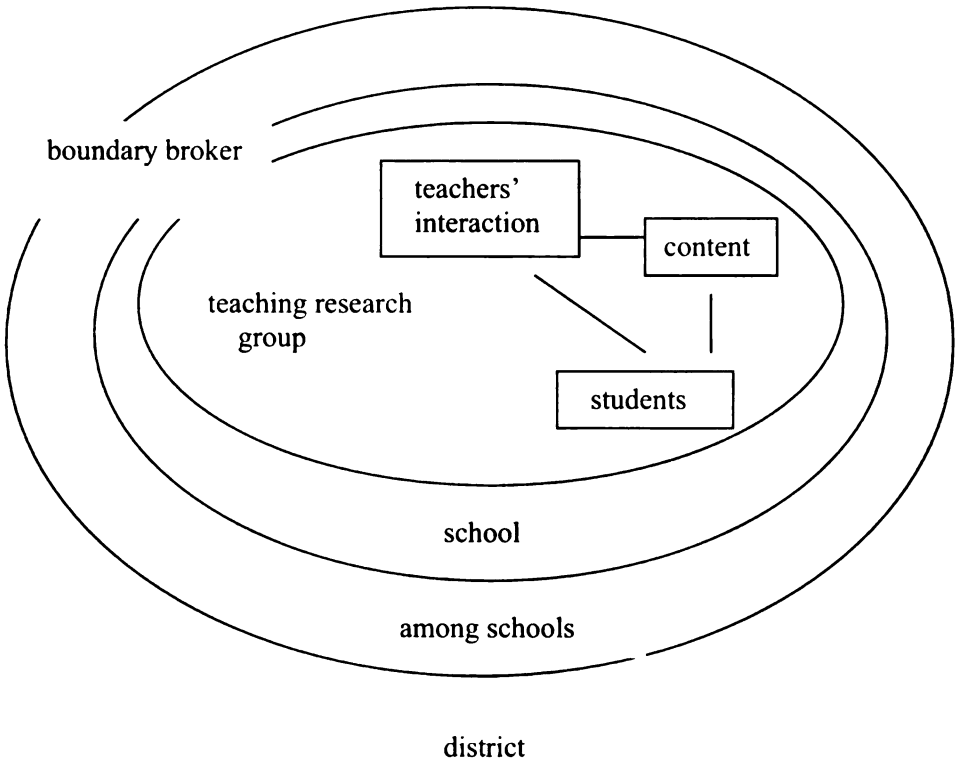

Figure 2.1 The teaching research group connected with multiple communities

Research methods

Multi-sited ethnography

This study adopted an ethnographic approach to explore the teacher's growth and life in their communities of practice and seek answers to the proposed research questions. As Erickson (1986) points out, the central research interest of interpretive or qualitative approaches is in human meaning in social life and in its elucidation and exposition by the researcher. Given my research interest in a group of teachers' participation in multiple

communities, the lens of this study fixes its focus on a plethora of "cases" happening across physical settings and different activities (Dyson & Genishi, 2005). In contrast to the single-site location in conventional ethnography, Marcus (1995) proposes "multi-sited ethnography" that is "designed around chains, paths, threads, conjunctions, or juxtapositions of locations in which the ethnographer establishes some form of literal, physical presence, with an explicit, posited logic of association or connection among sites that in fact defines the argument of the ethnography " (p.105). As I mention above, I identify the teaching research groups as the unit of analysis in the study. For exploring the group practice in a broader context, an approach of multi-sited ethnography is needed to picture what happens when the teachers participate in the multiple communities of practice, how the teachers interpret and understand what happens. By following and staying with "the movements of a particular group of initial subjects" (Marcus, 1995, p.106) that is my focal teachers in this study, I explore the teachers' practice in different locations and illustrate the connections among their participation in various communities.

Setting

General backgrounds about teaching and teachers in China

Most of Chinese elementary teachers in urban areas stay at school about 8 to 9 hours each workday. In many schools a teacher teaches only one subject matter, such as mathematics, Chinese or English. In some schools, especially in the lower grades, a teacher teaches

mathematics and Chinese to one group of students. Meanwhile, for social studies, science, fine arts, or music, there are teachers who are specialized in these areas.

Usually, my participant math teachers taught two class sessions, respectively, to two different groups of students each workday. One class session was about 45 minutes long. The two class sessions were often scheduled in the morning. After finishing the teaching tasks, they came back to the offices and spent a significant amount of time on marking student homework, guiding a class at noon or in the afternoon to correct mistakes in the homework, tutoring individual students in the offices during class break or lunch break, planning lessons, taking part in professional activities or taking up some other responsibilities such as monitoring student lunch, supervising dismissing a class, and talking or meeting with some students' parents about their students' academic performance and behavior in class.

Every Thursday afternoon the first grade math teachers taught a class session called "lesson for training how to think" (*siwei xunlian ke*) that aimed to engage students in solving math problems related to life in a creative way. Two of the fourth grade math teachers taught two science class sessions each week, respectively, in addition to five math class sessions. Another fourth grade math teacher taught one fourth grade class and one fifth grade class. Compared with the teaching loads of their American counterparts, these Chinese elementary teachers seemingly taught less classes each workday; however, as some researchers (Fang, 2005; Ma, 1999) observed, Chinese mathematics teachers spend a considerable amount of time each day grading homework, tutoring students to

correct mistakes in homework and planning lessons.

Given the large size of the country, there are great variations between urban and rural elementary schools in terms of teacher quality, teaching resources and teaching. What I discuss here refers to the general situations of urban schools. In many rural schools the size of school and class could be relatively small. Teachers could teach several subject matters at the same time and have few opportunities to take part in professional development activities.

Research sites

Deciding to study a teaching research group, I chose to focus on school-based teaching research groups. Thus I needed to locate a likely school. I set up two criteria for identifying the school. One was that the mathematics teaching research group in the school had a reputation for its collective work. That did not mean it must be an exemplary school and exemplary group. The second criterion was that the mathematics teaching research group had a mix of young teachers and experienced teachers. I had the second criterion because a teaching research group made up of all young teachers or experienced teachers might be too rare to be representative of teaching research groups in China. With the two criteria I chose the Tower Elementary School as the research site. The school was a relatively large and high quality elementary school in the West district. It included grades one to six. The total number of the students was about 1,200. Since 2001 the

school has been involved in the national curriculum reform as a pilot study site[4]. At the time of my study, the teachers from grade one to grade five were using the new textbooks and mathematics standards. Altogether there were 18 mathematics teachers at Tower Elementary School. The math teachers who taught the same grade formed grade-level teaching research groups, such as the first grade math teaching research group (TRG). The district was large, with a reputation of relatively high educational quality. Twice a semester the district provided professional development activities. The district teaching research specialists for different grades coordinated and organized those activities. In addition, to have teachers interact with more colleagues outside their own schools regularly, the district divided 90 elementary schools into several sub-regional groups. In each group the math teachers teaching the same grade met once a month in the associated lesson planning team. The Tower School and six other schools were part of the Bell associated lesson planning team.

Participants

At the suggestion of the principal of Tower, I chose the first and fourth grade mathematics teachers as my focal groups. Altogether I had seven informants, four in the first grade math TRG and three in the fourth grade TRG. The first grade teachers included Ms. Wu, who was the group head, Ms. Pu, Ms. Zhang and Ms. Li. The fourth grade

[4] The national curriculum reform started in 1999, aiming at changing the exam-oriented educational system and the corresponding ways of teaching and learning. During the reform new standards for student learning and textbooks were created. Before standards and textbooks were used widely in the country, some schools were selected as pilot sites to try out the new textbooks. Based on pilot studies the textbooks were revised.

teachers were Ms. Hu, Ms. Su and Ms. Lu. In the following I briefly describe each teacher.

At the time of my data collection Ms. Hu was in her thirties, having almost 20 years of teaching experience after graduating from normal school[5]. The tradition has been that students attended normal schools after graduating from junior high schools. Normal schools educated teachers for preschools and elementary schools. Ms. Hu was one of the head math teachers in the district and a part-time district teaching research specialist. Having worked in the Tower School for more than ten years, she mentored almost all the young math teachers of the school. In the 1990s she finished an Associate's degree in elementary education. Taking many responsibilities inside and outside the school, Ms. Hu looked older than her age. In the fourth grade TRG, Ms. Lu was the youngest teacher. She had just transferred from another district to the Tower School in the fall of 2005. Ms. Lu graduated from a teacher college with an Associate's degree in elementary math and science education. She had worked as an elementary teacher for four years. She was always very vocal in the office and did not look like a "newcomer" to the school. Ms. Su was a young teacher in her late twenties, but had already worked for six years.

[5] Before 2000 the educational attainment of Chinese elementary teachers was low. The majority of elementary school teachers were graduates of normal schools. In the educational reform that started in 1999 the central government tried to increase the educational attainment of elementary teachers. Most normal schools have been reorganized into teacher colleges or upgraded to become teacher colleges. Teachers with a normal school diploma are encouraged to pursue a college degree. However, on the whole Chinese elementary school teachers receive less education than the US teachers. For example, by 2003 only 40% of Chinese elementary school teachers have an Associate's degree or higher degree (Ministry of Education, 2003). In the city where the Tower School is located, mathematics and literacy in most elementary schools are taught by different teachers. But teachers in many elementary schools around the country teach both to a group of students.

Graduating from a teacher college with an Associate's degree in mathematics education, she was employed by Tower as a math teacher.

The fourth grade students were divided into five groups. Ms. Hu and Lu respectively taught two groups while Su taught one group, as she also taught a group at the fifth grade. Each group of students had five mathematics sessions each week. These three fourth grade math teachers shared an office with the fourth grade Chinese literacy teachers. In the office their tables were put together in the left corner of the room. Their weekly group meetings were held around the three tables each week.

There were four math teachers in the first grade math TRG. Although Ms. Wu, as the group head, she was not older than the other three colleagues. Ms. Pu and Ms. Li were the same age as her, but they had more years of teaching experience. Both Ms. Pu and Li had graduated from normal school and worked at Tower for ten years. Ms. Wu graduated from a selective teacher college of the city seven years before I started the data collection. Like Ms. Su, she majored in mathematics education in an Associate's degree program that was housed in the mathematics department of the college. She was considered a promising young teacher in the district, so she was selected to attend the district teaching research group. Ms. Zhang was the oldest in the group, as she was in her late thirties, having about 16 years of teaching experience. She had graduated from normal school too. She was new to the group while Ms. Wu, Pu and Li had worked together in the same group for two years. Before joining the first grade TRG Ms. Zhang taught upper grades mathematics for ten years, which made her unfamiliar with the new

textbooks for the first grade. In contrast to her colleagues, Ms. Li taught only one group of students. She was interested in fine arts, and was pursuing a Bachelor's degree in fine arts education at a normal university. While teaching math, she also taught the first graders fine arts. Her talent in fine arts was used to help her colleagues make manipulatives and other teaching materials.

In the study I also interviewed the principal and the head of the school math TRG. Ms. Fu, the principal, was in her fifties and had a reputation in the district for being open-minded. Her openness and support of my work lessened my unease and the discomfort caused by being in an unfamiliar environment. Ms. Jin, the head of the school math TRG, was also one of the head math teachers[6] in the district. She was considered smart and creative by the school math teachers. As part of her work responsibilities, she often observed the math teachers' lessons and helped the teachers prepare public lessons.

Researcher role

The relationship between researcher and researched can be complicated as they hold different social position, cultural perspectives, and political stances (Eisenhart, 1996). In this study, I tried to establish my role as a non-intrusive participant observer by familiarizing myself with the teachers, school staff and administrators of that school; recognizing influences of my presence and research on the teachers; and helping out with

[6] Some excellent math teachers were selected by the district as the head math teachers who played a leadership role in the district to support math teachers and improve math instruction.

some logistic tasks in the teaching research groups.

Being a Chinese and a teacher, I shared many similarities with the participants, and know the national culture and local contexts well, but I was well aware of the fact that I was a "halfies" (Abu-Lughod, 1991) who had been living and studying in another culture and country for years, holding perspectives and stances that might differ from those of the participants. My participant teachers knew about American education only through media and assumed that the educational system of the US worked better than their system. After I became acquainted with them, they liked to complain about the harsh competition Chinese students had to go through for getting into good schools and universities. They admired that American students and teachers did not need to work as hard as they did. One day a teacher brought her daughter who was a fifth grader to the office and introduced her who I was and what I did. She told her daughter that she needed to study hard and go to the US as I—"Dr. Han" did. At that moment I felt embarrassed and uneasy. My spontaneous reaction was to smile at the little girl and say nothing. I did not view studying abroad as a life goal for children or a motivation for children to study hard. Many different factors have shaped my life and choices I made. I believe that education is for pursuing happiness in life. I really did not want to tell the little girl studying in the US was a way for me or could be a way for her to gain a happy life. Meanwhile, no educational system is perfect. The educational system of the US is no exception. However, my participant teachers had heard a lot of stories that pictured a perfect and ideal school education of the US. I knew that it was hard to change their impressions of

the US education only through my description and explanation though I always tried to be objective when asked to compare the two educational systems.

In the field keeping these in mind, I insisted on not making any comment on the Chinese teachers' practice and the US teachers' instruction. One time the principal invited me to comment on a first grade math teacher's lesson in their collective debriefing meeting. I implicitly refused her invitation by saying that I basically agreed with what the teachers discussed about the lesson. On many occasions my participant teachers expressed that they wanted to know what I thought about their lessons. Each time I had to restate my role in the field and promised I would be glad to do that in the future if I got a chance to come back and work with them. Being a non-intrusive observer helped me gain the teachers' trust and get acquainted with them soon. However, I worried that my participant teachers might feel disappointed as they had the expectation that I might "help" them. They had no experience of working with a researcher who came to the school everyday and shadowed them in classrooms, offices, cafeteria, and other schools. So it was not surprising that they expected me to provide suggestions about and comments on their lessons.

While the staff at the Tower school seemed to see me as very different from them, at the same time, my former teacher experiences and other similarities shared with my participants shape my views and assumptions of what and how teachers learn in communities of practice. What I saw and how I interpreted what I observed was filtered through those experiences and assumptions. These also posed challenges for me. In a

sense familiarity, similarities and assumptions I made might blind or color my visions of observation and interpretation, such as not challenging something taken for granted by most Chinese teachers. This combined with writing up the study in a second language, made it difficult to show a whole real world of my participant teachers for my English readers.

Data collection procedures

The ethnographic fieldwork was conducted for about three months from late February to June in 2006. I was out of the field[7] during April. The data was collected from three sources. Table A in the Appendix summarizes the data collected in the fieldwork. Because I wanted to observe a community in action and see what happens naturally in it, observation was a key data collection strategy. One major data source for this study therefore was observation and fieldnotes in various sites of the school and district. I usually spent six to seven hours a day in the school and went to the school almost five days a week. As the participant teachers were in two different groups, I stayed with the first grade teachers on Tuesdays and Thursdays and with the fourth grade teachers on Mondays and Wednesdays. On Fridays the research needs arising from the field decided which group I stayed with. Fieldnotes were taken during my stay in the teachers' offices, observations of weekly group meetings, monthly meetings of the first and fourth grade Bell associated lesson planning teams, the district professional development meetings the

[7] In April I had to come back and fulfill my teaching responsibility at MSU.

participant teachers attended, some classes taught by the participant teachers, and the teachers' conversations and interactions outside the offices in the school. I audiotaped all weekly group meetings of the two groups that I observed and videotaped four group meetings of the first grade TRG and one group meeting of the fourth grade TRG. A weekly group meeting usually lasted from 20 minutes to two hours. In the three months of fieldwork I observed three public lessons conducted respectively by Ms. Wu, Ms. Pu and Ms. Lu. The joint work of preparing the public lessons was either audiotaped or videotaped. The videotaped or audiotaped data supplemented my fieldnotes in that it documented the teachers' specific interactions and helped me capture what I might miss in the fieldnotes.

The second source for this study was audiotaped interviews of the participants. I formally interviewed all participant teachers at the beginning and end of the semester. The structured interview conducted at the beginning of the semester was to gain information about their personal and professional backgrounds, their beliefs in teaching and learning mathematics, and their thoughts about learning opportunities in the school and district. The other structured formal one, done at the end of the semester, was to search for what the teachers thought and felt about their participation in the communities during that semester. In addition, I conducted many ongoing informal interviews. I chose to do these especially in relation to key activities, like before or after some group meetings, after giving a public lesson, or after observing the teaching competition in the district. All the questions in the formal interviews were open-ended, inviting my

interviewees to describe their experiences, explain their perspectives, and comment on certain activities they attended as a member of the communities. The questions in the informal interviews were not structured. I aimed to gain insight into their intentions and actions in the communities, their thoughts about some particular events or some special occasions that occurred during my observations.

The last data source was varieties of artifacts, including curriculum materials, lesson plans, written feedback on lesson plans, schedules of the Bell teams' monthly meetings, some articles the teachers studied in the group meetings, the teachers' observation notes in the district teaching competition, and some student tests. Curriculum materials included national curriculum standards, two versions of textbooks, teacher manuals, student booklets, and other relevant materials used by the teachers. While the majority of the district's schools used the textbook edited by a national publisher (PEP version textbook), as part of a reform experiment, the Tower School was selected by the district to use the textbook published by a local press.

It took time to gain the teachers' trust and get access to the data I wanted to collect such as observing their lessons, their lesson plans and requesting interview. I was introduced to the school by an administrator in the district. I entered the Tower School by first meeting the principal. At the beginning I could feel that the teachers were reserved when I tried to acquaint myself with them. They were curious about what I was going to do in their groups while they had concerns that I might be sent by the principal to evaluate their work. In order to let them trust me and know my position in the field, I kept

explaining to them why I was there, what I was doing, and how I would use what I collected from the field. Also in order to let the teachers know I was not an evaluator I did not actively reach out to acquaint myself with the school administrators. Whenever they asked me to comment on their lessons, lesson plans or US teachers' teaching, I told them I would like to be just an observer for the study. Gradually they saw me only as a doctoral student who did not possess power over them. They opened their classrooms to me and allowed me to make copies of the documents I wanted.

Data analysis procedures

As an ethnographic study, the data analysis process was an evolving process, including the following steps: arranging the data on the basis of the first grade and fourth grade TRG groups; reading through the data for each group to look for the key activities that stood out to be significant for the teachers and patterns of the teachers' activities and interactions; next developing coding categories for the key activities and identifying the different interaction patterns in each group; finally, deciding for each group on a different focus of the analysis that answered the research questions around teacher learning, participation and community. Although from this description the evolving process seems to be clean-cut and straightforward, the reality was that process started from the mess created by piles of data and then became clearer after detours.

Faced with stacks of data, at first I felt it hard to decide where to start. But when I was in the field I was informed by my participant teachers that conducting public lessons

was the key approach for them to improve instruction. I also witnessed that the teachers invested over a month of their time and energy into the joint work of preparing the pubic lessons. Thus I decided to start from the case of Ms. Wu's public lesson. Pulling out all the data related to her public lesson, I was able to divide the process of her preparation into four phases and developed preliminary coding categories of what Wu and her colleagues discussed throughout the four phases. Then I tried to link what they discussed with the changes Wu made in her lesson plan and the actual lessons for identifying how the collective reflection influenced her practice. Based on the analysis of Ms. Wu's case, I began to examine the case of Ms. Pu and Ms. Lu's public lessons. In Chapter Four I focus on the public lessons of Ms. Wu and Pu. I chose those two for the following reasons. First, Ms. Lu's public lesson was about knowing statistics charts in the fourth grade while Pu's public lesson was in the same unit with Wu's public lesson. Second, as the unit of analysis in this study is on the teaching research groups, focusing on the public lessons of two teachers from the same TRG allows me to examine how the first grade math teachers intensely engaged in the joint work and understand how this kind of joint work functioned as an approach to promoting the first grade teachers' learning. Third, Ms. Lu did not prepare her public lesson with her TRG colleagues. Instead, she worked with a teacher in another elementary school where she rehearsed and conducted the lesson. As it was not joint work collectively done by the fourth grade teachers, I consider it less helpful for understanding the school teaching research group as a community of practice. It appears to be meaningful for Ms. Lu's own learning and improvement and I will

explore her learning trajectory in later research.

In order to answer the research question, what the teachers' participation in the teaching research groups offered for the improvement of their instructional practice, I first developed analytic coding categories to illustrate the mechanism through which public lessons contributed to teacher learning and instructional improvement. The preliminary coding categories from the case of Ms. Wu were modified and refined to illustrate the mechanism. I used the categories of teacher knowledge to identify what kinds of knowledge were generated and discussed in their joint work. I categorized the knowledge into two types—mathematical knowledge for teaching and knowledge of instruction. I drew the data from both public lessons to illuminate how the teachers generated and shared the two kinds of knowledge. Second, using the concepts of material and symbolic tools, I analyzed how the teachers worked with the symbolic tools, such as terms and reform ideas on math instruction, and how they used the material tools, such as the written comments, to go about the joint work. Last, I identified being aware of the weaknesses in their teaching competence as one of the ways through which the joint work of preparing the public lessons contributed to possible teacher learning and improvement of instruction.

After carefully reading through the fieldnotes and transcribed data, I found out that the collegial relations among the fourth grade teachers were worth noting. The group head Ms. Hu acted like a mentor for Ms. Lu and Su on most occasions while their relations were also collaborative. Meanwhile, Ms. Hu played multiple roles in the

communities, which made it possible for her to travel across the different groups as a boundary broker. I clarified my research question by asking how the collegial relations among the teachers intersected with their efforts to improve instruction. I took the collegial relations of the fourth grade teachers as a pathway through which I examined their participation in the TRG and the groups outside the school. Drawing on the concept of boundary broker, I categorized what kinds of roles Ms. Hu played in the teaching research group, the Bell team and the district community to interpret her role.

In addition, in Chapter Three I did activity coding of what the teachers did or were offered in their TRG, Bell teams and the district. After categorizing the activities, I identified the representational episodes to illustrate what the category meant and how the teaches went about that activity. To show the changes in the teachers' practice that occurred in the process of preparing public lessons, in Chapter Four I used the method of discourse analysis to identify how Ms. Wu improved her ways of communicating and responding to the students. I employed the concept of "talk move" (Chapin, O'Connor, & Anderson, 2003) to categorize Wu's utterances in two lesson episodes into four types and then compared her utterances of the two lessons under each type.

Limitations of the study

Although I conducted intense fieldwork for three months, the short duration still led to some limitations of the study. First, the study includes little about the district teaching research group activities that Ms. Wu and Hu did. Ms. Wu claimed that she always shared

and discussed with her group colleagues what she learned from her district TRG weekly meetings, but I could not discern the influences in the interactions with her colleagues. I tried to get access to their weekly district TRG meetings, however, the district specialists were concerned about who I was and whether I would evaluate their work. Related to the district teaching research group activities, the study does not include the perspectives of the district specialists who were the organizers and providers of these activities. Knowing their perspectives would have strengthened the analysis of teacher learning in the multiple communities. They can bridge policy and practice by advancing teacher knowledge and skills, or they might suppress innovative ideas and practice produced by teachers.

Summary

The sociocultural perspective of situativity allows me to understand and examine the teachers' learning by focusing on the social and institutional contexts. With this perspective I employ several concepts to understand the teachers' joint work. I choose to interpret their learning as participation and examine the collegial relations and interactions in and across the communities. In this chapter I also describe the ethnographic approach for data collection, and explain how I analyzed the data. In the following chapters I draw on these concepts to answer the research questions. In Chapter 3 I outline the landscape of what the teacher did in the communities. In Chapter 4 I

illustrate how the joint work of preparing public lessons contributed to the teachers' learning and their improvement of instruction. In Chapter 5 I analyze how the collegial relations and interactions among the teachers brought up learning opportunities for the group and promoted their learning. In the last chapter I touch on the issue of different participation norms and point out the implications the study offers for teacher learning in a community of practice.

CHAPTER THREE

MAPPING WHAT THE TEACHERS DID IN THE COMMUNITIES

Introduction

In this chapter I describe and analyze what kinds of activities the teachers engaged in their professional communities including the teaching research groups, the Bell associated lesson planning teams and the district communities. Focusing in the first section on the weekly group meetings, I show that the teachers collectively worked with each other around curriculum and instruction by analyzing three key activities—planning lessons together, discussing practice problems in the textbooks and preparing the final review. In the second section I describe what the Bell teams and district offered to the teachers. I identify lesson observation as one of the key events the teachers engaged in when participating in the Bell and district group activities. By illustrating what lesson observation contributed to the teachers' learning, I argue that the activities organized by these groups provided the teachers meaningful learning opportunities.

What the teachers did in the teaching research groups

While sharing the same office space and teaching the same grade level, my participant teachers interacted with each other on a daily basis. When describing the organization of Chinese teachers' work, Paine and Ma (1993) noted that for improvement of instructional practice the range of the activities teachers participated in teaching research groups was

varied. Here I focus on the weekly group meetings that provided the focal teachers a fixed slot of time to collaborate with each other.

Who, when and where of the group meetings

All the teachers in the Tower School attended their teaching research group meetings almost every week. Each group chose a period of time when all the group members were free from teaching. Every Tuesday afternoon the first graders had no school. After lunch they were walked out by the teachers to meet their parents, grandparents or someone else who was waiting outside the school gate. After this, the hallway of the third floor where the first graders stayed soon quieted down. If it was Ms. Wu or her colleagues' turn to monitor student lunch, they often took a rest for a while after all the students were picked up. Around 1:30pm they started their weekly group meetings in an empty classroom, as the Chinese literacy teachers stayed in the office which they all shared to have their group meetings.

The fourth grade math teachers, Ms. Hu and her group colleagues, were not as lucky to have a whole afternoon in which the students had no school. The office shared by the fourth grade math and Chinese literacy teachers was at the same floor with the fourth grade classrooms. Ms. Hu and her colleagues also took on the duty of monitoring student lunch. Different from the first grade math teachers, they often used the time of monitoring student lunch to grade homework or tutoring individual students to correct mistakes in homework. If they were not on duty at noon, they sometimes spent time

marking homework in the office. They chose to have the weekly group meetings on Monday afternoons when they were all available. The other days involved a great deal of other group activities. For example, Ms. Su needed to attend the fifth grade TRG meetings every Tuesday afternoon. Ms. Hu went outside the school to take part in the district teaching research group activity every Thursday afternoon. Wednesday afternoon was scheduled for the Bell team activities or the district activities. As no classroom or conference room was available, they stayed in the office to have the meetings. Usually the fourth grade Chinese literacy teachers were in the classrooms when Ms. Hu and her colleagues met together in the office.

During the period of time I stayed in the Tower School, I observed nine weekly group meetings of the first grade TRG and seven meetings of the fourth grade TRG. For each of the observed meetings all participant teachers were present. The fourth grade math teachers' meetings usually lasted from 30 minutes to about one hour. The meetings of the first grade math teachers were relatively long, lasting from 45 minutes to two hours. The head of the school mathematics teaching research group, Ms. Jin, took part in their meetings twice. Also, the second grade math teachers joined the first grade teachers once to reflect upon Ms. Pu's public lesson.

What the teachers did in the school teaching research groups

Looking through all the meetings, I identified the following activities the teachers engaged in: planning lessons, determining the pace of instruction, discussing how to deal

with the practice problems in the textbooks, helping colleagues prepare public lessons and presentations, preparing the final review for the final exams, talking about parent-teacher conferences, and studying journal articles. In Table 3.1 I summarize the times of each activity the teachers had in all the observed meetings.

Table 3.1 Times of the activities in the two teaching research groups

	Plan lessons	Determine pace of instruction	Discuss practice problems	Prepare and/or comment on public lessons and presentations	Prepare the final review	Prepare parent-teacher conferences	Study articles
1st grade (total 9 meetings)	6	5	3	3	2	1	3
4th grade (total 7 meetings)	3	5	none	1	2	1	3

Because teaching research groups are sub-organizations of Chinese schools, school administrators have a say in what teachers should do in those groups. Facing the reform calls of school-based teacher education (Shi, 2002), schools were encouraged to take teaching research groups as a site of engaging teachers in instructional improvement. The Tower School responded to this reform by regulating the form and content of the group activities. First, each teaching research group needed to decide on a topic for study every semester. Around the topic the teachers were required to study relevant journal articles and try out the ideas in their classrooms. The topic the first grade math teachers studied

was having students learn mathematics through experience. The fourth grade teachers chose to study mathematical activities students could do in classrooms. Second, a new form of the group meetings was established that had teachers take turns to chair the meetings, rather than had the TRG head run every meeting. The teacher who chaired the meetings any week would lay out the pace of next week's instruction, talk through a plan of a key lesson, point out key and difficult points[1] of the content, and find articles for study.

Usually the teachers spent several minutes deciding on the pace of instruction for the next week in the group meetings. Even though the teaching guidance books usually made suggestions about instructional pace, such as how many class sessions a unit should take, and what part of content should be taught. For example, the teaching guidance book for the first grade suggested that addition and subtraction of two-digit numbers and multiples of ten take four class sessions. In the group meeting Ms. Li followed the suggestion to spell out the pace for the following week: addition of two-digit numbers and multiples of ten for one class session on Monday, subtraction of two-digit numbers and multiples of ten for one class session on Tuesday, dealing with the practice for two class sessions on Wednesday and Thursday. Generally, the teachers kept the same instructional pace and followed the suggestions made by the teaching guidance books. But they also adjusted the pace according to their own students' situations. For instance,

[1] Key or important point and difficult point are terms widely used in teachers' professional communications and teacher manuals. Key points refer to "ideas in the curriculum which are seen as most basic and/or crucial for the knowledge structure of that field". Difficult points refer to "ideas or points in the curriculum that tend to prove difficult for pupils to grasp or master" (Britton et al, 2003, p.378).

the teaching guidance book for the fourth grade recommended teaching the content of statistics in five class sessions, but Ms. Hu and her group colleagues thought that five class sessions were too much since the content was not hard for students. They decided to spend only two class sessions on that content. Having the same instructional pace made sure that the teachers were on the same page in terms of instruction, so it was possible for them to engage in collective sharing, discussion, and some joint work.

The teaching research groups were often held accountable for student performance on tests. Thus it was not surprising that the teachers collectively prepared the final review for final exams. Table 3.1 shows that the first grade teachers also discussed how they would handle practice problems in the textbook, but the fourth grade teachers did not. Both groups of teachers discussed what they would do and say at the parent-teacher conferences, and studied some journal articles together. The activities of preparing public lessons and lesson presentations involved but went beyond the teaching research groups and included other teacher groups. As these more expansive group activities created significant opportunities for the teachers to improve instruction, I discuss them in some depth in the following chapters. In what follows I focus on the three school-based activities that are tightly tied to curriculum and instruction—planning lessons, discussing practice problems and preparing the final review. I do not describe and analyze the other school TRG activities in detail here, as the two groups did not invest much time discussing the pace of instruction and studying articles, and discussions about preparing the parent-teacher conference were not closely focused on instruction.

Planning lessons together[2]

Some researchers (Hargreaves, 1994; Little, 1990) argue that collective curriculum and lesson planning can be the most important and powerful professional development activity. In the Tower School, during the group meetings a significant amount of time was devoted to lesson planning. However, the two groups engaged in collective lesson planning very differently. Collective lesson planning was done in different ways for different purposes. When the teachers planned lessons together, the two groups of teachers focused on different things although they did share some commonalities. Below I sketch the general approach of each group and then use an example to show how the two groups of teachers planned lessons collectively.

The general structure of the first grade teachers planning lessons followed the system set up by the school administrators. Each time when they planned lessons in weekly meetings, the week's chair talked through her lesson plan while her colleagues jumped in whenever they had questions, wanted to make suggestions or make comments. Out of nine observed meetings the four teachers collectively planned six lessons, but with different purposes. When Ms. Pu took up the task of conducting a public lesson for the monthly activity of the Bell associated lesson planning team, their lesson planning was to help Ms. Pu revise and refine her lesson plan in great detail. In the middle of May the

[2] Planning lessons collectively does not mean that those teachers used the exact same plans in their instruction. This joint work was to give them prompts and thoughts to plan their individual lessons. They tended to make adjustment and modification based on their instruction. Even when they spent a great deal of time collaboratively creating the lesson plan for Ms. Pu's public lesson, Ms. Zhang, Ms. Wu and Ms. Li all made slight adjustments in their classes.

district sent a group of supervisors to the school to inspect all aspects of the school, including teachers' instruction. The four teachers collectively adapted two lesson plans in preparation for this inspection. The two lesson plans had been created by two teachers in other schools for a district teaching competition that had been held in April. The award-winning lesson plans had been posted on the district website and all the first grade math teachers in the district had access to those plans. For preparing for the district inspection, the Tower first grade teachers chose two lesson plans from this website and collectively modified the plans according to their pace of instruction, the textbook they used and the knowledge level of their students. In the three other group meetings each teacher who chaired a meeting presented the lesson plans she created on her own for the purpose of identifying key and important points and providing thoughts for her colleagues to think about in their own lesson plans.

In contrast, the fourth grade math teachers planned lessons together only three times out of the observed seven meetings. The three teachers did not follow the school rule to take turns chairing meetings. Usually it was Ms. Hu who headed the meetings and initiated discussion of lesson plans. Unlike the first grade teachers who went through entire lesson plans, the fourth grade teachers talked through their lesson plan only once. That lesson plan had been produced by Ms. Hu the previous year. They adapted it to prepare for the district inspection. On the other two occasions where they collectively planned lessons, they aimed to make sense of content that was unfamiliar and new. The new textbook included some geometry content that had never been taught before in the

fourth grade. They all felt it was hard to teach because of their own understanding of the content and ways of teaching it. Thus the collective discussions became necessary to help each other understand the content and explore the possible ways of conveying the knowledge.

The fourth grade teachers had two foci in their collective lesson planning. One focus was on making sense of the knowledge and the other focus was on using representations to teach a concept. When the content was new to the teachers, their conversations were centered around helping each other understand the mathematical knowledge. The new version of the textbook had two new sub-units on observing objects and designing shapes. Observing objects aimed at having students recognize different two-dimensional shapes of a three-dimensional object from different directions. Through observing objects, students' spatial imagination can be developed. The section on designing shapes was to make students be able to appreciate and design shapes by using translation, rotation and tessellation. It was the first time for the teachers to teach these two parts of content. It is not surprising that they spent a remarkable amount of time making sense of the math content before teaching the content to students. In the meeting to discuss the lesson plan of observing objects, there were 23 out of 42 utterances devoted to the discussion about the content knowledge. Similarly, in another meeting there were 37 out of 53 utterances spoken to make sense of translation and rotation. In another chapter I use the case of discussing the knowledge of translation and rotation to illustrate how the teachers made sense of unfamiliar mathematics content and developed new

understanding through collective lesson planning.

Negative number was an old topic for the fourth grade teachers. When they went through the lesson plan, they spent half of the meeting time discussing how to use a graph of cities' temperature and a thermometer to teach the concept of negative numbers. Ms. Hu always stressed the importance of a structure of a lesson that allowed for presenting mathematics content in clear steps (Interview, 03/07/2006). To introduce the concept of negative numbers she teased out the key points and three steps of teaching the concept while talking through the lesson plan with Ms. Lu and Su. After having students read the graph Ms. Hu felt that they should ask students to observe what divided positive and negative numbers. They expected that students would say that positive numbers were above zero and negative numbers were below zero. Ms. Lu thought they needed to explain what zero Celsius degree meant. Shifting to a Celsius temperature scale, Ms. Hu suggested placing a "learning hurdle" for students at this step through which students would find the importance of zero in terms of learning negative numbers. The learning hurdle she recommended was giving students a scale without zero degree and asking them to find five degrees. They anticipated that students would discover that they could not locate five degrees on the scale because they did not see where zero degrees centigrade was. Before they turned their conversations to talking about how to guide students to see negative numbers in life, Ms. Hu recapped that using the temperature graph and thermometer to teach the concept of negative numbers should be done in three steps. The first step was to teach students the notation for negative numbers, the second

was to learn about zero degrees from the temperature graph, and the last step was to have students work on a thermometer to understand the importance of zero.

Compared with the fourth grade teachers' lesson planning activities, the first grade teachers went about their collective lesson planning in much more detail. While one of them talked through her lesson plan, the other teachers jumped in whenever they wanted to make suggestions and had questions. In their lesson planning they focused on two issues: the key and difficult points of a lesson and pedagogy. Table 3.2 showed what was discussed in each lesson planning activity. In what follows I discuss the two foci respectively.

Table 3.2 Collective discussions of each lesson plan of the first grade TRG

	Lesson plan 1	Lesson plan[3] 2	Lesson plan 3	Lesson plan 4	Lesson plan 5
Key and difficult points	√		√		
Design activities			√		
Teach sample problems				√	√
Use and prepare manipulatives	√			√	
Technical tips	√		√	√	√

First, as Table 3.2 shows, when they planned lessons together, they focused on handling key and difficult points. The key and difficult points were usually explained in the teaching guidance books. Based on their own instructional situations, the teachers sometimes decided on a key or difficult point of a lesson that was different from what the

[3] The teachers did not discuss that lesson plan when Ms. Li went through it. Following that they instead discussed how to handle the practice problems.

teaching guidance books stated. There were two occasions on which the teachers discussed the key and difficult points. In the first unit, *Knowing Numbers within 100*, addition and subtraction of multiples of ten was not considered as a difficult point in the teaching guidance book. But based on their own teaching experience, the teachers agreed that students had difficulty with learning this. The difficulty lay in communicating their understanding of the rationale of addition and subtraction of multiples of ten. To address this difficult point, they planned to let students work with sticks that can facilitate their expression of the idea of grouping tens. After Ms. Zhang talked through her lesson plan and pointed out the difficult point she thought students had, her colleagues made comments:

Ms. Pu: Students know the rationale intellectually, but if we ask them to accurately express their thinking process of calculation with concise mathematical language, they need teachers' guidance. For instance, 30+10, what students most likely say is that adding the numbers in tens place, 3 plus 1. They use the column form to calculate. In math language, what 3 and 1 refer to, should be described as 3 tens and 1 ten. It is a difficult point to have them accurately express this idea.

Ms. Jin: Students tend to say that because 2 plus 3 equals 5, twenty plus thirty equals 50. Here for 2 plus 3 students change the counting unit. Before 1 is the counting unit and now 10 is the counting unit. I feel that on the one hand as Ms. Zhang said, we need to emphasize the importance of expressing the rationale behind addition and subtraction of multiples of ten, on the other hand we can ask students to use sticks. Before they counted sticks one by one, but now they need to bundle ten sticks together. We have them see 3 bundles of ten sticks plus two bundles of ten sticks.

Ms. Li: I ask students to observe that moving one bean in the tens place represents Ten ones. Then I ask them to use a card in which ten sticks are pictured to Show one ten. So they will understand that 1 in the tens place refers to one ten.

Ms. Pu: While they are working on sticks, we can ask them to think aloud and speak out that idea. They will know two tens plus three tens. If they just observe the

operation, they would come up with the idea (2 plus 3).

Ms. Jin: Manipulatives are important. They need that. (Transcription, 02/28/2006)

In this conversation Ms. Zhang's colleagues drew on their own teaching experiences to further illustrate the difficulty students had with learning the lesson. Ms. Jin explained why students can not communicate the rationale of addition of multiples of ten. She thought they still used 1 as the counting unit to explain that 20 plus 30 equals 50 although they knew that 2 refers to twenty ones and 3 refers to thirty ones. For Ms. Pu, that difficulty was also caused by their knowledge of addition in column form. To address this difficult point those teachers suggested having students work on manipulatives while describing their calculation process.

On another occasion the first grade teachers collectively discussed what should be the key of a lesson. Following the lesson of two-digit numbers plus one-digit numbers with regrouping, the textbook presented a practice lesson to consolidate what students just learned. Altogether there were nine practice problems among which five were word problems. It was Ms. Li's turn to share her plan with the group. Ms. Li proposed two foci: mental calculation and solving word problems. With the two foci, she divided her lesson into two equal parts. But flipping through the three pages of the textbook about the lesson, Ms. Wu questioned what the lesson should focus on—mental calculation or solving word problems. Ms. Zhang followed up and felt that Ms. Li might not focus on solving word problems. It seemed reasonable that Ms. Li had two foci, as the textbook provided five word problems out of the total nine problems in the lesson. Agreeing with Ms. Zhang, Ms. Wu reasoned that they should focus on mental calculation in the lesson because at this

point students had learned the majority of different kinds of mental calculation in this textbook. This lesson should serve as an opportunity to go over the knowledge system of mental calculation and consolidate their knowledge about mental calculation. This semester students were expected to be able to mentally add and subtract numbers between 20 and 100, including addition and subtraction with regrouping, which was the key part of the textbook. At this stage both Ms. Wu and Ms. Zhang thought they first should have students review the knowledge of mental calculation and next gradually develop their ability to make sense of word problems. Ms. Li showed her agreement and the four teachers shifted their discussions to designing the activities for students. The collective lesson planning made Ms. Li adjust the focus of the lesson and gave those teachers a chance to plan a lesson by locating it in the knowledge terrain of the whole semester.

Pedagogy was the second aspect the first grade teachers concentrated on in their collective lesson planning. Each time when they planned lessons pedagogy was a usual part of their discussions. The pedagogical discussions focused on the following aspects: designing activities for students, how to teach sample problems, making manipulatives, and some technical strategies related to pedagogy. Table 3.2 above showed what pedagogical aspect was discussed in each lesson planning activity. Compared to their discussions about the other three pedagogical aspects, the four teachers spent more time planning how to teach sample problems, as instructing a sample problem was viewed by the teachers as a major and important part of a lesson plan.

Here, using the case of planning the lesson about knowing RMB (Chinese currency) on May 16, I illustrate that their collective discussions expanded their knowledge about student thinking and solved a problem they would face in class. The lesson of knowing RMB was the first lesson of the unit about RMB. Teaching this lesson, the teachers aimed at having students understand the units of RMB—*yuan*, *jiao* and *fen*—and be able to do simple calculation. The sample problem was as follows. Four pigs wanted to buy gifts for their parents and each of them had 1.00 *Yuan*, 1.40 *Yuan*, 0.60 *Yuan* and 0.90 *Yuan* respectively. They had two options for the gift: one toy cost 1.70 *Yuan* and the other cost 1.80 *Yuan*. Only if two pigs combined their money could they afford a gift, given the cost of the gifts.

This problem setting made students do simple calculation with RMB, which required them to understand the relationship between the RMB units, *yuan* and *jiao* (1 *Yuan* = 10 *Jiao*). After students chose which two pigs they wanted to combine their money, the teachers wondered if they should ask them to describe the calculation process step by step in their notebooks and what the standard way of describing the process should be. Looking at the textbook they were using, Ms. Zhang found that the textbook presented a one-step operation such as 1*Yuan* and 1*Jiao* + 9*Jiao*= 2*Yuan*. But when Ms. Wu checked the textbook of PEP version that all the other math teachers in this district were using, she wondered if they should ask students to write down their thinking process in a column form operation given by the PEP textbook, such as the following:

1*Yuan* and 1*Jiao* + 9*Jiao*

= 11*Jiao* + 9*Jiao*
= 20 *Jiao*
= 2*Yuan*

But Ms. Zhang anticipated that that column form operation would not work if students calculated this way: for 1*Yuan* and 4*Jiao* + 6 *Jiao*, instead of turning 1*Yuan* and 4*Jiao* into 14 *Jiao*, students first added 4*Jiao* to 6*Jiao*—4 *Jiao* +6 *Jiao*=1*Yuan*, and second they had 1 *Yuan* added to another 1*Yuan*—1*Yuan*+1*Yuan*=2*Yuan*. Thus she insisted that the thinking process was more important than asking them to write in a standard way of column form. She felt that most students would calculate automatically in their mind without going through the steps of column form operations. Ms. Pu and Ms. Wu disagreed with her because they thought writing down the calculation process step by step would make students be clear about their own thinking and teachers would know what they were thinking. Finally, they agreed on the alternative way offered by Ms. Pu, who suggested, "How about this? For 1*Yuan* and 8*Jiao* plus 8*Jiao*, we use two ways to show the process [the column form and the way Ms. Zhang mentioned]. At least we demonstrate the calculation process. The key is to have them know there are two ways to solve the problem. But the result is the same, 2*Yuan* and 6*Jiao*" (Transcription, 05/16/2006).

The collective discussion got the teachers to think about how students would solve problems, which made them find that the possible way of students solving problems did not fit in column form operations given by the textbook of PEP. It also helped them notice that their textbook skipped the calculation process. By referring to the two versions

of textbooks, ultimately they came up with a way to solve the conflict that would allow students to solve problems and demonstrate their ideas step by step in two ways. Collectively planning lessons helped the teachers teach according to the textbook with flexibility that stemmed from their keeping student thinking in mind.

Discussing practice problems in the textbook

Correctly handling practice problems has been an important part of Chinese mathematics instruction tradition. Teachers in China tend to believe that students should have sufficient exercises in order to consolidate the knowledge they learn in class (Zhang et al, 2004). Given this, the teachers not only needed to know correct answers and solution methods, but also needed to understand what the problems examined, how the problems might contribute to student learning, what kinds of mistakes students would make when solving the problems, and how they could teach students to solve the problems. In three out of the nine observed group meetings the first grade teachers discussed how they would deal with some practice problems in the textbook. Each time this topic came up, Ms. Li chaired the meeting. Below I illustrate what the first grade teachers discussed about practice problems in the textbook when they planned lessons together.

Ms. Li reminded her colleagues that students might misunderstand several word problems because they did not understand the key words in the problems. For example, the problem, "An elephant eats bananas. It eats 25 bananas in the morning and 20 bananas in the afternoon. How many bananas does it eat on that day? ( ) [ ] ( ) = ( )

bananas." She suggested that "eat" occurred twice in the problem and students might not know how to solve it because of that word. Later on in another meeting when she talked about a word problem that included a word students might not know, Ms. Zhang brought up the mistake her students had made on that banana problem and the teachers had a brief discussion abut why they had made that mistake. Ms. Zhang's students had filled in that blank with the operation 45-20=25. Ms. Wu interpreted that the operation showed the students could add 25 to 20, but did not make sense of what "eat" meant in the problem. Ms. Li reasoned that the students could understand "eat" as "gone", which could be connected with subtraction. Thus they gave a subtraction operation that did not answer the question. As Ms. Zhang's pace was faster than the other three teachers, this brief discussion informed them what they should pay attention to when teaching that problem.

To handle practice problems, the teachers showed their flexibility to adapt some problems and add new problems to complement what the textbook provided. Most of time Ms. Li's colleagues agreed with her on the adaptation she intended to make. But on one problem they had disagreement. The problem presented information in a table that there were 10 footballs, 15 basketballs and 50 badminton balls. The questions asked that how many basketballs and badminton balls there were, how many footballs less than basket balls there were, and what other questions could be raised according to the table. Ms. Li wanted to add another condition that the school needed 90 balls altogether. Ms. Zhang and Wu thought that adding one more condition could disturb their understanding of the problem. Ms. Zhang especially emphasized the importance of students' sense of

problems. Adding additional conditions could make students solve problems they could and wanted to solve. To convince her colleagues of the reasonableness of this additional condition, Ms. Li explained her intention. Because the textbook did not include problems combining addition and subtraction she wanted to use that condition to have students solve problems combining addition and subtraction. These problems needed to be solved in two steps. For example, first they added 10, 15 and 50 together, next subtracted 75 from 90. Her colleagues thought that it would be reasonable if she added that condition when she asked students to raise more questions at the end.

Creating more problems to complement what the textbook had was another suggestion Ms. Li made regarding dealing with practice problems in the textbook. When teaching the lessons of two-digit adding one-digit with rebundling, she recommended having students work on an open-ended problem that among the given six numbers students needed to choose two numbers that had the sum of 79. Her colleagues agreed with her.

In my observations of the fourth grade TRG meetings, I never saw them discuss how to handle practice problems in the textbook. I speculate it is because they discussed that in their informal interactions whenever they felt unsure about solution methods and answers. Checking my fieldnotes, I find that several times they consulted with each other about solution methods and answers when they just got back to the office after teaching a class or when marking homework in the office. But as I did not participate in all their group meetings in that semester, I might have missed their discussions of that in their

formal TRG sessions.

Preparing the final review

During the course of my data collection, the two groups of teachers both spent two weekly meetings preparing the final review for students' final exams. The exam-oriented educational system is deeply rooted in the Chinese school culture although there is an ongoing reform aimed at transforming it into a quality-oriented system. A quality-oriented educational system shifts the focus on test scores and rote learning to fostering student creativity, encouraging active learning and educating students to become good citizens in society. But the old tradition dies hard. By the end of May when the semester wound down, the final exams were around the corner like a finale. The teachers of the school were in an atmosphere of honing the knowledge and skills of students in order to achieve good scores on final tests. "It's terrible. I already hold piles of tests to walk around in the building when the semester hasn't ended yet" (Fieldnotes, 06/05/2006). To help students perform well on the final tests the teachers in the two groups held one meeting to discuss final review plans and one meeting to make a schedule for the final review in the last three weeks.

Continuing the collaboration among them, the seven teachers shared the responsibility of helping students review what they learned this semester. Each teacher developed a review plan of one or two units and created corresponding practice problems, which saved their time from making a review plan of each unit on their own. However,

collaboration in the two groups was different. The first grade teachers not only distributed the task of planning each unit's review, but also they had collective discussions about the review plans. In comparison, the fourth grade teachers did not collectively discuss the review plans they each made. Ms. Su and Lu turned in their electronic review plans to Ms. Hu for her review and approval. Ms. Hu did not publicly revise their plans with them in the meetings. Instead, she did the revision by herself. But in the second meeting that was held for preparing the final review, Ms. Hu briefly informed Ms. Su and Lu of her review plan of one unit. She pointed out the difficult points of that unit and outlined the knowledge they should help students review. Similarly, the first grade teachers did the same thing when discussing their review plans, but they talked more and discussed the plans in detail.

Before the meeting the four first grade teachers got their review plans ready for discussion. They took turns to talk about their plans in the meeting. Ms. Zhang's review plan was about knowing numbers within 100. Ms. Wu took the responsibility of making a review plan about computation within 100 that was the key knowledge of the whole textbook. Knowing RMB (Chinese currency) was planned by Ms. Pu and solving word problems was what Ms. Li was in charge of.

During their discussions of each of the plans, two features stood out. One was that the teachers summarized the knowledge across the units to present a sequenced and structured review of what students learned this semester. For example, computation between 20 and 100 was the key part of the textbook but that knowledge was presented in

three separate units. Ms. Wu pulled the knowledge of computation between 20 and 100 out of the three units for review in one package. Ma (1999) argued that a sequence in a certain knowledge package was considered by Chinese elementary teachers as a main path through which knowledge and skills about that topic developed. In the review, Ms. Wu aimed at helping students tease out the sequence of the knowledge package of computation within 100 and synthesized solution methods. Ms. Wu divided the knowledge package into two parts, including mental calculation and computation in column form. First she planned to review mental calculation in this sequence: from multiples of ten adding and subtracting one-digit numbers or multiples of ten (such as 30+20=50), to two-digit numbers adding and subtracting one-digit numbers without rebundling, to two-digit numbers adding and subtracting one-digit numbers with rebundling, then to two-digit numbers adding and subtracting two-digit numbers without and with rebundling. The second part of the knowledge package was to revisit the standard method of two-digit numbers adding and subtracting two-digit numbers without and with rebundling that were solved in column form.

The second feature of the teachers' discussions was related to student learning. While reviewing the knowledge in a sequence, they kept students' mistakes and difficulties in mind and thought about ways to address their mistakes and difficulties. Those mistakes and difficulties came from the teachers' observation of their students' learning in the semester. To clarify student misunderstanding and prevent them from making the same mistakes again was an important goal of the final review. For example,

Ms. Zhang pointed out that some of her students made mistakes on problems such as what the fourth number before 69 was and what the next three numbers following 69 were because they did not know that the numbers before 69 referred to numbers smaller than 69 and numbers after 69 referred to numbers bigger than 69. When Ms. Li presented her review plan, Ms. Wu jumped in to make a complementary comment that they should be cautious about student misunderstanding of certain word problems. She pointed out that students tended to connect some words with addition or subtraction because of a kind of rigid mind set. For instance, two problems asking the same question about how many books there had been in the library before can be solved either by addition or subtraction. The conditions of the two problems were different; one was that there were 30 books checked out and 40 left in the library and the other was that 50 new books were bought in and now there were 80 books in the library. Ms. Wu thought students tended to link the word "before" with addition. She suggested that the teachers should have students make sense of the relation between parts and wholes in concrete problem settings.

Collectively preparing the final review offered an opportunity for the teachers to recap the knowledge students learned in a package with a sequence that not only mapped out a terrain of the knowledge for students, but also contributed to the teachers developing a solid and deep understanding of the math knowledge for first graders. Meanwhile, sharing students' mistakes and difficulties provided the teachers with pedagogical resources which they could make use of in preparing their students for the final exams.

What the other communities offered to the teachers—Bell associated lesson planning teams and the district groups

Wenger (1998) pointed out that in life people participate in many different communities. My informant teachers were no exception. They shared the same office with the other teachers who taught Chinese literacy at the same grades. They communicated and interacted with other teachers in the teachers' cafeteria, the library, the hallway, and other offices of their school on a daily basis. They were also someone's wives, moms, and daughters. Meanwhile, they were required to take part in the Bell associated lesson planning teams and the district professional development activities with other first grade or fourth grade math teachers. What they did and talked about in these communities was consistent with what they did and talked about in the teaching research groups. The Bell associated lesson planning team and the district community were tightly connected with their core professional community, the teaching research groups. What they engaged in within their teaching research groups extended to the Bell team and the district community. The extension created coherent learning opportunities for the teachers.

Some researchers (Cohen & Hill, 2001; Feiman-Nemser, 2001; Porter et al, 2003) contend that coherence in professional education of teachers is important. From the perspective of instructional policy, Cohen and Hill (2001) argue for the coherence among policy instruments such as student curriculum, assessment and curriculum for teacher learning. They find that the coherence is conducive to creating meaningful opportunities for teachers to learn.

Recognizing the importance of continuity and progression of teachers' professional education, Feiman-Nemser (2001) proposes designing a professional learning continuum from initial preparation, induction to professional development in the early years of teaching. She especially criticizes professional development that consists of discrete and disconnected events. An empirical study (Porter et al, 2003) shows that coherence is one of the three core features of effective professional development. In that study coherence is "the degree to which the activity promotes coherence between teachers' professional development and other experiences" such as "encouraging the continued professional communication among teachers" (p.25). Given the fact that the teaching research groups are situated in the district community and connected with other groups, coherence among their learning experiences from participation in multiple communities becomes important in terms of improving instruction. Similar to the concept of coherence defined by Porter et al (2003), in this study I use the concept of coherence to interpret the various professional activities the teachers engaged in the different communities. I assume these activities offer the teachers coherent learning opportunities when they were directly around instruction and curriculum to satisfy the teachers' needs and address problems the teachers encountered in practice.

The three communities offered coherent learning experiences because the focus in the Bell lesson planning teams and the district community was like that of the school-based TRG, around curriculum and instruction. Some activities even occurred across the boundaries of the three communities. The basic activities offered by the Bell

teams and district included collectively planning lessons, observing and/or commenting on lessons, presenting lesson plans, analyzing textbooks, discussing issues and concerns the teachers encountered in instructional practice and preparing the final review. Table 3.3 shows the kinds of activities of the teachers in the two communities. Among the activities, several, such as conducting public lessons and presenting lesson plans, linked the teaching research groups with the other two communities. The linkage lay in making use of the expertise of the colleagues in the teaching research groups, but also involving other teachers in the teams and the district communities. In next two chapters I analyze in detail what the teachers learned from conducting public lessons and presenting lesson plans within the two communities.

What the activities of the Bell teams and district provided for the teachers were ongoing learning opportunities that guided the teachers to understand the textbooks, addressed their problems and concerns regarding teaching and student learning, and engaged them in reflecting upon their own or colleagues' instructional practice. In what follows I focus on lesson observation to illustrate how the teachers benefited from the learning opportunities offered by the two communities. Table 3.3 suggests that observing lessons was a regular activity the teachers did in their Bell lesson planning teams and the district communities. For some observed lessons, the teachers were involved in the preparation process. For the other observed lessons, they were just observer and/or commenter. Hu (2005) argued that lesson observation could be meaningful learning opportunities for teachers who observed. For example, although the participant teachers

did not attend the district teaching competition, they all felt that they did learn something from observation. The teaching competition was held for a week in April. The teachers were encouraged to re-arrange their schedule to observe the competition lessons.

Interviewed about their views on the teaching competition, the teachers felt that those lessons demonstrated what an excellent lesson should be in the district as they were the products of collective efforts. Ms. Zhang said, "Those lessons show you what kinds of goals you should achieve, and what kinds of teaching methods you could use. They show you a certain direction for your own instruction. Then you know what standards you could refer to for improving your own practice" (Interview, 05/11/2006). That intense lesson observation can provide meaningful learning opportunities was also because it offered the teachers opportunities to learn how to reflect upon colleagues' lessons. Ms. Wu looked back at her observations when she just entered the teaching profession. "At the beginning I felt that all the lessons I observed were good. But gradually when you discussed with other teachers and heard their comments, I found that those lessons could have been done much better. Now I know how to observe a lesson. My standards for an excellent lesson are increased" (Interview, 05/11/2006). Ms. Pu and Su held the same feeling. Lesson observation allowed them to develop abilities to reflect upon others' lessons, which in turn could help them improve their own instruction. In the interviews all the teachers mentioned the lesson episodes that most impressed them and commented how some episodes had been handled very well and how some could have been done better. For example, Ms. Pu shared the same view with Ms. Wu that a problem setting

should sound interesting and real for young kids and be consistent with the following instructional steps so that they could see mathematics in life. That idea came from their observation of a lesson about knowing RMB.

In addition, lesson observation offered the teachers a chance to link the knowledge taught at different grades. All the teachers observed several lessons that were not their grades. Although they already knew the knowledge system of elementary mathematics presented in their textbooks, observing lessons of other grades could allow them to be aware of knowledge connection, the depth of knowledge they should reach in their grades and what foundations they should lay for student learning in the future. An episode mentioned by Ms. Su illustrated this point. In a lesson she observed the students compared $\frac{1}{2}$ and $\frac{1}{3}$. One student said that $\frac{1}{2}$ was absolutely bigger than $\frac{1}{3}$, but another student argued that that could not always be right in life. For example, when people compared half of a small apple with $\frac{1}{3}$ of a large apple, $\frac{1}{3}$ was bigger than $\frac{1}{2}$. Su noticed that the teacher did not use this opportunity to point out the concept of the whole unit, but here she stressed the importance of $\frac{1}{2}$ of what and $\frac{1}{3}$ of what as the lesson was for third graders. She told me that students would learn the concept of the whole uni till the fifth grade.

Some researchers (Paine, Fang, & Wilson, 2003; Paine & Ma, 1993) recognized the tremendous power of official curriculum materials in the Chinese educational system. In my fieldwork I often heard the teachers and administrators mentioned the importance of "studying and understanding textbooks". Ms. Wu felt that conducting the public lesson

promoted her understanding of the textbook. Ms. Hu stressed how important it was for teachers to understand textbooks because "without a deep, thorough and comprehensive understanding of textbooks a teacher can not respond to student thinking appropriately" (Interview, 05/22/2006). If the textbooks are considered as representing a body of elementary mathematics knowledge in a systematic and coherent way, studying and understanding textbooks is to acquire "profound understanding of fundamental mathematics" (Ma, 1999). When the activities that the teachers attended in their Bell planning teams and district communities were organized around curriculum and instruction, their understanding of fundamental mathematics was promoted.

Table 3.3 Activities of the Bell teams and the district communities

	The first grade	The fourth grade
Bell Associated Lesson Planning Team		
Plan lessons	Unit 3. Combination of shapes (3.15)	Unit 4. Meaning and property of decimals (3.15) Solve word problems of planting trees (5.17)
Observe and comment on lessons	Two-digit numbers plus one-digit numbers with regrouping (**Ms. Pu**, 3.15) Find patterns (4.19) Mental calculation practice (6.07)	Simplification of multiplication (4.26) Statistical graphs (**Ms. Lu**, 5.17)
Discuss issues and concerns in teaching and student learning	3.15/4.19	3.15/4.26/5.17
Prepare the final review	6.07	6.07

Table 3.3 (cont'd)

The district community		
Observe and comment on public lessons	Solve word problems about difference (**Ms. Wu**, 3.29) Find patterns (5.17)	How to shift the decimal point (3.29) Features of triangle (5.10)
Study the textbooks	Unit 5 Knowing RMB and Unit 6 addition and subtraction within 100 (3.29) Unit 7 Knowing time and Unit 8 Finding patterns (5.17)	Unit 5 Triangle (5.10)
Lesson presentations		Unit 4. Meaning and property of decimals (**Ms. Lu and Ms. Su**, 3.29) Categories of triangle (5.10)
Introduce a school's math education reform experience	Presentation on a key school's experience of reforming math instruction (3.29)	
Observing lessons of the teaching competition	4.10 – 4.14	4.10-4.14

Summary

In general the teachers devoted a great deal of their group meeting time to discussing lesson plans, how to handle practice problems and preparing the final reviews. But the two groups of teachers had different patterns in collective lesson planning. The first grade teachers followed the school rule that each teacher took turns to chair meetings and put

her plan on the table for collective discussion. The fourth grade teachers seemed not to abide by the school rule of taking turn. They tended to collectively plan lessons when the content was new for them. They drew on each other's understanding to make sense of the new content. All the three core activities the teachers did in their TRGs were closely tied to their daily instructional practice and curriculum. That was consistent with what the Bell teams and district provided for the teachers' learning. Across the three communities, what the teachers did and discussed offered coherent learning experiences as all the activities were closely tied to curriculum and instruction, and engaged the teachers in joint work and educating each other.

CHAPTER FOUR

LEARNING WITH COLLEAGUES THROUGH PUBLIC LESSONS

Introduction

"So far I found that 'doing public lesson' is a key and effective way for teachers, especially young teachers to improve teaching practice. That's also an approach used widely and regularly by the districts and schools to push teachers to improve" (Fieldnotes, Mar.22, 2006). That is my reflection upon what I saw and heard in the field. Among the varieties of activities the teachers participated in, the joint work of preparing and conducting public lessons emerged as a key activity in their communities of practice. Public lessons opened a teacher's classroom practice to critical review and collective reflection, capitalized on different teachers' experience and knowledge to refine and polish instructional practice, and offered the teachers opportunities to share and develop knowledge for teaching mathematics. Drawing on the data of two public lessons conducted by Ms. Wu and Ms. Pu, I first describe the general and specific backgrounds of public lessons and point out that public lessons serve different purposes in Chinese educational contexts. In the second part of this chapter I argue that public lessons functioned as an approach to improving instruction in three ways, including using tools as learning resources, generating and sharing knowledge for teaching mathematics, and developing awareness of the teachers' weaknesses.

What are public lessons?

Flipping through Chinese journals for teachers or talking with teachers about how they gradually improve their instructional practice, I often read or heard that conducting public lessons[1] is the most powerful way to promote Chinese teachers' professional development. Public lessons are "lessons taught by a teacher to a class of pupils, with observers in attendance. Typically, an open [public] lesson involves a public debriefing or discussion following the lesson" (Britton, Paine, Pimm, & Raizen, 2003, p377). Specifically, the following features differentiate public lessons from everyday lessons.

First, the lesson plan of a public lesson is carefully created, discussed and revised by a teacher in collaboration with her colleagues. Sometimes the lesson plan is reviewed by expert teachers inside or outside of school. During the process of preparing a public lesson, the lesson plan is being revised continuously.

Second, public lessons are observed and often reflected on by other teachers. "Public" means they are open to colleagues, who can be teachers from the same school, from other schools, district, city, or even from other regions. For example, a public lesson conducted by a teacher who is designated by the government as "national excellent teacher" often attracts teachers from various regions to observe.

Third, public lessons are conducted with different goals in Chinese school contexts

[1] Public lessons share commonalities and differences with Japanese lesson study (Lewis & Tsuchida, 1998). It is not surprising that they have some in common as the two cultures have many aspects in common, such as collectivism, stressing the importance of academic achievements, and valuing efforts more than talents. They both are teachers' joint work, open to an audience of other teachers, have a similar preparation cycle, and create artifacts for record or dissemination. Also they are professional activities teachers take initiatives to engage in. Generally speaking, the differences between them could include: different purposes, different focus, and being situated in different contexts, etc. A careful scrutiny is needed to compare them.

(Wu, 2006; Wu & Wu, 2007; Yu, 2002). Schools and administrators use public lessons to evaluate a teacher's work. In the ongoing national curriculum reform public lessons can be conducted as study lessons for teachers and researchers to investigate how to teach certain topics, implement new ideas and instruct different types of lessons such as new lessons, review lessons and practice lessons. Also public lessons can be taught by an excellent teacher to show teachers how to implement new ideas in classrooms. To develop young teachers' competences, schools, districts or cities organize teaching competitions in which young teachers give public lessons to compete with each other.

Last, artifacts derived from public lessons such as videotaped lessons, lesson plans, teaching materials and objects, or teachers' reflection journals are often disseminated or kept by schools and districts as resources for teacher training. For example, the Tower Elementary School has kept videotapes of all public lessons conducted by its teachers in the past fifteen years. The teachers can check out any tape whenever they need.

Conducting a public lesson is a process stretching from several days to several months. As illustrated in Figure 4.1, this process has several steps and some steps might be repeated several times. Usually a lesson taught as public lesson is the first lesson of a unit or an important lesson of a unit. After the lesson is determined, a teacher who will teach it creates a lesson plan and revises it in collaboration with her colleagues who could be inside or outside the school. Next her colleagues are invited to observe the rehearsal lesson and make comments and suggestions following the lesson. The cycle of revising the lesson plan—rehearsing the lesson—debriefing and discussing the lesson may be

repeated several times. Repeating the cycle, a teacher rehearses the lesson to several different groups of students. As an excellent teacher puts it (Dou, 2006), like a person can not step into the same river twice, teaching different groups of students always brings up new problems that a teacher and her colleagues can work on to refine and perfect the lesson. The final step is to conduct the public lesson, teaching a real class of students before an audience of teachers. Most of the time a debriefing and reflection meeting follows.

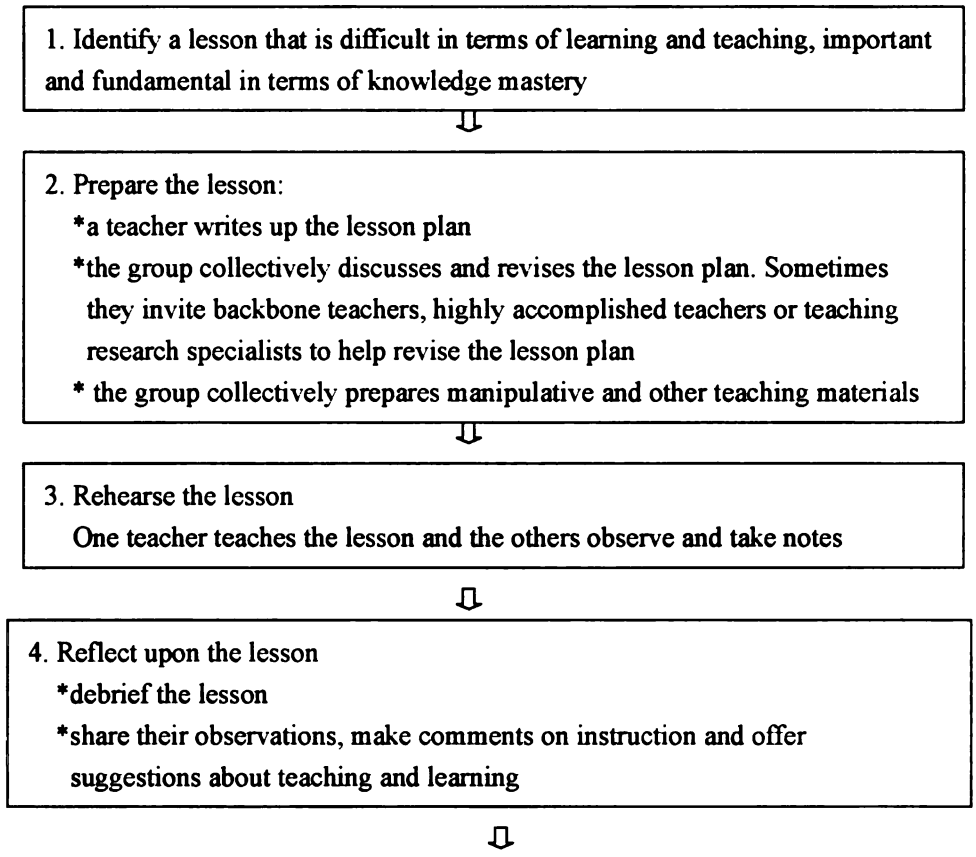

Figure 4.1 General procedure of preparing a public lesson

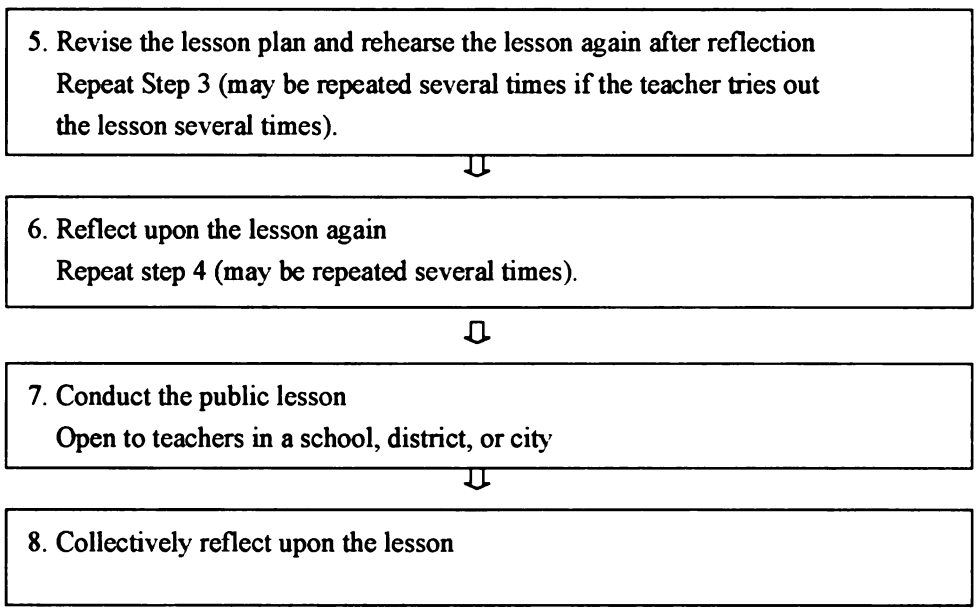

Figure 4.1 (cont'd)

Backgrounds of the two public lessons

The new semester started in late February. Upon entering the Tower School in late February, I saw Ms. Wu and Ms. Pu begin to prepare their public lessons. In the winter break Ms. Wu already knew that she would conduct a public lesson in the district. The task was assigned to her by Ms. Sun, who was the district teaching research specialist for first and second grade math. Usually in winter or summer break Ms. Sun convened the teachers of the district teaching research group for meetings and consulted with them about using the textbook for the following semester. The lesson Ms. Wu taught as a public lesson was considered by this group of teachers hard for students to understand and for teachers to teach. Thus the main purpose of Ms. Wu's public lesson was to show the first grade math teachers how to teach it. As Ms. Sun said, it could provide the

teachers prompts to design the lesson and get them to think about how they might approach the key and difficult points in certain classroom situations. For the district teaching research group and Ms. Wu, the lesson was a study lesson that offered an opportunity for them to enhance their knowledge for teaching similar topics.

Different from Ms. Wu, who was required to teach the public lesson, Ms. Pu took the initiative to do the task as a monthly activity of her Bell lesson planning team. At the request of Ms. Lin, who headed the Bell lesson planning team and taught in another elementary school, Ms. Wu asked her first grade TRG colleagues who wanted to conduct a public lesson for the Bell team. Ms. Pu volunteered to take on the task. She consulted with the other three teachers which lesson she would teach. As the lesson was a study lesson for the teachers of the Bell team, they chose a topic that was included in both versions of textbooks--the PEP version textbook and the Beijing version textbook. Also the topic represented key content for first grade mathematics because it laid foundations for students to understand regrouping in addition and subtraction.

The two public lessons focused the same unit of the Beijing version textbook. The unit included the following content: mental calculation of two-digit numbers adding and subtracting multiples of ten (10, 20, 30, and so on), mental calculation of two-digit numbers adding and subtracting one-digit numbers, and solving word problems. The PEP version textbook that the majority of elementary schools used had a similar unit. The lesson Ms. Wu taught was one of the difficult points of the unit. The lesson aimed to have students understand and be able to solve word problems about difference between two

numbers in real life situations. The textbook presented a picture of a reading room where there were 7 boys and 9 girls who sat around tables by groups of twos or threes. The problem was: Are there more girls than boys or more boys than girls in the room? What's the difference between the numbers of girls and boys? The teaching guidance book pointed out that it was hard for students to understand they should use subtraction to solve difference problems in life. It suggested that teachers should allow students to solve the problem using multiple solution methods and encourage students to demonstrate their understanding of subtraction for comparison.

In Ms. Pu's public lesson students were expected to be able to do mental calculation of two-digit numbers plus one-digit numbers with regrouping. The picture in the textbook showed a bookshelf that had 69 books and a girl putting 4 more books onto the shelf. The problem asked how many books there were now on the bookshelf. Two solution methods were presented in the textbook: 9+4=13, 60+13=73; 69+1=70, 70+3=73. The teaching guidance book stated that mental calculation of two-digit numbers plus one-digit numbers with regrouping was one of the difficult points of the unit. Teachers were encouraged to help students further understand the concept of rebundling—turning ten ones into one ten. Meanwhile, teachers also should focus on encouraging students to invent their own solution methods.

Procedures of preparing the public lessons

Ms. Wu and Ms. Pu followed a similar procedure to prepare their public lessons but

different groups of teachers were involved in the processes. Both of them first created a draft of the lesson plan on their own. Ms. Wu sent the draft to her colleagues of the district teaching research group for review. Ms. Pu discussed the lesson plan draft with her colleagues in the first grade math teaching research group. With the feedback from their colleagues, they revised the lesson plan. The next important steps were to try out the lesson with a class of students[2] and reflect upon the lesson with their colleagues. Ms. Wu rehearsed the lesson with different classes of students several times while Ms. Pu tried out the lesson only once. After each rehearsal lesson, they revised the lesson plan and incorporated their colleagues' comments and suggestions to refine their instruction.

Throughout the process of preparing the public lesson, Ms. Wu closely worked with Ms. Sun, who assisted Ms. Wu to refine the lesson bit by bit. Altogether she observed Ms. Wu's rehearsal lessons three times and watched with Ms. Wu alongside her the videos of two rehearsal lessons that she could not come to observe in class. Ms. Wu conducted the public lesson as a monthly professional development activity that all first-grade math teachers in the district had to attend. There were about 70 teachers who observed Ms. Wu's public lesson. Following the lesson Ms. Sun explained the rationale of the lesson design and commented on Ms. Wu's instruction. She asked the first-grade math teachers to turn in their written feedback to her later. The feedback aimed at having the teachers think of their instruction of the same lesson rather than evaluating Ms Wu's

[2] The two teachers tried out their lessons with different classes of students at the firs grade. There were seven classes of students at the first grade. Ms. Wu rehearsed the lesson with other five classes of students during their regular math sessions while teaching the final public lesson to one of her two classes of students.

teaching.

Compared to Ms. Wu's public lesson, Ms. Pu had a relatively simple preparation process. She tried out the lesson only once. The head of the Tower School mathematics teaching research group, Ms. Jin, was invited to observe and give comments[3] on the rehearsal lesson. Altogether there were 16 first-grade math teachers from other schools who observed and reflected upon her public lesson. The second-grade math teachers in the Tower School also observed this public lesson. A week later in the joint activity of the first-grade and second-grade math TRG, the lesson was reflected on again. Ms. Jin attended the joint activity. The timelines of Ms. Wu and Ms. Pu preparing and conducting their public lessons are shown in Figure 4.2 and 4.3.

[3] In the debriefing sessions after the public lessons, the teacher who taught the lesson usually reported how she designed the lesson and made self reflection on her teaching. Following that, the observers made comments that fell into several categories, such as pedagogy, student learning, math content knowledge, curriculum, etc. Some researchers (Han, 2006; Wang & Paine, 2003) studied how Chinese teachers reflected upon lessons collectively. The comments made by the observers can be very lengthy and specific. The teachers always felt free to jump in when their colleague was making comments. For example, when reflecting upon Ms. Pu's lesson, her colleagues debated over why the students did not come up with multiple solution methods. The next section of this chapter will show how the teachers reflected on the public lessons. On many occasions, I use "reflection" and "comment" interchangeably.

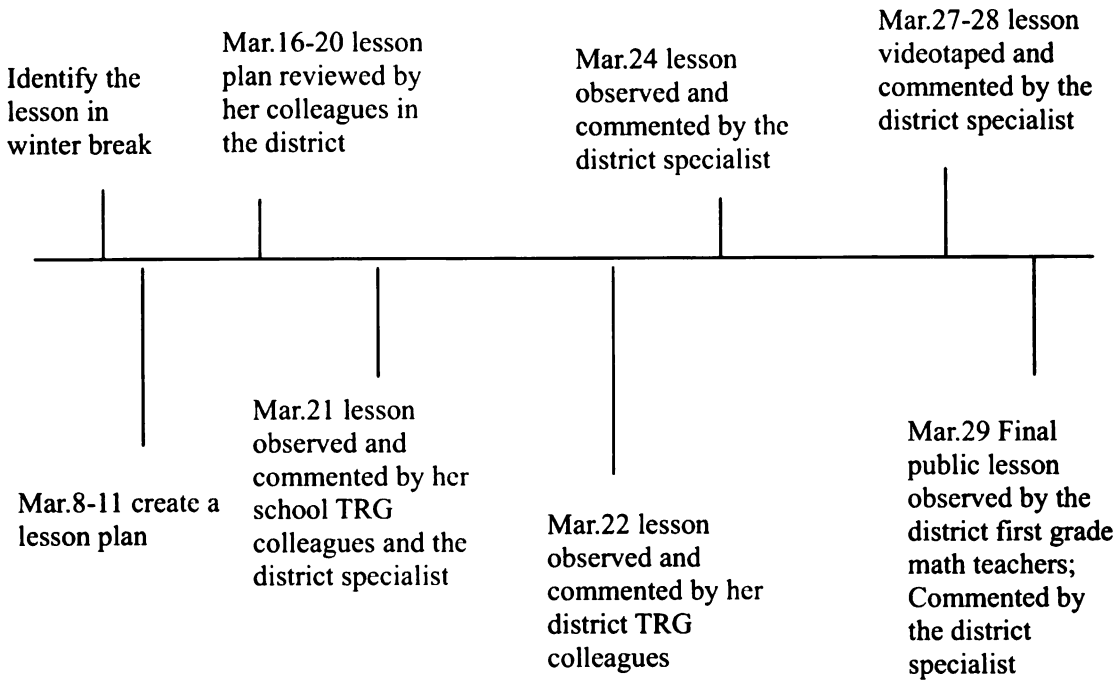

Figure 4.2 Timeline of Ms. Wu preparing her public lesson

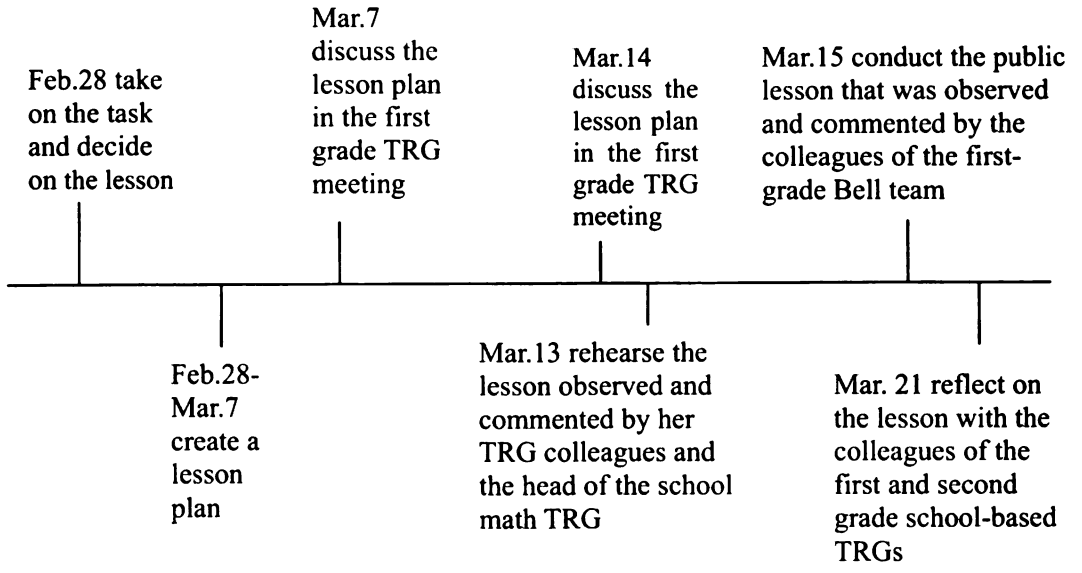

Figure 4.3 Timeline of Ms. Pu preparing her public lesson

Table 4.1 shows the variation in the procedures of the two public lessons preparation when compared with a general procedure. Ms. Pu rehearsed the lesson only once before the final public lesson, but she discussed her lesson plan with her TRG colleagues twice. Differently, Ms. Wu repeated Step 3 and 4 several times--trying out the lesson and reflecting upon the lesson with her colleagues. She did not discuss her lesson plan face-to-face with her colleagues; instead, each time she received written feedback from them. Following her final public lesson in the district, there was no collective reflection. Only Ms. Sun analyzed the design of the lesson and made comments[4].

Table 4.1 Procedures of the two public lessons

General procedure	**Ms. Pu's public lesson**	**Ms. Wu's public lesson**
1. Identify a lesson that is difficult in terms of learning and teaching, important and fundamental in terms of knowledge mastery	Take on the task and decide on the lesson	Identify the lesson in winter break
2. Prepare the lesson *a teacher writes up the lesson plan *the group collectively discusses and revises the lesson plan.	Create a lesson plan Discuss and revise the lesson plan in the first grade TRG meeting	Create a lesson plan Lesson plan reviewed by her colleagues in the district (communicate through emails) Revise the lesson plan

[4] There were about 70 teachers who observed the lesson. They were the first grade mathematics teachers in the district. The large number of teachers might be one of the reasons why no reflection followed the lesson.

Table 4.1 (cont'd)

Sometimes they invite "backbone teachers", "highly accomplished teachers"[5] or teaching research specialists to help revise the lesson plan * the group collectively prepares manipulatives and other teaching materials		
3. Rehearse the lesson One teacher teaches the lesson and the others observe and take notes	Rehearse teaching the lesson to a class of students Be observed by her first grade TRG colleagues and the head of the school math TRG	Rehearse teaching the lesson to different classes of students Be observed by the first grade TRG colleagues and the district teaching research specialist
4. Reflect upon the lesson *debrief the lesson *share their observations, make comments on instruction and offer suggestions about teaching and learning	Reflect upon the lesson with her first grade TRG colleagues and the head of the school math TRG	After each time she rehearsed the lesson, reflect upon the lesson with the first grade TRG colleagues and the district teaching research specialist

[5] Backbone teachers and highly accomplished teachers (*Teji jiaoshi*) are honorable titles for excellent teachers. Head teachers of a subject matter and backbone teachers are designated by local educational bureaus while highly accomplished teachers are national honorable designation and endorsed by the central government. In terms of teaching competences, head teachers of a subject matter are more excellent than backbone teachers.

Table 4.1 (cont'd)

5. Revise the lesson plan and rehearse the lesson again after reflection (Repeat Step 3)	Discuss and revise the lesson plan again in the first grade TRG meeting	Revise the lesson plan Rehearse the lesson again Be observed by her district TRG colleagues
6. Reflect upon the lesson again (Repeat step 4)		Reflect upon the lesson again with her district TRG colleagues (Repeat Step 3 and 4: lessons were observed and commented twice by the district specialist; lessons were videotaped and commented twice by the district specialist)
7. Conduct the public lesson Open to teachers in a school, district, or city	Teach the public lesson to her own class of students be observed by the colleagues of the Bell associated lesson planning team	Teach the public lesson to her own class of student Be observed by the district first grade math teachers
8. Collectively reflect upon the lesson	Reflect upon the lesson with the colleagues of the Bell team. Reflect upon the lesson with the colleagues of the first and second grade TRG at the Tower School	After teaching the district specialist made formal comments and other teachers wrote feedback

Public lessons functioned as an approach to improving practice

In the research literature there is no summative evaluation that shows public lessons contribute to teacher learning and result in improvement of instruction in China. This may be because public lessons are so deeply rooted in the tradition of Chinese teaching culture that their benefit has not been questioned. Chinese teachers practice public lessons as an integral part of their professional life. In the Tower School every semester almost all teachers need to conduct a public lesson inside their teaching research groups. When a teacher took her turn to analyze a unit and share her lesson plan with the whole group, she usually invited her group colleagues to observe her lesson and then discuss it in their weekly group meetings. Sometimes the principal and the head of the school math teaching research group came to observe those public lessons and joined the groups to make comments. For example, the principal and the school math TRG head, Ms. Jin, observed Ms, Li's lesson in March. The lesson was on the same content as Ms. Pu's public lesson the whole group had collectively planned and discussed. After Ms. Li's lesson the principal and Ms. Jin had a debriefing and reflection meeting with the group. As an integral part of teachers' professional life, for the teachers in this study, public lessons appear to be the most powerful fuel to push teachers to improve instructional practice. Ms. Hu thought conducting public lessons helps teachers grow with a leap as teachers draw on one another's expertise to deepen their understanding of the content and ways to teach the content (Interview, 05/22/2006). Similarly, the other participant

teachers held the same view on public lessons. So how did public lessons lean to instructional improvement and teacher learning? What mechanism in this process made teacher learning possible? I try to answer the questions here.

Lewis et al (2006) made a conjecture about how lesson study could result in instructional improvement. They speculated that three pathways to instructional improvement are strengthened by lesson study. The three include teachers' knowledge, teachers' commitment and community, and learning resources. I also see a mechanism at work in public lessons. I suggest public lessons contribute to teacher learning and instructional improvement by a set of pathways: tools as learning resources enable their learning in communities while collaboration promotes their use of tools to improve instruction; teachers develop awareness of their own weaknesses in their teaching competences through working with colleagues; and teachers collaboratively generate, share and enhance knowledge for teaching mathematics. In the following I draw on the data of Ms. Wu and Ms. Pu doing public lessons to illustrate the three pathways through which they and their colleagues improved their instructional practice.

Using tools as learning resources to improve instruction

Shared repertoire is defined as one of the dimensions of a community of practice (Wenger, 1998), including artifacts, tools, concepts and discourse, etc. Artifacts and tools congeal the experiences and knowledge of the community into concrete things, carrying the history and culture of a community of practice while mediating participants' actions

(Wenger, 1998). Preparing the public lesson, Ms. Wu and her colleagues worked with and on different tools for teaching the lesson effectively. Some researchers (Grossman et al, 1999) classify tools into two kinds: conceptual tools and pedagogical tools. Conceptual tools mean principles, framework and ideas about teaching and learning, and knowledge acquisition that teachers use as heuristics to guide their decisions about teaching and learning. Pedagogical tools refer to classroom practices, strategies and resources that have local and immediate utility. Similarly, Gauvain (2001) categorized tools into material tools and symbolic tools. Symbolic tools mainly refer to language that mediates participants' action in communities. Material tools refer to artifacts created and used by participants in communities. In the Tower teachers' groups, materials tools include lesson plans, textbooks, teaching guidance books, curriculum standards, other curriculum materials, student tests, and forms of technology.

In what follows I use the concepts of symbolic tools and material tools to analyze how the teachers worked around the tools to go about the joint work of preparing their public lessons. I mainly analyze the case of Ms. Wu to examine the symbolic tools and material tools used in the process and interpret what Ms. Wu and her colleagues understood about the reform ideas on mathematics teaching and learning, and how they envisioned teaching mathematics.

Working with symbolic tools

Wenger (1998) points out that two characteristics make shared repertoire a resource for

the negotiation of meaning. One of the two characteristics is that it reflects a history of mutual engagement (p.83). The long tradition of Chinese teachers working with colleagues in communities creates shared concepts which they refer to when making instructional decisions. The shared concepts, as symbolic tools, set up a framework for teachers, which in turn offers possible opportunities for teachers to improve and refine their teaching practice. The notions of "key" and "difficult" points are an important part of the framework. Key and difficult points refer to the math knowledge that is significant for students to learn and understand. They lay foundations for students to connect knowledge and learn new knowledge in the future. For example, rebundling is considered as a key and difficult point for students to learn in understanding of addition of two-digit numbers and one-digit numbers. This concept is not only related to addition but also to subtraction. When it is connected with the rate of composing (ten ones into one ten) and decomposing (one ten into ten ones) a higher value unit, students' understanding of addition and subtraction is deepened (Ma, 1999). The rate of composing and decomposing a higher value unit is also used to understand addition and subtraction of decimals. Usually teacher guidance books lay out what key and difficult points are in a unit and lesson, which allows teachers to reach a consensus about the focus of their instruction. Key and difficult points are not only significant for student learning, but also important for teachers to build up their knowledge package for teaching elementary math. With the conceptual tool of being aware of key and difficult points and the significance of understanding key and difficult points, teachers tend to focus their reflection about public

lessons on how a teacher understands and teaches key and difficult points.

In the whole process of preparing the public lesson, Ms. Wu and her colleagues had been thinking hard about how she could help the students make sense of the difficult and key points of the lesson. Among the written feedback Ms. Wu's colleagues of the district teaching research group provided, eight out of ten colleagues commented on her proposed way of dealing with key and difficult points. One colleague wrote, "The key point of this lesson is to help students understand the rationale of computation, understanding why they use subtraction to solve problems asking how much bigger or smaller one number is than another number. That is to understand the operation 9-7=2. It is necessary that students are able to express and understand the meaning of this operation at the beginning of teaching and learning this topic. Thus we should let students demonstrate and communicate their understanding of this operation in class" (documents collected, 03/2006). Following this statement, this teacher suggested having students compare the two kinds of problems—how much bigger number A is than number B and how much smaller number B is than number A, which she thought would help students understand the concept of difference and why they use subtraction to solve problems about difference.

In the debriefing and reflection meeting after those colleagues observed Ms. Wu's rehearsal lesson, their discussions focused on how Ms. Wu taught the key and difficult points and what she might do to improve her instruction. The meeting lasted one hour and forty-five minutes. They spent about one hour of it discussing Ms. Wu's instruction of the

key and difficult point and offering their suggestions for improvement.

Similarly, in the debriefing and reflection meetings Ms. Pu and her colleagues argued about how to deal with the key point of her public lesson. One of the key points of the lesson was to master the solution methods of solving problems of two-digit numbers plus one-digit numbers with regrouping. Ms. Pu intended to have her students grasp the basic method: ones plus ones, and then carrying ten ones to the tens place. However, her colleagues felt she should have encouraged multiple solution methods as that was the key point of the lesson. In the reflection meeting after the rehearsal lesson, Ms. Zhang and Ms. Jin offered their thoughts about why the students did not come up with various solution methods. In the week following the final pubic lesson to the Bell team, the first grade math teachers had a reflection meeting with the second grade math teachers. During the meeting, the issue was brought up again by one of the second grade teachers. She pointed out that Ms. Pu did well in helping the students understand the difficult point—regrouping, but she felt that Ms. Pu did not handle the key point well in two aspects. She noticed that the students did not really communicate with each other about their ideas on the solution methods. Also Pu overemphasized the basic method. Ms. Pu's first grade TRG colleagues, Ms. Wu and Ms. Li, explained that was because they wanted to make sure that at least every student could solve the problems with the basic method. Some of the first grade teachers in the district found that students tended to stick with the method they liked if a teacher did not stress the basic method and encouraged them to solve problems with multiple solution methods. Ms. Jin, the head of the school math TRG,

thought that encouraging multiple solution methods and having students master a basic method were all important. What a teacher can do was to guide students to compare different methods and understand that some methods were more efficient than others.

As the two public lessons of Ms. Pu and Wu illustrated, key and difficult points were prevalent symbolic tools the teachers worked around to refine practice. As symbolic tools, key and difficult points defined what the teachers paid attention to in their lesson observations and reflections. They served as a common framework that directed the teachers to think about and explore better ways to convey the content knowledge to students.

Some new ideas on mathematics instruction were accepted by the communities as symbolic tools for the teachers to talk about and improve teaching practice. Since 2003 Ms. Wu and her colleagues have been using the new textbooks that were created according to the new national mathematics curriculum standards. The ongoing national curriculum reform aims at restructuring teaching and learning in classrooms, with a focus on changing the deeply rooted tradition in schools in which teachers emphasize importing basic knowledge and skills and control everything in classrooms while students passively accept what they are taught and practice a lot to memorize and become proficient. The new national standards for mathematics (1-9 grades) (Ministry of Education, 2001) recommend that teachers view mathematics teaching and learning as a process of doing mathematics and teachers and students interacting with each other. Students should learn mathematics by connecting with their real life. Teachers are encouraged to change their

traditional roles in class and help students learn through exploration. Therefore, teachers should guide students to engage in mathematical activities, build up teaching on students' thinking, and encourage students to demonstrate different ideas. Mathematical activities include the following: observation, operation, comparison, synthesizing, conjecture, reasoning and justification, and communication (Ministry of Education, 2004).

However, some studies (Cohen, 1991; Cohen & Hill, 2001) have pointed out that reforming traditional teaching practice is a complicated process, the success of which is built on organizational supports, teachers' opportunities to learn, and teachers' beliefs and knowledge. Throughout the process of Ms. Wu and her colleagues preparing the public lesson, they tried to incorporate the reform ideas into the lesson, such as creating a problem setting that was connected with student life, using manipulatives to facilitate thinking, having students demonstrate and explain their own ideas, and organizing small group activities. These reform ideas became a reference Ms. Wu's colleagues used to observe the lesson and offer suggestions. Although they did not explicitly articulate what these reform ideas indicated for mathematics instruction, they did bear these ideas in mind to go about their reflection upon Ms. Wu's lessons.

Working around material tools

Ball and Cohen (1999) argue for incorporating tools and artifacts into teachers' meaningful professional education. When mapping out a landscape of this kind of professional education that was in and around practice across time and over topics, they

proposed that one of the key components was using suitable tools to investigate practice. During the process of preparing the public lesson, the lesson plan became a tool that aided Ms. Wu and her colleagues to revise and polish the lesson. Finishing the draft of the lesson plan by herself, Ms. Wu sent it out to her colleagues in the district teaching research group via email over the weekend. She got back their written feedback via email in the following week. Ten teachers offered feedback. The lesson plan was a symbolic representation of instructional practice Wu would carry out. It contained her thinking and reasoning about teaching and learning the topic. When it became the tool her colleagues worked on to help her achieve the goal of teaching the topic effectively, it was deciphered and understood by these teachers in different ways because they brought in their own experiences and abilities to use the representation.

The basic structure of the feedback included positive comments, suggestions and questions for Ms. Wu. When they commented on the lesson plan draft, some teachers provided their reasons to justify their suggestions while one teacher did not explain her reasoning about the suggestions. The reasons the teachers used to justify their suggestions fell into two categories—their own teaching experiences and general pedagogical principles. In what follows I use examples to illustrate the two categories.

One teacher drew on her own teaching experience to suggest that Ms. Wu could help the students understand what 7 in the operation 9-7=2 meant. "I taught my students to understand the meaning of 7 in this way: I asked them what 7 represented. If I used the question in Ms. W's lesson, most of my students would answer 7 represented the number

of boys' cards. Then I did what they answered to take away the seven boys' cards from the picture. Immediately my students questioned why there were still nine girls' cards left. They got a different answer. Some students would respond to this by saying that I should take away seven cards from the girls'. I feel my approach to this question worked very well. Hope it could be helpful for Teacher Ms. Wu" (Documents collected, 03/2006).

Five teachers suggested that Ms. W should skip the review of looking at the picture and answering the questions—comparing the numbers of green leaves and red roses at the beginning. For different reasons they all thought the review was redundant and inappropriate. Based on a general pedagogical principle, two colleagues felt it was inappropriate because Wu wanted her students to find out the method of matching one object in group A with one object in group B in the following activity. The review problems at the beginning would give the students a strong hint about this method that would decrease their feeling of success at exploring the new knowledge. Ms. Pei said in her feedback "The teacher should avoid using an obvious hint at the begging as she wants students to experience the method of matching" (Documents collected, 03/2006). One teacher mentioned that the two review problems were not strongly related to the next problem situation. Another two teachers argued that it was not hard for students to get answers to the review problems by using their previous knowledge. So it would be meaningless to have that at the beginning. They suggested that it would be better to directly present the problem situation and have the students explore the methods of solving the problem rather than repeating the previous knowledge at the beginning.

After the final public lesson Ms. Wu uploaded her lesson plan onto the website of the district that was accessible for all teachers in the district. Her refined and polished lesson plan became a learning resource for more math teachers. Symbolic tools established a framework for Ms. Wu and her colleagues to think about the lesson and engage in discussions about improving and refining the lesson. The framework that stressed the importance of teaching key and difficult points combined with the reform ideas such as connecting math with real life, and having students demonstrate their ideas. These functioned as learning resources for the teachers in the professional activities. When they were still exploring how to implement the reform ideas meaningfully in class, the collective discussions provided opportunities to develop their knowledge of teaching in the innovative way advocated by the reform.

Knowing their own weaknesses in practice

Teaching as practice in communities is a mixture of art, craft and science. Exposing a teacher's practice to her colleagues' critical eyes helps her realize the weaknesses she can work on for refining her practice. Knowing their own weaknesses could allow teachers to develop awareness of what competences they need to improve. Wenger (1998) points out that a community of practice functions as a regime of competence. That means participants of a community are expected to develop some competences for being competent members. In what follows I categorize and analyze what improvements the teachers thought they needed to make after participating in the joint work of preparing the

public lessons.

A math teacher's language should be concise, accurate, and mathematically appropriate

Ms. Li[6] acknowledged that her big weakness was her language—her ways to communicate mathematical ideas in class. She confessed that sometimes she did not feel comfortable to demonstrate a lesson because of that weakness. In the lesson the principal, Ms. Jin and her TRG colleagues observed Ms. Li did not use proper math language on several occasions. Ms. Zhang pointed out that Ms. Li made a mistake in terms of communicating the idea of rebundling and carrying one into the tens place. She found that when a student said 'adding ones, moving a place forward" Ms. Li repeated what the student said. That was a non-mathematical description of carrying one ten into the tens place used by many people in real life. But Ms. Zhang thought that description was not rigorous enough in a math class. According to her, Ms. Li should have told the students how to express that idea in rigorous mathematics language: carrying one to the tens place after adding ones and bundling.

Another inappropriate usage of math language was pointed out by the principal. She questioned if it was scientific that Ms. Li asked "There is an extra one in the tens place. Where is the extra one from?" Ms. Zhang and Ms. Jin followed her comment. They thought the first statement "There is an extra one in the tens place" was acceptable, but the question was not accurate. It should be put this way—where is the extra ten from. The

[6] Ms. Li taught the same lesson as Ms. Pu's public lesson on the day following Pu's public lesson. The principal, the head of the school math TRG, and the other three first grade math teachers observed her lesson that was counted as a public lesson within their TRG.

principal thought her inaccurate math language might confuse the students. She recommended that Ms. Li needed to think carefully about her language when she prepared each lesson. In the lesson when Ms. Li asked the question, a student answered that "there is a ten in the ones place so moving a place forward". That showed that the student understood the question "Where is the extra one from". But when Ms. Li pointed to another problem 27+9=36 and asked the same question, only one student responded to her. Then she summarized what they learned in the lesson. I can not conclude if her question confused the students so that they did not respond to her, but obviously pointing out the extra ten would help students understand rebundling better. For her colleagues, she was expected to be able to use rigorous mathematics language in class. However, as Ball et al (2005) state, knowing when imprecise or ambiguous language might be pedagogically useful and when it might do harm to the development of correct understanding is a competence teachers need to have. For Ms. Li, she still wrestled with when she should communicate mathematical ideas with accurate mathematical language and when she should allow the students to use imprecise language to demonstrate ideas.

Responding to situations effectively that emerged in class

Teachers need to make spontaneous decisions in every class as they can not anticipate all that would happen in class. Preparing and conducting a public lesson provided a chance for the teachers to reflect upon the teaching opportunities they missed and could have used to push students to think. After Ms. Sun watched and commented on the videotaped

final public lesson of Ms. Wu, Ms. Pu and Ms. Li sought advice from Sun on how they could respond to some situations effectively that emerged in class and they had not anticipated. There are no other ways than accumulating and reflecting upon experiences. That was Ms. Sun's answer. In the interviews with the teachers, Ms. Li, Ms. Pu and Ms. Wu all mentioned that one of the aspects they needed to improve was to effectively respond to some pedagogical situations that emerged in class so that they would make use of the situations to enhance student learning.

Looking back at the public lesson, Ms. Pu thought there was one situation she did not handle well. "Like what Ms. Lin commented, I did not take hold of the opportunity to reinforce the new knowledge when we worked on 8+33" (Interview, 03/16/2006). In the lesson a boy composed a problem 8+33 and called on another boy to answer it. The boy who was called on first said the answer was 91. Ms. Pu paused and looked at the class. Some students murmured the answer was 41. The boy immediately corrected his answer. Then Ms. Pu asked him to explain his solution method. The boy said he added 8 to 3 in the ones place and add 11 to 30. Ms. Pu asked the whole class why he added 8 to 3. A girl said it was because they added numbers in the ones place. Ms. Pu paraphrased her answer that they needed to add 8 ones to 3 ones. In the reflection meeting with the colleagues from other schools, Ms. Lin suggested that she could have spent more time on this problem. It was a good opportunity to deepen students' understanding of the concept of place value and rebundling. She felt that Ms. Pu could have asked students which 3 they added 8 to.

In the interview Ms. Pu told me that she did not anticipate students would create such a problem, which made her fail to make use of the features of the problem for hammering student understanding of rebundling and place value. Problems such as 8+33 had two features: a one-digit number goes before a two-digit number and the two-digit number has the same digit in the ones and tens place. But she could not come up with an idea on how to seize the opportunity to help student learn the concepts at that moment. She realized that she needed to develop her ability to effectively respond to some situations that occurred in class but went beyond her anticipation.

Ms. Li made a similar reflection in her interview. She said, "I need to pay attention to what students say and make sense of their thinking. Listening to their ideas carefully is really important" (Interview, 03/16/2006). She gave an example to show her failure to listen to what her students said and understand their thinking. When they studied the problem 27+6=33, one student was called on to explain his own solution method. He said he wanted to add 27 to 3. But Ms. Li interrupted him and asked him what he said. The boy changed his answer: 7+3=10, 10+3=13, 13+20=33. That was the method the textbook provided and Ms. Li had planned. In the interview she said the boy's original method was really good. He used the method of making multiples of ten: 27+3=30, 30+3=33. In the lessons of Ms. Pu and Ms. Zhang no student came up with this method. She felt she should have taken hold of that opportunity to encourage students to solve the problem in different solution methods.

The joint work of conducting public lessons offered a chance for the teachers to see

the aspects they needed to improve in practice. Without the colleagues' critical reflection, the teachers such as Ms. Pu might not be able to realize how hard and important it was to grasp pedagogically meaningful opportunities that surfaced in class. As a teacher with ten years of teaching experience, Ms. Li still struggled with her language. That weakness even made her reluctant to teach a public lesson. It was understandable that Ms. Li felt being put on the spot when conducting a public lesson because she knew she would make mistakes in her speech. However, it was the joint work that bit by bit helped her develop the ability of using accurate and proper mathematical language. The school-based teaching research groups worked as regime of competence to make it more visible for the teachers what teaching competences were expected, and to help teachers develop those competences. Below, I discuss how the TRG's public lessons actually created possibilities for the teachers to generate new knowledge

Generating and sharing knowledge for teaching elementary mathematics

A third pathway to instructional improvement is through enhancing and deepening teacher knowledge. When the teachers collectively studied and refined the lessons, they generated knowledge in practice that was socially constructed in the communities through reflection and inquiry. It was not personal knowledge possessed only by experts who had the knowledge needed to teach well; instead, it was shared and situated knowledge developed by the teachers together in the communities. In this part I argue that the activities of Ms. Wu and Ms. Pu preparing and conducting their public lessons

generated mathematical knowledge for teaching and knowledge of instruction. First, with two cases I illustrate how the teachers discussed and generated the mathematical knowledge for teaching. Then I analyze three cases to show the knowledge of instruction produced and shared by the teachers.

Mathematical knowledge for teaching

I first analyze the case of Ms. Pu and her colleagues preparing the public lesson to show how the community generated local math knowledge for teaching. The case was about the numbers Pu should use in the key sample problem of the lesson. Next drawing on the data of the two public lessons, I explain that mathematical language was an important part of the mathematical knowledge for teaching.

Case 1: What numbers should be used in the sample problem?

Originally Ms. Pu used the following numbers in the sample problem setting: 27, 2, 38, 5 and 9. The problem was:

Mingming will celebrate his birthday. His mom gives him $50 to buy two gifts. Mingming can choose his gifts from the following toys—car $27, chicken $2, basketball $34, rabbit $6, and bear $9. Please choose two toys for Mingming that you like most and calculate how much you spend.

She expected that the students would choose two numbers to add together. With these numbers in the problem setting, she held the rationale that students would find four types

of addition, including one-digit numbers plus one-digit numbers, two-digit numbers plus one-digit numbers without carrying, two-digit numbers plus one-digit numbers with carrying, and two-digit numbers plus two-digit numbers with carrying. The new content of the lesson was to learn how to add a two-digit number to a one-digit number with carrying. She chose to use 27 and 5 as the numbers to teach the new content. Around the numbers in the problem, Ms. Pu and her colleagues discussed three issues. Their discussions of the first two issues happened in the weekly group meeting of the first grade TRG where the four teachers collectively revised the lesson plan. For the third issue, they discussed it in the debriefing and reflection meeting after the rehearsal lesson.

First, in order for students to understand rebundling in addition better, Ms. Pu's colleagues suggested that she replace 38 with 34, and 5 with 6. Ms. Pu planned to have students make sense of rebundling through comparing addition of two-digit numbers plus one-digit numbers without carrying to addition of two-digit numbers plus one-digit numbers with carrying. Ms. Wu and Ms. Zhang suggested if she could add one more addition without regrouping as with the current numbers, students could only find one addition operation without carrying 27+2. Ms. Li and Ms. Pu quickly went through the numbers and realized that there were five addition operations of a two-digit number plus a one-digit number with carrying. Ms. Wu thought that having only one addition without carrying was not enough for students to observe the difference and compare the two kinds of addition. Meanwhile, after changing 38 into 34 and 5 into 6, there would be a "special" addition with carrying that was 34+6. This addition would allow students to see ten ones

making one ten more clearly as 4+6 equals 10. Ms. Pu accepted their suggestion and used 27 plus 6 as the key problem to teach addition with carrying.

Second, the teachers argued about what an appropriate estimation of 27 plus 38 should be for first graders. When students were asked to pick two gifts, it was possible that 27 and 38 were chosen although the problem implicitly indicated that the total cost of the two gifts could not be more than $50. Ms. Wu and Ms. Zhang asked Ms. Pu why she gave students these two numbers as students had not learned two-digit number plus two-digit number with rebundling. Ms. Wu even suggested changing one of the two numbers into a one-digit number. Ms. Pu responded that she picked the two numbers on purpose. She wanted to have students estimate the sum of the two numbers. Ms. Zhang expressed concern about whether or not students were able to estimate the sum of the two numbers. Ms. Pu assumed that some may know how to mentally calculate the sum, and some who can not compute may estimate the sum in this way: 27+30=57, 57+10=67, 67 was close to 70 and 70 was bigger than 50. Ms. Zhang continued and surmised that students might say twenties plus thirties equaled fifties so that the sum of 27 and 38 was more than 50. She questioned if Ms. Pu allowed students to estimate that way. Ms. Pu disagreed because in real life a good estimation of the sum should be more than 60. Ms. Li thought students might consider 27 as 30 and 38 as 40 because both 7 and 8 are bigger than 5 and they can be rounded as 30 and 40. That was the way Ms. Pu anticipated her students would estimate the sum. Ms. Wu mentioned another way of estimation that was to consider one number as a smaller one and another number as a bigger one. Ms. Pu

thought that there were multiple ways of estimation and the methods mentioned by Ms. Li and Wu were both workable. Her purpose was to develop students' sense of estimation, although that was not the key of this lesson. But she did not share the same concern with Ms. Zhang, who doubted if students had the ability to estimate. She and Ms. Wu and Li seemed not to accept what Ms. Zhang proposed, that something in the fifties could be an appropriate estimation.

"Estimating before solving a problem can facilitate number sense and place-value understanding by encouraging students to use number and notational properties to generate an approximate result" (Kilpatrick et al, 2001, p.215). Ms. Pu had the intention to develop students' number sense. She wanted to use the problem 27+38 as an opportunity to have students estimate a two-digit number plus a two-digit number with rebundling. Estimating the result of 27+38 requires students to have a good understanding of place value, especially understanding the tens place. Both methods offered by Ms. Wu and Ms. Li required reformulating the numbers 27 and 38. One is to estimate the result of 27+38 by rounding 27 as 30 and 38 as 40. The other is to estimate the result by reformulating 27 as a smaller number and 38 as a bigger number. As for Ms. Zhang's method--27 is more than 20 and 38 is more than 30 so that the sum should be more than 50, Ms. Pu did not think it was a proper method. She argued that estimation should be connected with real life. In real life an appropriate approximation of the result should be more than 60. However, the appropriateness of an estimate is related to the problem and its context (Markovits & Sowder, 1994). Regarding the condition of the

problem that the total sum can not be more than 50, Ms. Zhang's method was reasonable. In the final public lesson, some students did shout out their answer to the problem of 27 plus 34 as more than 50. However, Ms. Pu, Ms. Wu and Ms. Li expected that students would give a more exact estimate of the sum than did Ms. Zhang.

Last, untangling the phenomenon that students did not come up with multiple solution methods to calculate 27 plus 6, Ms. Pu and her colleagues argued if that was because of the two numbers she chose. In the debriefing and reflection meeting after Ms. Pu rehearsed the lesson, Ms. Jin, who was the head of the mathematics TRG of the Tower School, commented that Ms. Pu could have done better to engage students in solving the problem 27+6 with multiple solution methods. The standard method of mental calculation was first adding ones--7+6=13, and then having the number 13 added to 20--13+20=33. Another solution method offered by the students was to have 7 add 3, 10 add 20 and then add 30 to 3. Ms. Jin felt that reinforcing this standard solution method constrained student thinking about their own solution methods too much. Drawing on her observation experience of a study lesson in the district, Ms. Pu defended her instruction. No matter how many solution methods students could invent, the teacher in that study lesson aimed at having every student master at least one solution method proficiently. Ms. Pu took that lesson as a reference to design her public lesson. She wanted all students to be able to mentally calculate problems of a 2-digit number plus a 1-digit number with rebundling by using the standard method. Ms. Zhang offered her alternative explanation why the students were not able to invent more solution methods. She reasoned that the numbers

Ms. Pu used might cause that phenomenon. She said,

> I think the numbers given in the problem partly led to the fact that kids did not have various solution methods. The numbers in the book are 69 and 4. If you used these two numbers, students might get different solution methods. Because 69+1=70, 70+3=73.The numbers you used today, 27 and 34, are not like the number 69 that is close to multiples of ten [70]. And what kids already learned, multiples of ten plus one- or two-digit numbers does not allow varieties of solution methods. Only a two-digit number plus a one-digit number with regrouping allows kids to come up with various solution methods. The numbers in the book could be given on purpose for getting kids to think about different methods. When you asked the students to solve the problem in different ways and they could not, I sat there and thought that was because of the numbers you used (transcription of the meeting on Mar.13, 2006).

Ms. Wu followed this comment and suggested if Ms. Pu might change the numbers to elicit multiple solution methods from students. Ms. Zhang continued her comments and speculated that using sticks to learn addition and subtraction of multiples of ten might restrain students from inventing multiple ways to solve problems because they always wanted to bundle ten sticks [such as 7+3=10]. However, Ms. Pu did not respond to Ms. Zhang's comment in the meeting. She insisted using 27 and 6 in the final public lesson. In the interview she explained her disagreement,

> I think the feature of numbers has little impact on student thinking. If they do not know the method of making ten, the feature of numbers cannot lead to that kind of method [69+4=69+1+3=73]. The feature of numbers does not play a key role. But, of course, if the number is close to multiples of ten, it might be easy for students to think of that method (Interview, 03/14/2006).

Although no research justifies either Ms. Pu's or Ms. Zhang's idea, and the teaching guidance book does not spell out if the two numbers 69 and 4 are given on purpose, the public lesson offered an opportunity for the teachers to interpret the textbook and probe into the phenomenon that students were not able to come up with multiple solution

methods. For Ms. Zhang, because 69 is close to 70 students might find it easy to invent their own methods for solving 69+4. The numbers 27 and 34 used by Ms. Pu might constrain student thinking by leading them to the method of making ten that they learned before. In the rehearsal lesson and final public lesson, the only extra method offered by her students was to add 7 to 3--7+3=10, add 10 to 20--10+20=30, and add 30 to 3--30+3=33. No other solution method was invented by the students although Ms. Pu envisioned in her lesson plan that students might solve the problem with another three methods: counting up from 27, breaking 27 into 24 and 3—24+6+3=33, or breaking 27 into 23 and 4—23+(4+6)=33. Ms. Zhang's speculation seemed to be proven reasonable. Collective reflections upon the lesson opened up a possible opportunity for the teachers to think about the math knowledge pedagogically. Yet, it is unfortunate that the teachers did not have a chance to test out either Ms. Zhang's hypothesis or Ms. Pu's reasoning.

Discussing the numbers Pu should use in her lesson called into play different kinds of knowledge, which engaged the teachers in thinking about math knowledge in a pedagogically useful way. The numbers she used were changed to be more conducive to students' learning the new content of rebundling and reviewing the old knowledge about addition. Regarding the fact that students could not produce more solution methods, the teachers related the feature of the numbers to student thinking about multiple methods. Although they disagreed on whether the feature of the numbers mattered, they acknowledged that numbers close to multiples of ten might more easily lead students to invent more methods. To decide on the appropriate estimation of the value of the sum, the

teachers connected their knowledge about the ways of estimation with math in real life and first graders' ability to estimate appropriately. Conducting the public lesson opened up an opportunity for the teachers to generate and develop their knowledge for teaching addition to first graders.

Case 2: Using mathematical language to communicate mathematical ideas clearly, accurately and concisely

In their research Ball et al (2005) raise the issue of the centrality of mathematical language in the work of teaching. Mathematical language is centered in teachers' instructional practice because it is necessary for clear mathematical communication and foundational to mathematical reasoning. They found that teachers need to decide on how to define and use mathematical terms, whether to allow informal language to express mathematical ideas, when and where to introduce and use formal mathematical vocabulary. Paine (1990) describes a "virtuoso model" of teaching that Chinese teachers taught in a precise and elegant language. In my fieldwork, the teachers in the Tower School thought highly of mathematics teachers' language. Ms. Zhang and Ms. Hu mentioned that being able to use accurate and concise math language is an important part of math teachers' competences. Amazed at the shared math language I heard and did not know, one day I told Ms. Su that I would like to learn about the terms. Ms. Su responded to me that as a math teacher they must use accurate math language to communicate ideas concisely. When the teachers prepared their public lessons, mathematical language was

one of the foci the communities paid attention to.

In the case of Ms. Wu, she and her colleagues discussed whether Ms. Wu should allow students to use their own term to express mathematical ideas and when she could expect them to use the formal mathematical term in class. Although her students learned the method of *matching* to compare two groups illustrated in Figure 4.4, they can not use the mathematical term *matching* to describe the method. They used their own language to explain how they made matching to solve problems. Ms. Wu corrected her students in the rehearsal lessons when they used the informal math term. After class Ms. Sun suggested that Ms. Wu could allow them to use their own term and she could use their informal term too. The students' informal term vividly described the method of matching as it gave them a concrete image of linking one item in group A to one item in group B. According to Ms. Sun, using students' term first would help Ms. Wu lead the students to the formal mathematical language later without being confused.

In the public lesson the students learned a new term about comparing difference that was "differing from" (*xiangcha* in Chinese). This term has a connotation about comparison that A is more than B or less than B. Students must make a judgment about its meaning in a specific problem setting. Ms. Wu introduced this term at the end of the second sample problem after the students learned the concept of more than and less than. In the lesson plans Wu wanted students to be able to use the term to express the concept of more than and less than, but the rehearsal lessons told her that students could not use the term to communicate the idea on difference although they knew its meaning. Thus she

gave up pushing them to apply the term to expressing the concept of more than and less than.

In the case of Ms. Pu her colleagues were concerned about whether her use of mathematical language was accurate. In her first draft of the lesson plan, Ms. Pu designed a practice problem: *What's the digit in the tens place of the sum? 57+8=□5, 6+54=□0. Where does the extra one in the tens place come from*?" When she and her first grade TRG colleagues collectively reviewed the lesson plan, Ms. Zhang questioned the appropriateness of the problem. She asked Ms. Pu what she would expect her students to answer. For her their answers to the first problem could be 60 or 6. Ms. Pu responded that she expected students to answer the digit was 6 while they must give an answer like this--the digit in the tens place was 6. Ms. Zhang showed concern that the problem might make students misunderstand one in the tens place as one instead of one ten. Ms. Pu explained that she wanted to present two concepts—the digit in the tens place and place value. She used an example. Last fall some of her students thought that the digit in the tens place of 12 was 10. What the digit in the tens place means and what that digit is are two different concepts. Ms. Zhang kept questioning her idea. She said, "This problem would have students confused about addition with rebundling". Yet, she confessed, she was not so sure about what caused the confusion. It could be that students focused on 6 while ignoring the one more ten in the tens place. 6 and the one more ten in the tens place could conflict with each other because the 6 referred to six tens. Ms. Pu disagreed with her because she thought students should be trusted to be able to understand the two

concepts. Ms. Wu jumped in to support Ms. Pu's idea. She anticipated that students would know that the one more in the tens place was one more ten and 6 was 6 tens when they were further asked where the extra one in the tens place came from. Ms. Zhang said they needed to see students' reaction when Ms. Pu tried out the lesson next week.

In the subsequent interview Ms. Pu thought the problem was appropriate. Her aim was to help students develop a clear concept of place value—digits in different places mean different values though they look the same. She guessed that Ms. Zhang may be afraid to let students confront their confusion. She continued to emphasize her idea that students should have an opportunity to confront the mess of their thinking and gradually get a clear picture of concepts with the teacher's help. She noticed that sometimes teachers felt fearful of letting kids be confused for a while. The key was to guide students how to get out of their confusion and messy thinking.

In the rehearsal and final public lessons, Ms. Pu did not use that problem. But in the final public lesson, she raised a similar problem when having students compose problems of two-digit numbers plus one-digit numbers with rebundling. After one boy explained his procedure of mentally calculating 22 +9, Ms. Pu wrote down the operation 22+9=31 on the blackboard and asked:

Pu: I'd like to know what the digit in the tens place of that sum is.
S1: 20.
Pu: What is the digit in the tens place?
Ss: 30.
Pu: What's it?
Ss: 3.
Pu: The digit in the tens place is 3. It means three tens, 30.
(Transcription, 03/15/2006)

Obviously, her students reacted the way Ms. Zhang anticipated they would. Their original thinking about the answer was 30 instead of 3. As Ms. Zhang mentioned, it was not surprising that the students thought the answer was 30 because the teachers had been reinforcing the concept of place value—what a digit in the ones place or tens place means. They did have confusion about the digit and the meaning of the digit in the tens place, but the problem seemed not to lead to misunderstanding of rebundling. In Ms. Li's class, she asked the similar question. For 32+8=40, she asked the class where the digit in the tens place-4 came from. A boy was singled out and answered it was because there were ten ones in the ones place and moved the one into the tens place. Although both of the two lessons did not confirm Ms. Pu's reasoning that students were able to understand place value and rebundling ten ones into one ten while being clear about the question—what the digit in the tens place was, the students were exposed to the two concepts and their conception of rebundling was further solidified. Ms. Zhang's concern about the language Pu used in the problem could in a sense remind her colleagues of the importance of having students understand the meaning of a digit in the tens place and the concept of rebundling.

The joint work of preparing the public lessons gave the teachers an opportunity to dig into the important area of using mathematical language in teaching. They discussed whether to allow students to use informal language, where to introduce formal math terms, and when to require students to use formal math terms. Also as the case of Ms. Pu demonstrated, the public lesson engaged the teachers in arguing about their different

ideas on students' understanding. When they could not settle their disagreements in the meetings, they went to test their different hypotheses in the lessons. They wanted to see what would happen when different ideas were adopted and implemented in class. That eventually would increase their knowledge of student understanding.

Knowledge of instruction

The public lessons not only helped the teachers discuss and acquire mathematics knowledge for teaching, but also enriched their knowledge of instruction, especially knowledge of innovative instruction called for by the reform. In this part I draw on both of Ms. Wu and Pu's cases to illustrate the following knowledge of instruction was generated and discussed by the communities: helping students unpack the mathematical ideas through demonstration, explanation and comparison; using manipulatives appropriately to facilitate student learning; and designing good practice problems to consolidate and apply new knowledge. Below I explain the three kinds of knowledge in detail.

Case 1: How could Ms. Wu help her students unpack the mathematical ideas?

First graders learned the method of "matching" to solve difference problems that were presented in pictures in the fall semester. For example, they knew how to solve the following problem (Figure 4.4) by matching each red rose with each green leaf and finding out how many green leaves were left.

Figure 4.4 Use the method of matching to solve the problem

This semester students were expected to solve word problems about difference by using subtraction operations. As I mentioned above, the key point of the lesson was to help students build on their previous knowledge to understand the new method of solving word problems about difference. The problems were not presented in concrete pictures any more; instead, they were stated in words with different expression. The different ways to express this kind of problem in words include: how many more A is than B, how many less B is than A, and what is the difference between A and B. "Difference between" is a formal mathematical term in Chinese. The difficult point of the lesson was to understand the rationale of using a subtraction operation to solve word problems about difference. In other words, it was to understand the comparison interpretation of subtraction.

In the process of helping Ms. Wu prepare the public lesson, Ms. Wu, Ms. Sun, and her five colleagues of the district TRG focused their discussions on how Ms. Wu could better help students understand the key and difficult mathematical ideas. Based on their own teaching experience and their understanding of the math knowledge, they suggested that Ms. Wu should allow students to demonstrate and explain their own ideas. They tried to help her change from the IRE interaction format (Meghan, 1979) with students to a format that engaged students in demonstrating, discussing and arguing. That was one of

the innovative instructional approaches recommended by the new math curriculum standards. To learn the key concepts, they recommended that Ms. Wu ask students to compare problems in which the three concepts were used respectively.

First, Ms. Wu and her colleagues thought it was important and necessary to have students understand what each number in the operation of 9-7=2 referred to concretely. Subtraction can be interpreted in two ways, comparison and "take away". For a subtraction operation 9-7=2, common sense tells that we take away 7 from 9. But in concrete problem settings that does not hold true always. The sample problem in this lesson--There were nine girls and seven boys who were selected to join the Young Pioneers[7]. How many more girls there were than boys, was to compare the two numbers representing two different groups. Ms. Wu and her colleagues anticipated that most students would misunderstand that 9 minus 7 was to taking 7 boys away from 9 girls. They wanted students to understand the comparison meaning of subtraction that 7 in the operation referred to the seven girls that were as many as the seven boys. What was "taken away" from 9 was seven girls instead of seven boys.

The teachers thought it was important for students to understand this point when they first learned the comparison meaning of subtraction. In the reflection meeting Ms. Gu asked if it would be appropriate that the teacher told students to subtract a small number from a big number in the lesson. Ms. Sun said 'no" and explained that students

[7] The Young Pioneers are a national youth organization run by the central government in China for elementary students. It is an honor for students who are approved to join it.

needed to understand what was subtracted. "Telling them to subtract the small number from the big number would get them confused at what is subtracted in the operation" (Transcription, 03/22/2006). But ultimately, Ms. Sun thought the teachers could help students know the quantitative relationship between two numbers without thinking about what concrete representations each number matched. They agreed that the steps through which the teachers helped students unpack the mathematical difficult point was: to start off from the symbolic representation 9-7=2 that most students were able to compute; next, the teachers wanted students to map the symbolic representations onto the concrete representations in the problem setting; and then students were led to come back to the symbolic representations and understand the quantitative relationship between compared numbers without concrete aids.

To help students get at the difficult point, Ms. Wu's colleagues suggested that she could allow students to demonstrate their different ideas and argue with each other to find the comparison meaning of the subtraction operation. After observing the rehearsal lesson, her colleagues observed that Wu did not motivate the students to discuss their different interpretations of the meaning. Ms. Rui felt that teaching students to understand the operation 9-7=2 should have been the hot lava of the lesson by engaging them in demonstrating their different ideas. But she observed that Wu did not motivate students to argue and justify their answers with each other. She described, "You gave the answer instead. 'Is this right?' The students said 'yes'. They did not have a chance to discuss. You should have them figure out the right answer through discussion" (Fieldnotes,

03/22/2006). Ms. Sun, held the same opinion with her that Ms. Wu should have allowed students to discuss what was circled[8] because the discussions would lead to cognitive conflicts among students and finally help them understand what 7 referred to in the picture and their manipulatives. She noticed that some students questioned why the seven yellow squares were covered and there still left the nine red squares, but Ms. Wu failed to take this chance to push them into deep discussions. Ms. Wu offered the answer herself instead of having students explain and demonstrate their ideas.

In the next reflection meeting, Ms. Sun offered specific strategies to invite students to explain their thinking about the meaning of the operation. "If they [students] were frozen there, you should have broken the ice immediately. You can ask them who else does it the same way. If someone does, you can ask her or him to talk about the reason" (Fieldnotes, 03/24/2006). Ms. Wu continued to consult with Ms. Sun about what she could do if her students could not articulate their reason. Ms. Sun suggested inviting other students who did differently to demonstrate their reason. If the students still could not explain clearly or Wu could not follow their ideas, Sun said that Wu could do what the students did-- circle the seven boys. She imitated what Wu could respond, "Let's see if I take away the seven boys, what's left? Do you think that the number of the girls changes?" (Fieldnotes, 03/24/2006). Sun offered two options for Wu to react to the situation, showing the answer directly or having the students who had a different answer

[8] In this rehearsal lesson Ms. Wu provided students nine red squares and seven yellow squares, and a paper loop. Students were required to use the loop to circle the seven things that matched 7 in the operation.

to explain their thinking. Wu decided to take the second option.

In addition, for understanding the key concepts of the lesson—more than, less than and difference between, Ms. Wu's colleagues thought it would be helpful to have students compare problems each of which used a different concept . As Ms. Sun pointed out, the three concepts were simple but basic because they laid foundations for students to solve complicated word problems related to difference. "In fact it is not hard for students to solve them using subtraction within 100, but they need to realize that they use subtraction to solve the problems. At least they develop an imagery to react to those kinds of problems. Later on when numbers become bigger and the relationships among numbers become more complex, they cannot use concrete representations to solve similar problems.... understanding the three concepts clearly will help them solve difficult problems" (Transcription, 03/22/2006). After reviewing the draft of the lesson plan, Ms. Zhao in her feedback wrote that Ms. Wu could ask students to observe how the two problems that respectively asked how many A was more than B and how many B was less than A were related to each other. Similarly, in the reflection meeting Ms. Pin, Ms. Rui and Ms. Gu mentioned again that Wu should have emphasized the three concepts through having students observe and compare the problems on their own. For example, Ms. Gu commented, "Regarding the questions that which is more and which is less, I feel that you might spend more time helping students see the commonality and difference between the two problems. They need to understand what the reference is in each question. The reference changes, but they ask about the same thing—the difference between two groups.

This will prepare them to learn what the reference is and what compares with what in the future. I think you went too fast in this part and the students seemed not to understand it fully" (Fieldnotes, 03/22/2006).

Here Ms. Wu's colleagues took a deep look at the simple concepts. They related the concepts to students' future learning and pointed out the importance of reference to understand the concepts of more than and less than that would prepare them to solve complicated word problems in the future. Comparing the problems that used different expressions could allow students to see the basic relationship embedded in a problem about difference that involved two things or two numbers and one of the two things was the reference for comparison. After understanding this relationship, students would come to discover that they can use the same subtraction operation to represent the quantitative relationship between the compared two numbers.

In what follows, by comparing the two episodes of Ms. Wu's instruction of the first sample problem on Mar.22 and 29, I try to demonstrate the changes in her ways of interacting with students. I code her responses in the two episodes and come up with four categories of her "talk moves" (Chapin, O'Connor, & Anderson, 2003). "Talk moves" are a teacher's talk strategies used to support mathematical thinking. The four categories include inviting students to demonstrate ideas, using wait time, revoicing and inviting students to explain and justify their thinking. Appendix B shows examples of the four categories. I find, with her colleagues' help, Ms. Wu tended to use wait time and give students more floor to justify their ideas in the final public lesson than in the rehearsal

lesson.

On Mar.22 Ms. Wu tried out the lesson the second time. That was the first rehearsal lesson I videotaped and her district colleagues observed. The lesson conducted on Mar.29 was the final public lesson. I focused on how Ms. Wu interacted with her students in the two lesson episodes in order to identify the improvement she made with her colleagues' support. The first episode on Mar. 22 was about ten minutes long, with 58 utterances. The second was about fourteen minutes long, with 86 utterances. Obviously, Ms. Wu spent more time communicating the understanding of the first sample problem with her students on Mar.29 than on Mar.22.

On the whole, inviting students to demonstrate their ideas was the strategy she used in both episodes, but there was no significant difference identified in her use. She always invited the students who were called on to spell out their answers by asking "how do you know?". In a revoicing move, a teacher repeats or rephrases what a student says and asks him or her to verify whether or not the revoicing is what he or she means. She did not use the strategy of revoicing in the lesson of Mar.22. On Mar.29 she used it once, but that did not weigh a lot to help students unpack the mathematical idea. The significant changes lay in employing the strategies of using wait time and inviting students to explain and justify their ideas.

Using wait time means giving a student who is called on time to organize thoughts. In the lesson episode of Mar.22 I do not find Ms. Wu used this strategy. In contrast, on Mar.29th Ms. Wu adopted the strategy of using wait time to allow the

particular student to put his thought into words. After discussing that the problem can be solved through matching one red cube with one yellow cube, Ms. Wu asked the students if they had other solution methods. The boy raised his hands and said he wanted to compute directly. But he could not spell out what he meant when he was asked how he would compute directly. Ms. Wu gave him time to organize his thought. When no response came from the boy, she ensured him that was not a big deal if he could not speak out his idea now. Using wait time is conducive to stopping students from jumping to conclusions too quickly. When Ms. Wu discussed the meaning of the operation 8-6=2, the students thought 6 referred to the six yellow cubes or the six students of Class One (See the transcription of the lesson on Mar.29 in Appendix. The problem setting was changed in the final public lesson). Ms. Wu told the students not to be in a hurry and asked them to discuss with their partners.

The significant difference was obvious in her use of the talk move—inviting students to explain and justify their ideas to deepen their mathematical thinking. Only one utterance in the episode of Mar.22 was identified as this kind of talk move; however, it was not done directly by Ms. Wu. She had other students raise questions for the boy who was singled out to circle the cubes that corresponded to the subtrahend in the operation 9-7=2[9]. Another boy (B5) stood up to ask him why he circled the yellow seven cubes. No response was followed. Then Ms. Wu asked B5, "Do you want to ask if the circled yellow

[9] The numbers in the two sets were 8 and 6 in the final public lesson. The original were 9 in one set and 7 in the other set.

cubes include any red cubes?" She got no response from him. It seemed that the boy did not make sense of Ms. Wu's question or her paraphrasing his question why the yellow cubes were circled. He might not have thought about whether or not the yellow cubes included the red cubes. Ms. Wu's question for him was not clear enough to push the student to explain his thinking.

In the lesson conducted on Mar.29 Ms. Wu used this strategy in a better way, which was shown from her relatively long conversations with the students compared to the conversations she had on Mar.22. When a boy raised a question for the girl about how she knew the answer was two more as she circled the six yellow cubes, the girl was not able to answer it. She kept silent. Ms. Wu guided the students to re-look at the operation 8-6=2 and had them think about the meaning of 8. The students had a consensus that 8 referred to the quantity of Class Two and did not include any student from Class One. Then Ms. Wu invited other students who did the problem in a different way to share their ideas. A girl came to the blackboard and circled the six red cubes. Different from what she did on Mar.22, Ms. Wu did not hurry to explain it to the students. She had the girl explain her thinking to the class. The girl's explanation was that the operation was to subtract 6 students in Class Two from 8 in Class Two. Then she got the answer that was two more. Following her explanation, Ms. Wu synthesized "In fact we take away 6 from 8 in Class Two. The six is as many as the number of students in Class One. Then we find the answer is that Class Two has two more students than Class One".

In general there was no breakdown in communication in the episode of Mar.29.

Ms. Wu accepted her colleagues' suggestions to give her students more opportunities to organize and explain their thinking. Learning became engaging when she made her questions and responses clear to the students and used the talk moves to support the students' mathematical thinking.

Case 2: Using manipulatives in a way to better student learning

Using manipulatives is highly recommended as a constructivist approach to learning in the national curriculum reform. How to incorporate manipulatives into instruction and have students use manipulatives to solve problems is a new issue most Chinese mathematics teachers are still exploring. One study (Cai & Cifarelli, 2004) reveals that Chinese students strongly prefer using abstract strategies and representations to solve problems compared to concrete strategies and representations. The researchers infer that might be related to a fact that Chinese math teachers highly regard abstract strategies. Chinese math teachers tend to have students master generalized solution methods that can transfer to other problem situations. The new math standards call for learning math through working on manipulatives that could facilitate students to solve problems. Reading the articles written by elementary teachers (Bai, 2007; Liu & Chi, 2007), I find that teachers sometimes felt manipulatives were not used meaningfully by elementary math teachers.

In the Tower Elementary School, Ms. Zhang claimed to her colleagues that she felt manipulatives might constrain student thinking. In her class she found her students

always tended to make ten because they were used to bundling ten sticks. Therefore, this proclivity led students to always use the method of tens combination to solve problems (Fieldnotes, 03/13/2006). For example, when solving 27+6, most students liked to break 6 into 3 and 3, and add 7 to 3 instead of adding 27 to 3. For Ms. Zhang, using sticks restricted students from inventing multiple solution methods to solve problems. The reform call was not implemented successfully in terms of promoting student math learning.

The public lesson activity offered Ms. Wu an opportunity to carefully think about using manipulatives. With her colleagues' suggestions Ms. Wu kept revising the design of having students use manipluatives. Ms. Wu made red and yellow cubes or girls' and boys' figures for students to learn the first sample problem. How to use the concrete objects to serve the goal of teaching and learning was refined and changed. In the rehearsal lesson that her colleagues observed on Mar.22 Ms. Wu asked the students to use the manipulatives to solve the problem of how many more red cubes there were than yellow cubes. When debriefing the ways to solve the problem, one student was called on to come to the front. The student worked on the representations on the blackboard and showed the class that he matched one red cube with one yellow cube to find the answer. Then all the students were required to use their own manipulatives to find the answer as that student did. In the next step when teaching the students to understand what 7 in the operation 9-7=2 meant, she directed the students to work on the manipulatives again for using a loop to circle the seven things that matched the number 7 in the operation.

Ms. Sun revised the lesson plan[10] in which students were not asked to use the manipulatives to find the answer to the key problem—how many more the girls were than the boys. As Sun pointed out, most students can mentally tell the answer from the picture shown in the PowerPoint file. Working on the manipulatives to find the answer became meaningless. Instead of encouraging them to work on the manipulatives to find the answer, according to Sun' suggestion, Ms. Wu gave students more room to use their own ways to solve the problem. In the final public lesson her students offered two ways to solve the problem. One was matching one by one and the other was counting and calculating. The changes she made saved her several minutes to engage students in more important activities such as understanding what 8, 6 and 2 in the operation 8-6=2[11] referred to. She showed the students Class Two can be divided into two parts on the blackboard. One part was as many as Class one and the other part was two more children than Class One. She required the students to do what she did on the blackboard--using their manipulatives to divide Class Two into two parts while speaking out their thinking process. After this step Ms. Wu organized students to discuss with their partner what 6 in the operation matched and used a loop to circle the six children in their manipulatives that matched 6 in the operation. Thus the manipulatives was only used to facilitate students to make sense of the comparison meaning of subtraction. Finally, Ms. Wu used

[10] Wu sent her lesson plan to Ms. Sun via email over the weekend following the rehearsal lesson on Friday.
[11] In the final public lesson Ms. Wu used the numbers 8 and 6 instead of 9 and 7 because the problem setting was based on a real school event.

the manipulatives in a more productive way that helped students understand the difficult mathematical ideas. That also saved time for her to instruct the new content.

Case 3: Designing good practice problems to consolidate and apply new knowledge

Practice problems are an integral part of a standard procedure of a lesson in Chinese classes, as it is taken for granted that practice problems can be used to assess if students master the knowledge as well as consolidate and apply what they just learn in a lesson. For a public lesson teachers usually design practice problems carefully and continue refining them throughout the rehearsal process.

When Ms. Wu revised her lesson plans and tried out the lesson, she kept working on practice problems. According to her colleagues' suggestions, practice problems should make sense to students. In the reflection meeting, both Ms. Gu and Ms. Le thought that some students got confused at some of the problems in the practice. One reason was that some words in the problems did not make sense to them, such as "expensive", and "cheaper". Another reason lay in that Wu imposed those problems on students who were too young to relate their life experience to what Wu asked. "When you asked what other vocabularies can describe more than and less than in life, I observed the students got confused and had no clue. Anyway they are first graders and have less life experience in this", (Transcription, 03/22/2006). Following this, Ms. Sun told Wu that she did not need to ask students to do that. She can tell students in life there were some words to express a similar meaning as more than and less than.

To design the practice problems, Ms. Sun provided some general guidance:

* Practice problems should be comprehensive and related to life. Comprehensive practice means it connects old knowledge with new knowledge, includes different types of problems such basic procedural problems, problems with multiple conditions, problems that need conditions, problems that can be solved in multiple solution methods, and some open-ended problems that "typically require novel exploration of the problem situation" (Cai & Cifarelli, 2004).

* Students should be organized to work on practice problems in different ways such as independent work, chorus answering, using gesture and small group work.

With this guidance, Ms. Wu worked with Sun to revise each problem in the practice. The key changes were in small group activities and designing the open-ended problem. In the rehearsed lesson Ms. Wu had students work in small groups to figure out the last two practice problems. The students were grouped into four and she circulated the class to help out. Ms. Sun thought that it was not necessary to arrange group activities for finding the answers to the two problems. Ms. Rui agreed with Sun that she did not see how the small group activities were helpful and useful for students' learning. Ms. Sun suggested designing an activity to engage students in meaningful group work. To have meaningful small group activities, they decided that students would be organized in a group of four to compare how many awards they won in the math class this semester. Based on the information, the four students could compose problems using more than, less than and difference between to ask each other. Then Wu would call on several small groups to

report to the whole class. For the last practice problem, Sun suggested designing an open-ended problem. The final practice problem was as follows: Mary has 6 candies and Kate has 10 candies. How many more would Mary have to get from Kate so that they have the same amount of candies? Ms. Sun pointed out that the goal of this problem was to expose students to a problem of equal distribution and connect that type of problem with problems about difference.

The joint work of preparing the public lessons enhanced the teachers' mathematical knowledge for teaching and knowledge of instruction through engaging them in arguing, discussing, justifying, and explaining their different ideas. Interweaving mathematics knowledge and pedagogical knowledge, these teachers carefully designed the lessons to better student learning. They brought in their observations of the lessons, their teaching experiences, conjecture, and puzzles to the open discussions, which built up shared knowledge for teaching mathematics. Also as the case of Ms. Wu changing her ways to interact with students showed, the joint work provided the teachers an opportunity to learn to implement the reform ideas on teaching and learning mathematics through refining their repertoire of practice. Their understanding of the reform ideas can be deepened during the process of doing the joint work.

Summary

All my participant teachers felt that conducting public lessons was an effective way for them to grow and improve instruction. As Ms. Wu said, "In addition, inviting your colleagues to observe your class is an important way of improvement. In my first cycle of the reform, every teacher in the group conducted a public lesson each month. As you know, it is tiring to do a public lesson. Meanwhile, sometimes we were required to conduct public lessons in the district. During the preparation process, you revised your lesson plans, had other teachers observe and comment on your lessons. Then you knew how to conduct this kind of lesson" (Interview, 03/02/ 2006). Both Ms. Pu and Ms. Wu went about their public lessons for almost a month. They closely worked with their colleagues to revise the lesson plans and polish the lessons bit by bit. I argue that through conducting the public lessons, their mathematical knowledge for teaching and knowledge of instruction were enhanced and enriched. The symbolic and materials tools made their collaborative work possible and functioned as learning resources that promoted the teachers to reflect upon practice and explore the possible ways of incorporating the reform ideas in their instruction. With the colleagues who offered critical comments and suggestions, the teachers became aware of their own weaknesses in terms of teaching competences. That could lead to possible improvement of their teaching competences. Doing public lessons is a prevailing activity teachers engage in around the country. It provides sustained support for teachers' learning and improvement. Conducting public lesson is a joint activity that involves different groups of teachers at different levels,

which indicates complicated and various relationships among teachers within communities. Connecting with colleagues in different ways could influence teachers' learning and practice. I address this issue in the next chapter.

CHAPTER FIVE

LEARNING AND WORKING IN INTERCONNECTED COMMUNITIES

Introduction

One of prominent features of a community of practice is mutual relationships among participants that arise out of mutual engagement in practice. In this chapter I focus on the fourth grade teachers to examine the interplay of their learning and the dynamics of their relations. I analyze the multiple roles Ms. Hu played in the TRG, the Bell team and the district community influenced the three teachers' learning and relations. As a highly regarded math teacher in the district, Ms. Hu played an important part inside and outside her school through mentoring young teachers, organizing the associated lesson planning team activities, and facilitating the district professional development activities. She moved in-between the communities as a boundary broker (Wenger, 1998) to help colleagues improve instruction while in the process keeping refining her own practice. Her influences as an exemplary teacher were activated and expanded in the communities.

Mentoring and collaboration

A situative perspective emphasizes that teacher learning as participation occurs through engagement in "actions and interactions" that are embedded in institutional culture and history (Wenger, 1998). In the case of the fourth grade TRG, the three teachers interacted

with each other on a daily basis. Their interactions embodied different collegial relations and were influenced by the institutional context—the district context. They were mentor and mentees while they also collaborated on many activities to go about their instructional practice. As Ms. Hu played the role of boundary broker in the communities, who she was and how she viewed mathematics teaching and learning were important for the group's learning.

Who they were

As I described in Chapter Two, Ms. Hu, Ms. Lu and Ms. Su worked in the same office where their tables were put together. This gave them more room to pile books, student workbooks, worksheets and assignments, and also made their communication convenient. Ms. Hu was thought of highly by the principal and her colleagues. When I first entered the Tower School, the principal proudly introduced Ms. Hu to me and praised her lessons as a perfect mix of art and science. She used concise and accurate language to engage students in active learning. In the eyes of her colleagues, she had solid knowledge of elementary mathematics and focused on teaching students the ways of learning math. As a highly regarded math teacher in the district, Ms. Hu took many responsibilities inside and outside the school. She was the head of the fourth grade math teaching research group. Meanwhile, she mentored two teachers in other elementary schools who were assigned to her by the district. Also she was in charge of the Bell associated lesson planning team for the fourth grade and facilitated the district math specialist Ms. Ya to

organize the district teaching research group activities. Ms. Su also took part in multiple communities in her daily teaching life. The school sent her to attend a district workshop about using technology in mathematics classrooms. The workshop was held twice a month, each time lasting about three hours. As she taught a fifth grade mathematics class, she worked with other three math teachers in the fifth grade math TRG. Ms. Lu, who had transferred to this school several months before my data collection started, was the youngest math teacher in the school. Like most of the math teachers in the Tower School, she was required to participate in professional development activities provided by the associated lesson planning team and district. In their daily school life, they moved between the classrooms, the office, and the communities they attended, brought in and took away what they saw, heard and thought in the communities that could change their practice. The knowledge, experience, information and identity carried by them flowed through the communities.

The school did not officially appoint Ms. Hu as the mentor of Ms. Lu and Su, but implicitly, she was expected by the school to mentor them. Neither Ms. Lu nor Ms. Su was a beginning teacher, each teaching elementary math more than four years. Generally, mentoring was provided to novice teachers who needed scaffolding and supports to become experienced. In Chinese contexts, mentoring also can be offered to young teachers who are considered promising. To advance the promising young teachers' knowledge and skills, they are mentored by expert teachers with the expectation that they can become expert teachers in the future. Although she was not the official mentor for Ms.

Lu and Ms. Su, and there were no official mentoring meeting time, Ms. Hu acted like a mentor in her formal and informal interactions with Lu and Su.

She guided them to prepare their lesson presentations in the district. That activity stretched over a month. In their weekly group meetings Ms. Hu often chaired the meetings, had a final say about the pace of instruction and other instructional decisions such as when to give students a test and what kinds of worksheets or tests should be created for students. In the meantime, Ms. Lu and Ms. Su also observed her lessons that were thought hard to teach and learn. This spring semester Ms. Lu and Su observed her three lessons. In the interview with Ms. Hu, she especially mentioned that the lesson about solving problems of planting trees along a line or in a circle was very difficult for students as the problems were originally from International Mathematics Olympiad. Neither Lu nor Su had taught the problems before. Therefore, she invited them to observe her teaching after they discussed the lesson plan in the group meeting. Outside the formal settings, Ms. Lu and Su sometimes sought advice from her on instruction, especially on how to handle and solve some problems in the textbook, student workbooks and tests. In this regard, Ms. Hu played a mentor role in the fourth grade math TRG; however, they were also collaborative colleagues on some occasions when they tried to make sense of the new content in the textbook. Their collaborative relations paralleled the mentor and mentee relation in the communities. In what follows I use the key events to discuss their learning and relations in detail.

Ms. Hu's views on teaching and learning mathematics

Having worked for almost 20 years, Ms. Hu formed her own teaching styles and developed her own views on teaching and learning mathematics that were influenced by the tradition of Chinese mathematics education and the current curriculum reform. When she mentored and worked with her colleagues, she brought her points of view on teaching and learning mathematics to the interactions.

First, she emphasized teaching students to see connections among knowledge and make use of connections to learn new knowledge. Ma (1999) argued that understanding a topic with depth was "connecting it with more conceptually powerful ideas of the subject. The closer an idea is to the structure of the discipline, the more powerful it will be" (p.121). Ma's argument pointed out relating a topic to a powerful idea can deepen students' understanding of that topic. Connections between knowledge do not only mean that knowledge is related, but also means linking the topic to powerful ideas. What Ms. Hu indicated about knowledge connections was connecting knowledge with conceptually powerful ideas. On many occasions Ms. Hu mentioned that helping students see connections among knowledge was very important. Teachers should teach students to learn new knowledge from connecting it with more conceptually powerful ideas. She used an example to illustrate her point of view when she was asked about her perspectives on teaching mathematics. "Mathematics is a systematic body of knowledge. All knowledge has a growing point. The knowledge of shifting the decimal point lays foundation for later learning. Learning addition and subtraction of decimals can be

connected with the methods of solving integer addition and subtraction problems...I try to not only teach the knowledge of a lesson, but also to have students understand knowledge connections and knowledge system. For example, the method of comparing values of integers can be used to compare values of decimals. Actually we start from comparing places" (Interview, 03/06/2006). She pointed out place value was the key concept that was applied to both integers and decimals. If students have a clear understanding of place value of integers, they can use their understanding to compare values of decimals.

Second, Ms. Hu stressed that a lesson should be structured. In her point of view, a good lesson had a clear structure that included two aspects. She thought teachers should present knowledge to students in a structured way. She further explained that first teachers needed to have a clear picture of the knowledge they would convey to students and then present the knowledge from easy to hard. The second aspect of a lesson's structure was about teachers' questions. For her teachers should design and think about the questions in advance that they would raise in class. She observed that many young teachers had no clue about how to ask questions in a structured way. She gave an example to show her point. "When teaching word problems, we first have students read the problems, find conditions and questions, and analyze conditions and questions by working on manipulative or discussing within small groups. We want them to understand why and how they can solve problems in a certain way. The last step is to use operations to get answers" (Interview, 03/06/2006).

The current curriculum reform calls for a constructivist teaching model. Ms. Hu embraced the ideas that students can learn mathematics by conjecture and discovery, and need to be able to apply knowledge to solving problems. She considered learning mathematics as a process of making inquiries into knowledge that included several steps--discovering problems, solving problems, finding results and applying knowledge. For example, teaching approximations of decimals, she encouraged her students to find that rounding off was the method they learned to get approximations of integers that can be used to find approximations of decimals. She first had the students solve a problem of an approximation of 13486. With working on this problem, she helped them review the knowledge of rounding off. Next she pushed them to guess how they might find an approximation of a decimal 8.357 with an accuracy of 1.0, 0.1, and 0.01 that appeared in a word problem. After discussing their answers in small groups, Ms. Hu called on a student to report her answer and other students to explain their solution methods. In the end, she asked her students to think about what an accuracy of 1.0, 0.1 and 0.01 meant when using the method of rounding off.

Mentoring lesson presentations in the district

Three years ago the district created a new activity for math teachers' professional development. The so-called "lesson case study" activity was to assign several teachers to introduce to all the fourth grade math teachers of the district a lesson plan they created or introduce part of a lesson plan while showing videotaped episodes of the corresponding

lesson for discussion. In the district monthly professional development meeting those teachers would present their lesson plans or lesson episodes. After the meeting their presentations would be uploaded to the website of the district that all math teachers in the district had access to. This activity aimed at deepening teachers' understanding of textbooks by sharing and discussing colleagues' experiences of teaching a specific lesson. As the district specialist Ms. Ya said, the "lesson case study" activity was a process for teachers to improve and share resources collectively (Fieldnotes, 3/15/2006).

In the winter break the district assigned the Bell associated lesson planning team the task of analyzing the unit of Meanings and Properties of Decimals through "lesson case study". The unit was the fourth unit in the PEP version textbook. In the district only the teachers in the Tower school used the textbooks published by a local press. The district professional development activities were around the PEP version textbooks. Ms. Lu was assigned to address several key issues about teaching how to find an approximation of a decimal. Ms. Su took on the task of presenting a lesson plan about the meaning of decimals. In their textbook, the same content was in the first unit. When they made their presentations to the district in late March, they had already finished that unit.

In Ms. Su's presentation she introduced a whole lesson plan and explained her ideas on the lesson design. Ms. Lu did not present a whole lesson plan; instead, she picked up four key issues in the lesson to address. When sharing her experiences, she used the episodes of her class to show how she dealt with those issues. Both of them spent a month preparing the presentations. In the first week of the semester, they turned

in the drafts of the lesson plans to Ms. Hu who helped them revise the plans in their weekly group meetings and offered suggestions whenever Ms. Su and Ms. Lu asked for help. She also observed Ms. Lu's rehearsal lesson and formal lesson that Ms. Lu presented in the district. In the middle of March Ms. Su and Ms. Lu rehearsed their presentations in the Bell associated lesson planning team activity. The district math specialist Ms. Ya presided over the activity with Ms. Hu. With Ms Y's comments they continued working on the plans. On Mar. 29 they made final presentations in the district activity.

The focus of Ms. Hu's mentoring

In the process of mentoring Ms. Lu and Ms. Su to prepare their presentations, Ms. Hu used some forms of mentoring common in China, including observing and commenting on Ms. Lu's lessons, inviting both of them to observe her instruction of the lessons, and reviewing and revising their lesson plan drafts through informal and formal discussions with them. Throughout the whole process, Ms. Hu's mentoring focused on teaching students to make connections among knowledge, creating a structured and sequenced lesson, and encouraging students to discover and discuss, which echoed her own views on teaching and learning mathematics.

One of the aspects Ms. Lu needed to improve, according to Ms. Hu, lay in connecting the old and new knowledge. After observing Ms. Lu's rehearsal lesson, she commented,

> "For example, the method of finding approximations of integers is similar with the method of finding approximations of decimals. They share commonalties and differences. How can we facilitate students to master the method of finding approximations of decimals based on what they already know? Then through comparison they will develop clear understanding of the knowledge structure..... In her rehearsal lesson, I want students to guess the method of approximation of decimals according to the method of approximation of integers. Through comparison we help students establish a knowledge structure and know the way of learning by making connection. For instance, when they learn fraction, we need to study similar knowledge. So students would stand on a higher point. She failed to make students guess the relation and develop a deeper understanding of the connection through comparison" (Interview, 03/08/06).

In the following week Ms. Lu videotaped her lesson for the district presentation. Ms. Hu observed the lesson again. It was obvious that she followed Ms. Hu's suggestion. She designed two steps to teach students the knowledge connection. After reviewing the method of rounding off for finding approximations of integers, she had them conjecture about the possible method to find approximations of decimals. As Ms. Hu suggested, next she put students in small groups to compare the methods of finding approximations of integers and decimals. However, Ms. Hu still felt that Ms. Lu did not reach her expectation. She thought Ms. Lu gave students too much of a hint before she asked them to work in small groups for discussing the connection between the method of finding approximations of decimals and integers. Therefore, she observed that the students came up with too perfect answers so that there were no arguments in class.

Another aspect Ms. Hu focused on in her mentoring was about encouraging students to discuss and discover the new knowledge. When talking about how she helped young teachers to improve their instruction, Ms. Hu commented that young teachers

usually did not have a deep understanding of the new curriculum standards and the corresponding new teaching methods. One of the goals of her mentoring young teachers was helping them produce a creative lesson. When she revised Ms. Su's lesson plan face to face in their weekly group meeting, she sighed and said to Su, "How can you present your lesson in the district? It is too conventional" (Transcription, 03/13/2006). Following this commentary, she gave her suggestion to increase the creativity of the lesson plan. Her suggestion was to allow students to discover the basic counting unit and place value of decimals through independent work and group discussions. First, she suggested that Su can have students work on two tasks independently. One task was to observe a ruler and find out the relations between 1m and 1dm, and 1m and 1cm, expressed in fraction and decimals, such as 1cm = $\frac{1}{100}$ m and 0.01 m. The next task students did was to think about the relations between 1m and 0.1m, 1m and 0.01m, 1m and 0.001m. Next she wanted Su to check students' observation results with the whole class. Using what students reported on their observations as raw materials, she recommended having students work in small groups to discuss what they could find from their observations. She and Su anticipated that students would arrive at two findings: one was that the rate for composing a higher unit value was ten; the other was about the basic counting unit (such as 0.1, 0.01, 0.001, ect.). For Ms. Hu, the tasks and the ways of having students work on the tasks made the lesson creative because students were engaged in active learning through observation, discussion and discovery.

The next focus of Ms. Hu's mentoring in this activity was about the structure of a

lesson. As she mentioned in the interview, she paid special attention to helping young teachers create lessons with a clear structure. Ms. Su felt that the biggest improvement she made in her lesson plan was making it more structured and clearer. She said, "When she reviewed my plan, she helped me smooth the structure of the lesson, every step and transition, starting from decimals in life, pictures with measures, hundreds square, to the abstract presentation. The structure became very clear" (Interview, 03.09/2006). The underlying rationale Ms. Hu used to tease out the structure of a lesson was presenting knowledge from easy to hard, and from concrete to abstract. The condition under which a teacher was able to do so was to map out a clear and whole picture of the knowledge she would present and convey to students. Ms. Su summarized the structure of her lesson plan that Ms. Hu helped her develop. "We first make use of rulers because the relations between meter, decimeter and centimeter are ten-based. Next higher level is to show the model of hundreds square that is more abstract than the ruler. Based on their understanding of fraction students could synthesize the meaning of decimals at this stage. Next level we use no models, asking students what 0.1 means. It is to divide 1 into 10 parts, written as $\frac{1}{10}$, or 0.1" (Interview, 03/09/2006).

Ms. Su and Ms. Lu were not officially assigned by the school as Ms. Hu's mentees although the school administrators expected them to learn from Ms. Hu. This unofficial mentor and mentee relation influenced their interactions and the ways Ms. Hu helped the two teachers. In the semester I did not see the systematic mentoring provided by Ms. Hu that was seen in official induction programs other researchers had observed

(Wang & Paine, 2001). Nevertheless the case described and analyzed here shows Ms. Hu's mentoring around the key event offered opportunities for the two young teachers to learn from her. The teaching research group as a community made it possible that Ms. Lu and Su received her informal mentoring on a regular basis. It seems that there might be a possibility that the effects of mentoring on teacher learning could be sustained without systematic guidance and assistance. Ms. Su confessed that she wished she could have more chances to be mentored by Ms. Hu (Interview, 03/27/2006). However, their collegial relations were more than mentor and mentee. They also educated each other by drawing on their different strengths to improve instruction.

Collaborating on teaching translation and rotation

Designing shapes through translation, rotation and tessellation is part of the unit five of the fourth grade textbook. All three teachers felt it was hard to teach this part. Their difficulty lay in their knowledge about translation, rotation and tessellation in mathematics. Even Ms. Hu confessed that she was a bit confused about the content. During the week of teaching this part, they had a formal discussion about the content, the goals and steps of the lessons in their weekly group meeting. Following that meeting, they had conversations to continue to make sense of the content and share the information about what happened in their classes.

The content of translation and rotation was new to the three teachers, as it was recently included in the mathematics curriculum in the current reform. Teaching students

translation and rotation aims at enriching elementary geometry curriculum. Some researchers (Shi, Ma, & Kong, 2006) argued that the value of the knowledge of translation and rotation was embodied in two aspects. In life translating and rotating shapes is a common phenomenon. Mathematically, students will use the knowledge of translation and rotation to solve geometry problems in secondary schools. Although the researchers thought it was hard to convince elementary teachers of the importance of the knowledge, the case presented here shows the three teachers did not play down the importance of the knowledge. The difficulty of teaching the lessons was caused by the teachers' limited mathematical and pedagogical knowledge of translation and rotation. Facing the unfamiliar knowledge, their collaboration became the key to make sense of it.

First, they made sense of the knowledge of translation and rotation through talking with each other. The textbook and the teacher guidance book did not provide definitions of translation and rotation. How to define and distinguish translation and rotation was what they most intensively talked about in their weekly group meeting. At first Ms. Hu thought rotation was around a central point, but she felt confused at the V shape in the textbook (Figure 5.1). She was not sure around which point the V shape flipped around. Ms. Su thought it should rotate around Point A. Ms. Lu asked if they needed to pay attention to the degree at which a shape rotated. Ms. Hu thought it could be any degree. But basically they would just require students to make rotation at 90 degrees. When they moved to discus two special shapes—an equilateral triangle and a square, the problem of how a shape flipped popped out again. Ms. Lu thought they can rotate that

square in a grid worksheet around any point. Ms. Hu was not sure about that. She doubted that it should flip around a side. Ms. Su chimed in, "it is to see where the side goes after rotation". But Ms. Hu still felt unsure that the square should rotate around a point or a side while they were flipping it on computer. Ms. Su continued to explain her point, "Actually it is, (using her hands to show the movement of the shape) now to look at the left side (lifting her left hand to refer to the left side) and see where it goes (using her right hand to refer to the moved side). Then they [students] can decide the degree of flipping". Ms. Su tried to convince her colleagues that rotation should be around a side. Ms. Hu decided that they needed to consult with others about around which, a point or side to rotate a shape.

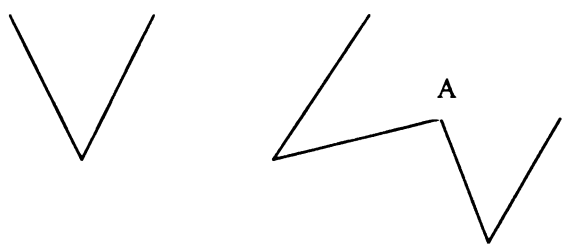

Figure 5.1 Rotate the V shape

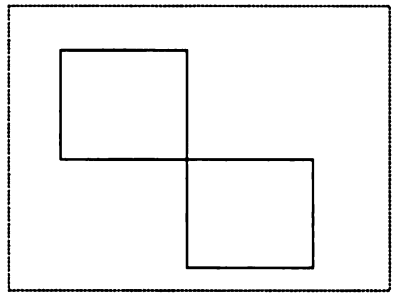

Figure 5.2 Rotate the square

With this unsolved problem, Ms. Lu questioned the difference between translation and rotation referring to that square (See Figure 5.2). She though the moved square can be through translation—moving to the right and down, or through rotation. How can she and students distinguish translation and rotation? Ms. Hu tried to answer her question by saying that rotation was around a central point, but she paused there. She went back to the unsolved problem again. Ms. Su pointed out that rotation meant that the direction of a shape was changed, but the direction of a shape remained the same if it was translated. It seemed that Ms. Su's explanation did not completely address Ms. Lu's question. She continued to ask, "(pointing to the equilateral triangle and square on computer) For the two shapes, we can not see the difference, right? So for these two, after sliding or flipping the shapes look exactly the same as before". Ms. Hu and Ms. Su agreed with her.

In the meeting, through talking, questioning, explaining, the three teachers came out with an unsolved problem about rotation and a clear understanding of the difference between translation and rotation. Translation was defined as moving an object along the

same direction. Rotation could be around a central point, but with only a central point it is impossible to tell how a shape is rotated (Shi, Ma, & Kong, 2006). A line or side is needed to judge how many degrees a shape is flipped around.

In order to develop a clear and correct understanding of the knowledge, they kept consulting with each other as well as reached for other resources. Ms. Su sought help from fine arts teachers of the school to learn about teaching students to draw translated and rotated shapes and shared the information with Ms. Hu and Ms. Lu. The fine arts teacher felt that the content in the math book made translation and rotation was complicated and hard. Students already learned about translation and how to draw translated shapes and objects in fine arts classes. Su cited the word used in fine arts classes—"two continuous directions" to describe they ways of drawing a translated shape students did in fine arts classes. She explained to Hu and Lu that two continuous directions meant sliding a shape along two directions that followed one after another continuously. Ms. Lu felt she did not know how to teach rotation yet. "It is too hard. The difficulty level is increased too much" (Fieldnotes, 05/25/2006). Ms. Hu agreed and told Su and Lu that her students did not have any clue when they were required to draw rotated shapes. She felt that what they did was messy. Ms. Lu turned to Ms. Su and asked her help to rotate an equilateral triangle.

Lu: How can I rotate it?
Su: How many degrees do you want to rotate it?
Lu: 90 degrees.
Su: Clockwise or counter-clockwise?
Lu: Clockwise.
Su: (drawing the shapes) Point O, after rotating, it is 90 degree. You see, the OA

side is vertical to OA', and OB is vertical to OB'. (See Figure 5. 3)

Lu: It is too hard for students.

Su: Did you read our teacher guidance book? The guidance is too little and thin.

Lu: It just says that students are expected to be able to translate and rotate, and design something.

Su: It does not say to what extent students need to master the knowledge. It is hard for them to draw.

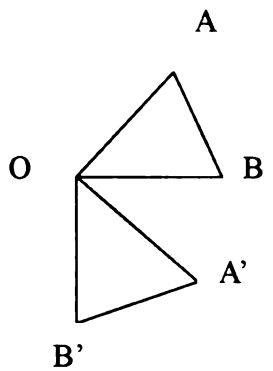

Figure 5.3 Rotate an equilateral triangle

In this conversation Ms. Su actually pointed out three key aspects when rotating a shape. The three key aspects were a central point (O), the degree of flipping a shape (90 degree) and the direction of rotation (clockwise). Ms. Lu told Su that she would just ask students to flip a shape at 90 degree and tell them they need to pay attention to a central point, degree and direction. Su said she would do the same thing in her class.

The last resource the three teachers drew on to make sense of the knowledge and teaching the knowledge was the teacher guidance book of PEP version textbook. Although I did not have a chance to witness the three teachers using that guidance book, Ms. Lu did tell me that Su brought in the book and they adopted some suggestions about teaching rotation given by that book. The same content appeared in the fifth grade PEP textbook. The corresponding teacher guidance book recommended that teachers should

ask students to clearly express their ideas on three questions, including around which point the shape rotated, toward which direction it rotated, and how many degrees it rotated. Following this, the book provided mathematical definitions of rotation, and used formal mathematical language to describe a central point, rotation angle, and rotation direction. Rotation was defined as "A shaped is moved around a certain point O at a certain degree." The point O was called the central point of rotation, the rotated angle at a certain degree was called rotation angle, and the same moving direction was called rotation direction. In Ms. Lu's class she guided her students to study rotation from the three aspects. She wrote down the three mathematical phrases on the blackboard to remind students of how they could rotate a shape: a central point of rotation, rotation degree, and rotation direction. That unsolved problem was solved finally after the three teachers referred to the external resources.

This small case showed a collaborative relation among the three teachers. Ms. Hu was not the mentor any more in this case. Instead, they made sense of the unfamiliar math knowledge through collective discussions, sharing information and drawing on outside resources. The mentor and mentee relation was not fixed in this teacher community. In this case Ms. Su was the one who seemed to be more confident about her knowledge of translation and rotation. She insisted on her idea that a shape should rotate around a side instead of a point. When Ms. Lu was confused at the difference between translating and rotating certain shapes, she offered her understanding. Meanwhile, she actively reached for other resources to educate herself and her colleagues about the content. The dynamics

of their relations allowed them to grasp the opportunities that naturally occurred in their daily work life to grow together regardless of their experiences and reputations.

As I described above, Ms. Hu played multiple roles in the district. She was not only the mentor and colleague to Ms. Lu and Su., but also she was an organizer and facilitator for the district professional development activities, and a teacher researcher working with the district specialist on some projects. Her multiple roles that connected the fourth grade TRG with the broader communities impacted on their learning and relations. In the following I describe and analyze the two roles she played.

Playing multiple roles in the district

Inexorably, a community of practice is not located in an isolated context; correspondingly, a teaching research group is nested in broader social contexts. Because I conceive of teachers communities as existing in broader social and institutional settings, the way members of a community negotiate within and across communities is important. In what follows I draw on Wenger's (1998) concept of boundary broker to interpret and examine Ms. Hu's participation in the multiple communities that are located in the institutional setting of school and district. Boundary brokers provide connections among communities by introducing elements of one practice into another, and coordinating and aligning perspectives (Wenger, 1998). Using the concept of boundary broker, Cobb et al (2003) try to pin down the important role boundary brokers played in developing alignment between

three different communities, including the district mathematics leadership community, the school leadership community and the mathematics professional teaching community. In this study I ask about how Ms. Hu moved across and worked between communities and explore that issue by identifying her as a boundary broker. Playing multiple roles in the communities she belongs to, Ms. Hu coordinates the different perspectives between the different communities and brings in learning opportunities for her colleagues in the teaching research group.

Ms. Hu was designated as the head teacher of elementary mathematics and part-time teaching research specialist in the district. With this high reputation, she took on multiple roles to make contributions to teacher professional development of the district while continuing to refine her own instruction. She acted as a boundary broker to connect the school communities with the communities outside the school by coordinating different perspectives, facilitating and aligning professional activities across the communities, and bringing in elements of her practice in the district into the fourth grade TRG.

Teacher developer

One of the roles Ms. Hu played was as a teacher developer of the district. She was in charge of the Bell associated lesson planning team, which meant that she made plans for the monthly team activities, organized the activities, assigned tasks to the teachers and

coordinated cooperation among teachers. As a part-time teaching research specialist[1] in the district, she attended the weekly activities of the district teaching research group that aimed at raising the talents of young teachers with potential through interacting with seasoned excellent teachers. Those young teachers were identified and selected by the district. In the district teaching research group the teaching research specialist such as Ms. Hu exemplified how to study textbooks and other curriculum materials, conduct a good lesson, think about instruction from the perspective of student learning, and reflect upon lessons. In each winter and summer break she took on the task of teacher training that usually lasted a week. For example, in the coming summer break, for the teacher training, Ms. Hu was assigned to overview the textbook of the third grade, outline and analyze key and difficult points of a unit, and demonstrate a lesson in a unit.

Ms. Hu was a classroom teacher as well as a teacher developer. The multiple memberships allowed her to travel across the different communities—the TRG, the Bell team and the district. Wenger (1998) recognizes the complexity of the job of brokering because

> It involves processes of translation, coordination, and alignment between perspectives. It requires enough legitimacy to influence the development of a practice, mobilize attention, and address conflicting interests. It also requires the ability to link practices by facilitating transactions between them, and to cause learning by introducing into a practice elements of another (p.109).

Ms. Hu's legitimacy to develop other teachers came from her excellence as a math teacher and being a classroom teacher currently. Her excellence gave her insight into

[1] Ms. Hu got a small stipend for being a part-time teaching research specialist in the district. She was given release time to attend the weekly district activities.

elementary mathematics instruction, curriculum and student learning. Being a classroom teacher let her breathe what other teachers breathed in. In other words, she knew and understood teachers' concerns and problems, and students' problems of learning mathematics. Therefore, when linking practices of communities, she could speak for teachers and speak to teachers, which could cause teachers' and her own learning by having participants exposed to different perspectives and practices. In what follows, I use the case of the district lesson presentations to illustrate how she could speak for teachers and speak to teachers.

When Ms. Su rehearsed her lesson presentation in the Bell associated lesson planning team activity, the district teaching research specialist Ms. Ya raised two concerns about her lesson plan. First, she felt that Ms. Su should allow students to gain more concrete experiences about decimals in order for understanding the meaning of decimals. She suggested using fractions to understand decimals. The task students could do was to divide a one-meter long ruler into 10, 100 and 1,000 parts. Then students could see the relations between fraction and decimal, such as $\frac{1}{10}$ and 0.1. But Ms. Hu and Su disagreed with her. They thought students already had enough concrete experiences of decimals as they learned about decimals in the third grade. They expected that students should be able to extract the meaning of decimals from the model of a hundred square.

Another suggestion Ms. Ya provided was about how to teach two concepts about decimals—the basic counting unit and rate for composing a higher value unit. As I described above, Ms. Hu guided Su to allow students to find out the meanings of the two

concepts on their own. They designed a task in which students worked on a ruler to make sense of the basic counting unit and rate for composing a higher value unit by examining the relations between meter, decimeter and centimeter. Because that task required students to change decimeter into meter, and centimeter into meter, Ms. Ya felt students could be confused. She thought the model of a hundred square could be a better choice. In addition, she did not think that students were able to find out the meaning of the two concepts on their own. Su should provide students step-by-step guidance to understand the concepts. Ms. Hu and Su tried to convince her that students could find out the meanings of the two concepts by working on the ruler task because they already taught students that way in their own classes. They argued with Ms. Ya in the activity meeting. But Ms. Ya insisted on her point of view. After the rehearsal meeting, Ms. Su changed that task and had students work on the model of hundred squares. But another problem came out. She used ten blocks, 100 blocks and 1000 blocks instead of the traditional hundred square model that divided one whole into 10, 100 and 1000 parts. The model of 10 blocks, 100 blocks and 1000 blocks did not do that. Ms. Ya felt that this model did not consistently present one whole to students. It would be easy for students to see the relation between 0.1 and 0.01, but would be hard for them to understand 0.001 because it was shown in a cube having 1000 blocks. Ms. Ya suggested Su still using the meter ruler but she needed to give students some guidance.

Based on her own teaching experience, Ms. Hu had a different expectation of student ability from Ms. Ya. She anticipated students would be able to make sense of the

knowledge by discovery. Thus she tried to defend why Ms. Su designed her lesson plan that way. She used her legitimacy to speak for teachers, but because the presentation was for the whole district Ms. Ya was concerned whether all students with different abilities could do what Ms. Hu and Su expected. She felt she had to be more conservative given school differences, teacher differences and student ability differences.

While speaking for teachers, Ms. Hu also collaborated with Ms. Ya to speak to teachers in the activity meeting. For each teacher's presentation, Ms. Ya provided very detailed comments and suggestions. Ms. Hu, as the Bell team leader, offered her suggestions too, but sometimes she complemented and paraphrased Ms. Ya's suggestions and comments. For example, a teacher mentioned that there were three ways to categorize decimals. One was according to the places of decimals, such as decimals with tenths place, with hundredths place, ect. In Chinese teachers call decimals such as 4.5-- a decimal with one place, 4.56—a decimal with two places, 4.567—a decimal with three places. The second way was based on the table of decimal places. The third way was that decimals have two kinds, having zero or not in the integer part. Ms. Hu followed that a decimal having zero in the integer part was called proper decimals and the other was improper decimals. Ms. Ya corrected the teacher that there were only two ways to categorize decimals, the first and the third. Ms. Hu then chimed in and said that the teachers must teach the content of proper decimals and improper decimals although the textbook did not include that knowledge. Ms. Ya agreed with her and explained what proper decimals and improper decimals were. In the whole meeting, they both played a

role of expert who offered professional comments and suggestions for the teachers. Although Ms. Ya as the district teaching research specialist had more authority than Ms. Hu, Ms. Hu's comments were heard and valued. They both made contributions to refining the teachers' lesson plan.

Teacher researcher

In the current curriculum reform the policy makers and educational researchers called for school-based research on teaching and encouraged teachers to participate in action research on issues and problems that stemmed from practice (Zhang, 2004). Responding to the reform call, the school tried to engage its teachers in school-based research. Ms. Hu was expected to play a leadership role in the school-based research. Meanwhile, as a head elementary math teacher of the district, she was invited to take part in the district research projects. The school-based research project was teaching research groups-based. In that semester each teaching research group decided on a topic to study. The fourth grade math group set their study around the topic of mathematical activities in classrooms. For the district research project, she worked with the district specialist Ms. Ya and other head teachers. Currently, they were collecting issues and problems the district teachers encountered when teaching the new curriculum. Next they would scrutinize the issues and problems to identify what they would study in the following five years.

However, having no research experience and facing the heavy work load, Ms. Hu felt confused. When talking with the district expert who was invited to give a talk about

how to conduct school-based research, Ms. Hu expressed her concern, "I feel that there is no a general goal for the school-based research projects. We did an activity after another. But what we did is not systematic. ...I am not clear about how to do school-based research projects. So it is unrealistic for me to guide other teachers" (Fieldnotes, 03/21/2006). Although Ms. Hu and her two colleagues decided they would study mathematical activities in class, in fact what they did that semester was just reading and commenting on four articles about that topic in one of their weekly group meetings. I did not see the other research taken by them. It was obvious that, as she complained to the district expert, she had no clue about doing research as a teacher.

In contrast with the superficial school-based research project, what Ms. Hu did for the district research project was meaningful. Her participation in the project brought up an important topic for her, Ms. Su and Lu to discuss in their weekly group meeting. In that semester at the request of Ms. Ya she worked on an article in which she described the problems teachers had in implementing the three dimensional instructional goals in practice and tried to provide her own explanations about teachers' concerns and problems. The three dimensional goals include knowledge and skills, process and methods, and dispositions and attitudes. Ms. Hu asked about Ms. Su and Lu's views on the three dimensional goals. Ms. Lu noted that the dispositions and attitudes goals were too vague and not operational. Su thought that teachers could not get guidance about how to realize the three dimensional goals from the teacher guidance books. The books only provided guidance related to the content. Regarding the dispositions and attitudes goal, they

referred to the new curriculum mathematics standards. Ms. Hu commented, "the dispositions and attitudes goals are too grand and general [in the standard]. Teachers all know that we need to develop those dispositions and attitudes, but we do not know how to do that. For example, students learn one-digit addition, two-digit addition and thee-digit addition. How can we connect their learning with those goals? I feel that's hard" (Fieldnotes, 05/30/2006). Ms. Lu added onto her comments and said that teachers wanted to know how they can carry out those goals in each specific lesson. Why do teachers feel it hard to realize those goals in practice? Ms. Hu continued to brainstorm with her two colleagues. One reason they agreed on was that it was related to the teaching styles and methods of Chinese mathematics education. Ms. Hu pointed out that Chinese mathematics education focused too much on conveying knowledge. It was knowledge-centered. Another reason they thought came into play was that tests and evaluations did not touch on student dispositions and attitudes. In addition, teachers got no guidance to develop students' dispositions and attitudes required by the standard.

Conducting research as a teacher researcher was a brand new thing for Ms. Hu. When no guidance was provided, what she did was perfunctory. With guidance and support, her involvement in research projects could open up an opportunity for her and her colleagues to think big and reflect upon Chinese math teachers' practices. Being a teacher researcher could be a burden as well as a prompt to initiate serious thinking.

The concept of boundary broker defined by Wenger (1998) and used by Cobb et al (2003) pointed out the importance that brokers can bridge the activities of different

communities. Wenger argues that good boundary brokers stay at the boundaries of many practices rather than at the core of any practice. In the case of the fourth grade teachers, Ms. Hu acted as a broker connecting the TRG, the Bell team and the district community; however, as the head of the TRG, the coordinator of the Bell team, and the part-time district specialist, she stayed at the core of the different communities of practice. It was her full participation in the communities that made it possible for her to align and coordinate different perspectives and meanings. That she helped Ms. Su and other teachers prepare the lesson representations to the district demonstrated her role of being a broker.

One the one hand, she tried to facilitate Ms. Ya, the district specialist, in refining the teachers' knowledge. Ms. Ya proposed the activity of lesson presentations that aimed at providing guidance for all the first grade math teachers of the district to teach an important unit. Ms. Ya assigned the task to the Bell team. As the coordinator of the fourth grade Bell team and the district part-time specialist, Ms. Hu gave each lesson of the unit to different teachers in different schools. While she reviewed and revised their lesson plans, she encouraged the teachers in the same school to collaborate on preparing the lesson presentations. Before the team teachers presented their lesson plans to the district, Ms. Hu scheduled a team monthly meeting to collectively discuss the plans. Ms. Ya was invited to attend the meeting. When the teachers did their presentations to the district, Ms. Hu chaired the district meeting. By facilitating and coordinating the professional activities in the Bell team and the district community, Ms. Hu related the activities in the

two communities.

On the other hand, with her knowledge of the classroom teaching, she tried to coordinate the different perspectives of Ms. Ya and Ms. Su. While Ms. Ya had her own concern about the differences among schools, teachers and students, she was reserved about how Ms. Su taught the lesson. But within the communities of practice power and authority influenced how Ms. Hu as a broker enabled alignment and coordination. Ms. Ya as the district specialist had more power than Ms. Hu as the district specialists evaluated and assessed a teacher's work. That could influence the joint inquiry into math instruction in the district.

In addition, as a teacher researcher in the district, Ms. Hu linked her practice in the district to the teaching practice she and her colleagues went about everyday. Her involvement in the district project got Ms. Lu and Su to discuss with her about the goals of instruction called for by the policymakers and university researchers in the current reform. That provided an opportunity for them to reflect upon the weaknesses of mathematics instruction in China and identify the difficulties teachers had in realizing the goals in practice. It was her brokering that brought in this opportunity to the fourth grade TRG. Ms. Hu incorporated Ms. Lu and Su's thoughts about the instructional goals set up by the reform into her essay. The essay was prepared for the district research project. Her brokering invited Ms. Lu and Su to contribute to the improvement of mathematics teaching in the district.

Some teachers acting as a broker in a community of practice could broaden the

views of the community members on teaching and learning. But regarding doing research, it could be problematic to require teachers to be researchers. It was unclear what kinds of research the teachers were expected to do and what counted as teacher research in the current reform.

Summary

In conclusion, the collegial relations within the teaching research group were dynamic as they drew on each other's knowledge and experience to go about teaching and improve teaching. The dynamics contributed to the teachers' learning by enhancing each other's knowledge. The broker role Ms. Hu played in the different communities affected the group's learning. The group's views on math teaching and learning were connected with the broader social context. But sometimes her broking was constrained by the unequal power relation between the district specialist and her.

CHAPTER SIX

TEACHER LEARNING IN A REGIME OF COMPETENCE

Introduction

In the last chapter I summarize what I find in the study and point out the pros and cons of teachers communities or groups with a hierarchical structure. Then I use the concept of identity, professional resources and social resources to briefly illustrate the norms of the teaching research groups and how the teachers' different identities, professional and social resources shaped the norms. In the end I point out what can be done in the future to enhance the competence of a professional teacher community.

Teaching research groups as a regime of competence

The teaching research groups and related communities such as the Bell teams and the district community acted as a regime of competence that defined what competent participation in teaching should look like. As I mentioned in the previous chapters, the teaching research groups can be recognized as a regime of practice because they were well-established communities over a long time. The teaching research groups and related communities outside the school defined competent participation through engaging teachers in working on tasks that were closely tied to curriculum and instruction. In other words, the teacher can become competent members of the communities by doing these tasks such as collective lesson planning, conducting public lessons, and studying

curriculum materials. As Chapter Four shows, preparing and conducting public lessons in and across the teaching research groups produced the intense engagement of the first grade teachers in improving instruction. I identify that the mechanism by which the joint work of preparing public lessons contributes to improvement of instruction consists of three pathways: enhancing the teachers' mathematics knowledge for teaching and knowledge of instruction, using tools as learning resources to refine teaching practice, and becoming aware of the weaknesses of their teaching competences.

Wenger (1998) argues that the interaction between the individual experience and the competence defined by a community goes two-way. In the teaching research groups, the individual teachers needed to align and transform their individual experience and knowledge with the competence recognized by the teaching research groups. The case of Ms. Wu struggling with having students demonstrate their thinking in the public lesson illustrated that she had to change her way of interacting with students in class to become a competent teacher in her communities of practice. Another first grade teacher, Ms. Li was expected by the communities to use accurate, rigorous, concise and proper mathematics language. The joint work of public lessons gave her an opportunity to consider the use and construction of math language in first grade classes. Ms. Lu, one of the fourth grade teachers, thought that the professional activity of "lesson case study" deepened her knowledge of elementary mathematics. In the interview she commented that she felt she had adequate mathematics knowledge, but had no clear idea on how elementary mathematics was developed. She used an example to illustrate her learning.

"The new textbook does not address why the concept of basic units of decimals is there and where it comes from. What's the basic unit in each place of decimals? For example, in the tenths place, the basic unit is 0.1 or $\frac{1}{10}$; in the ten thousandths place, the basic unit is 0.0001 or $\frac{1}{10000}$. So I feel my understanding of decimals is deepened. That is helpful for me to understand the textbook and elementary math knowledge" (Interview, 03/20/2006). The teaching research groups and related communities, as a regime of competence or knowledge, offered the teachers opportunities to acculturate into the communities by transforming their individual experience and knowledge to become competent practitioners.

Meanwhile, the teachers as participants of these communities can add new elements to the repertoire of the teaching practice when they collaboratively generated knowledge for teaching elementary mathematics and engaged with their colleagues in different ways. In the first grade math TRG the teachers generated local knowledge in their joint work of public lessons. They put a lot of thought into which numbers should be used in the sample problem of the lesson so that the numbers could realize the instructional goals better. Around the numbers, they argued about the methods of estimating a sum students could use. These teachers brought in their individual experience and knowledge to the joint work; thereby the overall competence of the communities was enhanced. Especially when they reified their learning and competence by demonstrating the lesson to more teachers and publicizing the lesson plan in the district, the repertoire of the teaching practice in the communities was transformed and

expanded. More math teachers would use their public lesson as learning resources to strengthen their knowledge. The reified join work of public lesson became a tool from which more teachers would benefit.

The discussions about the collegial relations within the fourth grade TRG showed that engaging with each other in different ways—as collaborative colleagues or as mentor and mentees— also can lead to learning and contribute to expansion of the teaching repertoire. Ms. Hu informally mentored the young teachers in the fourth grade TRG; however, when they tried to make sense of the unfamiliar content knowledge and explore the ways of conveying that content, their collegial relation became collaborative. By collective discussions, seeking help from other colleagues and referring to media resources such as books, they clarified their confusion and deepened their understanding of knowledge about translation and rotation in elementary geometry. The joint work of both TRGs shows that the experience and knowledge of individual teachers can drive the competence of the whole communities. Learning happens in the transformation of individual experience and the competence of the communities.

Developing the link between research and practice

The teachers' collaborative work around curriculum and instruction in the communities of practice enhanced and generated knowledge for teaching mathematics. However, we have to think about how educational research can contribute to the knowledge generated and discussed by teachers. Researchers (Ball & Bass, 2000; Ball, Hill & Bass, 2005) try to

identify a special body of mathematics knowledge for teaching that teachers need for their work. This notion calls attention to the "dynamic interplay of content with pedagogy in teachers' real-time problem solving" (Ball & Bass, 2000). The uncertainty and situated nature of teaching practice could give rise to needs for the knowledge to address real-time problems in mathematics teaching and learning. To create such kind of knowledge, a collaborative inquiry community that involves researchers, teachers and other practitioners is needed. For example, in the case of the public lessons the teachers disagreed on if the different numbers could have effects on students inventing multiple solution methods. Ms. Pu insisted that the feature of the numbers was not related to that while Ms. Zhang speculated that the numbers used by Pu might prevent students from inventing more solution methods. Using their knowledge of the curriculum, mathematics, and students' learning, they debated on that issue that might not be important enough to be addressed by researchers. Though that expanded their views on mathematics instruction, unfortunately, their knowledge of that became knowledge without solid evidence. But this could become a point to link research to practice, which could ultimately enhance teacher knowledge. How to bridge research and practice, researchers and practitioners to generate mathematics knowledge for teaching needs further study.

The importance of boundary brokers across communities

The study by Cobb et al (2003) points out the importance of boundary brokers in teachers' communities in terms of aligning professional activities and learning experience.

In this study I identify Ms. Hu as a boundary broker who played an important role in the school-based TRG, the Bell team, and the district TRG. As a part-time teaching research specialist of the district, she co-organized and facilitated the professional activities for the math teachers. At the same time, she took charge of the Bell team that included all fourth grade math teachers from about nine elementary schools. To coordinate the lesson case study activity in the district, she helped her team teachers revise and polish their presentations of the lesson cases in the monthly team activity. As a highly regarded math teacher in the school and district, Ms. Hu was involved in the research projects of the district. That brought in learning opportunities for her school-based TRG. The group got an opportunity to think big and reflect on the current reform and the drawback of math education in China. This study suggests that having some member in a teacher community act as a boundary broker can broaden the views of the community and bring in learning opportunities for the community members. However, because of the relatively limited access to Ms. Hu's participation in the district activities, this study does not go into depth about how a boundary broker may affect the learning of members in a community of practice and the competence of the community. Further research is needed to answer this question.

The teaching research groups were situated in the institutional context of a hierarchical educational system. The hierarchical structure of the teaching research group as a teacher community of practice has pros and cons in terms of teacher learning. In what follows I discuss the pros and cons.

Pros and cons of teaching research groups as a community of practice

The teaching research groups my participant teachers worked in were placed in a network that had a hierarchical structure[1] from the district, the associated lesson plan team, the school math teaching research group to the grade math teaching research group. The teachers were mandated to participate in the multiple communities. On one hand, the network interweaving the multiple communities could spread ideas and educate teachers to implement what they were expected to teach through kinds of approaches, which created coherent learning opportunities for the teachers from the school to the district.

The coherent learning opportunities were created closely around curriculum and instruction that was at the center of the school and teacher work. Take the example of the lesson presentations made by Ms. Lu and Ms. Su. The unit of the meanings and properties decimals was considered important and difficult for teaching and learning. The district organized the activity of presenting lesson plans and lesson episodes to give teaches prompts to think about how to handle the unit and inform teaches of possible mistakes and misunderstanding students could have. That created an opportunity for Ms. Lu, Ms. Su and other teachers who presented to engage in improvement of practice through the following steps, including being mentored to create and revise the lesson plans, trying out the lessons and receiving feedback from Ms. Hu, and collaborative

[1] I claim that the institutional structure is hierarchical from two aspects. For the district and the school-based TRGs, the hierarchy is bureaucratic as the district teaching research specialists take a role of evaluating teachers and teaching quality of a school. Meanwhile, the hierarchy is also based on expertise as the district teaching research specialists are former seasoned excellent teachers. They are promoted to the position of teaching research specialists because of their expertise in teaching and learning. But for the intermediate groups, the Bell teams, the hierarchy is more based on expertise as the teams are informal part of the educational system.

reflection upon the lesson plans and lesson episodes with the district specialist and colleagues from the associated lesson planning team, and finally writing up their reflective thoughts on teaching the lessons and presenting the lesson plans and their thoughts to all the fourth grade math teachers in the district. This activity stretched over time to connect the teachers' inquiry into instruction from the school to the district and address possible difficulties and problems the teachers could encounter in classrooms. By coherent learning opportunities I do not mean the continuity and progression from teacher preparation, induction to professional development (Feiman-Nemser, 2001). Instead, the coherence resided in connections of teachers' experiences in their school with their professional development experiences outside the school. An empirical study (Porter et al, 2003) reveals that coherence is one of the core features of effective professional development experience.

On the other hand, as Little (1990) pointed out, collegiality as joint work may incur costs, such as vulnerability to external manipulation, loss of individual prerogative, and interpersonal conflicts. The mandated participation in collective and collaborative work could impose conformity on the teachers about how to teach mathematics well. My observations reveal that the teachers sometimes had to cope with conformity. For example, the new math standards called for connecting math learning with student real life. In accordance with the reform call, the textbook presented problems in real life settings and teachers were highly encouraged to create such problem settings. Having an interesting problem setting that was linked to student real life became one of the criteria

to evaluate if a lesson was successful. However, the teachers held a reserved attitude toward this reform idea or how to carrying out this reform idea. Ms. Hu criticized that some problem settings designed by the textbook was fake in Chinese contexts, such as renting cars when traveling around. Indeed, it was so rare for ordinary Chinese people to rent cars when they traveled to other places. Similarly, Ms. Zhang felt uncomfortable with having to be imaginative enough to come up with that kind of problem setting in daily practice. She observed that many teachers created that kind of problem setting for the sake of problem setting instead of for student learning. In addition, conformity could result from the hierarchical relations among the participant teachers (Paine & Ma, 1993; Hu, 2005). In the case of Ms. Su preparing her lesson plan presentation, the district specialist Ms. Ya had different ideas from Su on which model should be used to present 0.001, the hundred squares or the cube. For Ms. Su, after observing and working on concrete models, students should understand decimals by observing the cube that was abstract, but Ms. Ya was afraid students could feel confused at the cube to represent 0.001. Finally, Ms. Su had to give in and used the traditional squares to show the meaning of 0.001. Sometimes conformity coerced young teachers to follow the ideas of seniors in a community of practice.

The norms of participation in the TRGs

In the previous chapters I analyze what the teachers did in the communities and how what they did impacted on their instructional practice. But until this point I have not discussed

the norms of their participation in the communities that enabled or constrained their learning and what shaped the norms in the communities, which constituted an important dimension of a teachers' community. As this is not the focus of this study, I try to briefly analyze the norms of the teaching research groups and the resources that shaped the norm.

Wenger (1998) points out that participation involves all kinds of relations in a community. Collegial collaboration was one of the relations among my participant teachers. Working under the strong tradition that teaching practice is reflective and collaborative, the teachers in this study still carried out different norms of participation in their groups. The first grade teachers collaborated with each other on an equalitarian basis while the fourth grade teachers' participation was relatively "hierarchical" and around a "center". When collaborating with each other, the first grade teachers had to manage their different perspectives on teaching and learning. There was a relation of mentor and mentee among the fourth grade teachers. What caused the different norms and the dynamics of relations? What resulted in the various relations among teachers was multiple-faceted. I argue that teachers' identities, professional resources and different access to social resources, the teachers possessed and brought in played a major part. Adapting the concepts of professional resources and social resources defined by Barnes (2002), I define professional resources as the teachers' experiences and understanding of mathematics teaching and learning. The term social resources refer to opportunities to

engage in sustained or intense activities for instructional improvement and work with more knowledgeable others in a broader community.

Although Ms. Wu as the group head of the first grade TRG convened the weekly meetings and coordinated the group work, she did not dominate the discourse whenever the group collectively planned curriculum and instruction. All the four teachers voiced their perspectives and ideas in an equal sense. They followed the school rule that each week one of them took charge of a unit to arrange instructional pace and put her unit and lesson plan on table for the group to discuss. In contrast, in the fourth grade group that school rule was not well implemented. In the seven observed weekly group meetings Ms. Hu, as the head of the group, made decisions on their instructional pace. In their formal and informal interactions, Ms. Hu was the person who seemed to position at the "center" of the group from which the other two teachers sought approval and advice. The event of preparing the lesson presentations in the district that I discussed in Chapter Four showed that Ms. Hu acted as a mentor for the other two teachers. She assisted and guided them to refine their lesson plans for presentations. From her firm tone in the meetings her mentor position was clear. For example, when she looked through Ms. Su's lesson plan for the district presentation, she made direct and pointed comments. She firmly disapproved Ms. Su's arrangement of introducing the history of decimals in the middle of the lesson by saying "No, you can't do that". After reading the lesson plan more, she openly sighed out her disappointment as the plan was not creative enough to be presented to the district. She asked Su to take notes of her suggestions and revise the plan after the meeting.

Hu: Can you put the history at the end?
Su: I want to introduce that when I summarize. See, we have studied so much...
Hu: No, you can't do that. Do you know why? Usually we put the introduction of history at the end.
Su: I plan a practice at the end.
Hu: Anyway, you cannot put the history introduction here (pause).
Hu: How can you present your plan to other teachers? Ai, it's too conventional (pause). Can you arrange two more practice problems? Take notes down and revise later. (Fieldnotes and transcription, 03/13/2006)

As the group heads, Ms. Wu and Hu participated in the groups differently. What led to their different participation was their sense of identity and different professional resources they possessed. Identity in a community of practice can be defined "by the ways we experience our selves through participation as well as by the ways we and others reify our selves" (Wenger, 1998, p.149). Ms. Hu was considered in the school and the district as an excellent teacher, being designated as part-time district teaching research specialist and a math head teacher of the district. She was clearly aware of her reputation and position in the school and the district communities. In the interview, she proudly told me that almost all math teachers of the Tower were mentored by her. The school principal thought highly of her and set her as an exemplar for the math teachers. When I queried if the school unofficially wanted her to mentor Ms. Su and Ms. Lu, without any hesitation she confirmed my observation. As Wenger said, her identity of being a mentor was reified by Su and Lu. Both of them viewed her as their mentor. Ms. Lu commented, "Throughout our collective lesson planning I feel I change my points of view and improve my teaching methods. Although she [Ms. Hu] does not observe my class everyday, not like my previous mentor who observed my class more than 20 times each semester, Hou might just observe my class three or four times, I feel I learn something and improve bit by bit

after each of her observations" (Interview, 03/08/2006). Ms. Su expressed her wish that she could have had more opportunities to interact with Ms. Hu if they were not that busy (Fieldnotes, 03/27/2006). When the semester approached the end, Ms. Lu was very happy to tell me that she would continue to work with Ms. Hu in the third grade next semester. She would be lucky to attend a district research project with Ms. Hu as Ms. Ya, the district specialist for the fourth grade math decided to involve Hu and her third grade colleagues in the new project. Working with Ms. Hu not only meant that Ms. Lu will be continued to be mentored by Hu, but also she gained more opportunities brought in by Hu to engage in instructional improvement.

Differently, Ms. Wu was still a "young" teacher although she already taught for seven years. Of her first grade TRG colleagues, Ms. Zhang was an experienced teacher, teaching more than ten years and having a higher rank on teachers' designations, and Ms. Li and Ms. Pu had ten years of teaching experience. She realized that her strength as the group head lay in her richer experience of teaching the new textbooks. "Actually, my experience and qualification is not that enough. I am the youngest one, having the least working experience. In our group Pu is the one who has rich experience of teaching lower grades. I consult with her on many things. And Zhang has a different perspective from us because she taught upper grades for years. I should say that she stands at a higher point than us. Wang is versatile and warm-hearted. My experience is only that I am involved in the curriculum reform several more years than them. What I could do is to share my experience of teaching the new textbooks with them and tell them what we should pay

attention to. That's what I can do" (Interview, 03/02/2006). Her awareness of her own identity and her colleagues' strength positioned herself as a colleague who needed to collaborate with others on achieving certain goals and polishing practice.

As Ms. Wu mentioned in the interview, she noticed that Ms. Zhang held a different perspective on teaching and learning from her and the other two colleagues. She explained that was because Zhang brought in her years of experience of teaching upper grades. The norms of participation in the communities were also influenced by the participants' professional resources. Ms. Zhang and Su's participation in their communities exemplified this point.

Ms. Zhang's rich experience of teaching upper grade mathematics contributed to the group discussions. In the first grade group Ms. Zhang was very active in collective discussions, which was seen from the case of helping Ms. Pu prepare her public lesson. She questioned Ms. Pu's mathematical language in a problem, offered her different perspective on how students might estimate the sum of 27 plus 38, and reasoned if the numbers chosen by Ms. Pu impeded students to produce more solution methods. In the other group meetings she was also very vocal. For example, she always attended to a math teacher's language that she thought should be accurate and rigorous. In the meeting where they discussed the lesson plan of knowing RMB (Chinese currency), Ms. Pu and Ms. Wu talked about how they would teach students to know the RMB notation expressed in decimals. Ms. Wu said, "Yuan [dollar] goes before the decimal point and Jiao [dime] and Fen [cent] go after the decimal point". Ms. Pu followed that they might

tell students to say the dot instead of the decimal point for avoiding any possible confusion. Ms. Zhang corrected them that it was more accurate to say the right or the left of the decimal point than before and after. She was very sure about that when Pu and Wu questioned her.

As Ms. Wu said, her years of teaching experience in upper grades might allow her to think about teaching and learning from different perspectives. Ms. Zhang just joined the group last fall from the sixth grade. In the past ten years she did not teach lower grades. Her understanding of first grade mathematics teaching and learning was affected by that experience. On one hand, she acknowledged that she knew little about the new textbook as she taught the old version in the past ten years. She thought working with her colleagues in the group was an effective and efficient way for her to catch up with the reform. On the other hand, she sensed that her thinking sometimes was different from the other three colleagues. She did not want to focus on "trivial things" in instruction such as requiring a standard way of taking notes and writing homework, and using the same stamp to mark student homework. "Their way of thinking is different from upper grades teachers. They focus on details too much. ..Even we have to use the same stamp to mark student homework. That should be a private thing, decided by a teacher herself. The stamp has two columns, handwriting and score. Each time we give grades in the two columns. But that should be used in upper grades. First graders do not know the two words and care much about it. So I decided not to use the standards stamp. I created a stamp with cartoon that is attractive for kids" (Interview, 06/15/2006). It was

understandable that teachers in upper grades usually did not spend much time establishing routines and habits for students as some routines and habits have been set up in lower grades. Ms. Zhang needed time to adjust her role as a lower grade math teacher. Although she disliked focusing on details of establishing routines, she still followed her colleagues to do that. But she resisted using a standard stamp.

Ms. Su taught both the fourth and fifth grade math this semester. With an Associate's degree in mathematics education, she seemed to have more preparation in mathematics than her colleagues Ms. Hu and Ms. Lu. Her expertise in mathematics knowledge contributed to the group learning. Compared to her colleagues, Ms. Su was not very active in their group interactions. But when the group tried hard to make sense of the new content they never taught in the textbook, she actively engaged in the conversations and demonstrated her understanding of the new knowledge to her colleagues. In Chapter Five I showed the fourth grade teachers collectively planned the lesson about translation and rotation that was a new geometry content for elementary mathematics. Ms. Hu and Ms. Lu felt confused at which a shape should flip or slide around, a side or a central point. Ms. Lu even questioned how she can differentiate translation from rotation. Obviously, Ms. Su was more confident at her knowledge of the new content. In the meeting she firmly illustrated a shape should flip around a side. After the meeting she reached out to seek other resources to make sense of the knowledge. She brought in the PEP version teaching guidance book and consulted with fine arts teachers who told Su students already learned how to draw translations of shapes in the third grade.

When Ms. Lu could not draw a triangle that was flipped 90 degrees, she asked for help from Ms. Su.

Another professional resource she brought in to the group was her expertise in technology. That academic year she was selected by the school to attend a technology for mathematics organized by the district. On many occasions she mentioned to me that the workshop was not quite helpful as it did not take the teachers' needs into account. I followed her to the workshop twice and had to agree with her. But her technology competence was still somehow improved. Thus she often took the tasks of making PowerPoint if animation, audio or video files or three-dimension shapes are included. Ms. Hu told me that Ms. Su was good at technology. Because of the different professional resources the teachers carried with them, the collegial relations among the fourth grade teachers were full of dynamics. They could be mentor and mentees while they could be colleagues who collaborated with each other to make sense of teaching and learning. They drew on each other's expertise to refine their practice.

In the communities my participant teachers had unequal access to social resources that were provided by the district. In the long run the unequal access to social resources influenced their participation in the communities. The teachers had equal access to shared resources within the school-based teaching research groups, but Ms. Hu and Ms. Wu were given opportunities to enjoy more social resources available in the district. Currently, both Ms. Hu and Wu attended the district teaching research groups respectively for the fourth and first grade mathematics. In the district TRG Ms. Hu

worked with other excellent math teachers to study textbooks and lessons while Ms. Wu as a promising young teacher was selected to attend the district TRG and learn from working with other excellent teachers. The district teaching research groups were organized with two goals. One was to make use of excellent teachers' expertise to study curriculum and instruction for guiding the whole district math teachers. Another goal was to develop promising young teachers' talents.

Unfortunately, I was not able to shadow Ms. Hu and Wu in their district TRGs to allow me to make claims about what they learned and how what they learned impacted their participation in their school-based TRGs. But in the interview Ms. Wu said that interacting with her district TRG colleagues expanded her views on teaching and learning. She gave me an example. Visiting an elite elementary school made her think about the importance of sharing a common goal among teachers for student learning. That elite school was experiencing a reform that aligned goals for student learning cross subject matters and classes and sought parental support and involvement to realize the goals. She felt the Tower School lacked a common goal for student learning cross subject matters.

As a seasoned and excellent teacher, Ms. Hu still felt that she could continue to improve by attending the district TRG as she had opportunities to work with other excellent math teachers. Collaborating with them promoted her to think more and enrich her views on math instruction. In 2000 Ms. Hu had another great learning opportunity that was a milestone for her growth. She was selected by the district to study as a full-time student for half a year in the district Educational College. Many excellent math

teachers with national reputation were invited to teach the class and do lesson study with the class. The class went to other regions to study lessons with teachers who were famous in the field of elementary education. The intense learning experiences greatly advanced her knowledge and skills for teaching mathematics. She thought highly of that experience's contribution to her professional growth.

Obviously, both Ms. Wu and Hou benefited from the social resources that were scarce in the district. They could extend the benefits into their school-based communities, but it could be problematic that the scarce resources were only used to improve individual teachers who had access to the resources while most teachers would feel disappointed at the unequal access. How to distribute and use resources within a community could be an issue.

A teachers' community of practice entails dynamics of collegial relations. Teachers do joint work to refine practice through debating, arguing and discussing. Meanwhile, they share stories, anecdotes and feelings after coming back from class. They also provide emotional and moral supports to each other for going about life and work. In the study I show their collaborative work for improving instruction. The personal and emotional dimension of a community of practice was left out. But that does not mean it is not significant for teachers and even for researchers because it is an integral part of teachers' life.

The future

This study employs an ethnographic approach to exploring what the teacher did in the school-based teaching research groups and related district communities and how what they learned might influence their teaching practice. Overall, the study reveals that the communities as a regime of competence provided coherent learning experience for the teachers through their engagement in the joint work and other tasks that were closely tied to curriculum and instruction. Creating and using tools as learning resources and having some teacher work as a boundary broker across different communities also contribute to creating coherent learning experience for the teachers. In the future this study suggests the following actions need to be taken for maximizing what a professional teacher community can offer for teachers:

First, we need indicators for effective and meaningful discussions among teachers.

Second, a professional community of practice needs to develop strategies to help teachers overcome their weaknesses in their teaching competence after the weaknesses are identified.

Third, educational researchers should be part of the professional community for creating a better link between research and practice. Knowledge of teaching practice comes from careful observation and examination of teachers' real work in the field.

Fourth, learning resources are important for teachers to improve instruction in communities; however, two issues are worth mentioning. One is how to use and create tools that reify teachers' experience and the competence of communities. The other issue

is teachers' access to learning resources within and across communities. Unequal access to learning resources might lead to unequal learning opportunities for teachers.

Last, recognizing the importance of a boundary broker across communities, who should be boundary brokers and how they work across communities need further studies.

APPENDICES

Appendix A

Table A.1 Data sources of the study

Types of data	Data sources	Status of data
Observations in various sites—classes, school offices, the Bell team s and district	Feb. 20 to Mar. 29 May 8 to Jun. 26	Fieldnoted
Observed group activities	Fourth grade: Monday afternoon	Audiotaped and one videotaped; fieldnoted
	First grade: Tuesday afternoon	Audiotaped and four videotaped; fieldnoted
Observed Bell teams and district activities	* Fourth grade teachers' district activities (twice) * Fourth grade teachers' monthly Bell team activities (three times)	Audiotaped and fieldnoted
	* First grade teachers' district activities (twice) * First grade teachers' monthly Bell team activities (twice)	Audiotaped and fieldnoted; One videotaped
Observed lessons	* first grade teachers' lessons during the district supervising group visit * Li's study lesson to the first grade group	Audiotaped and fieldnoted
	* fourth grade teachers' lessons on shapes	Videotaped and fieldnoted

Table A.1 (cont'd)

	*three public lessons	Videotaped and fieldnotes
Interviews	* the principal * First formal interviews with all participant teachers * Interview with the district specialist of first grade * Interview with first-grade teachers about Pu's public lessons * Interviews with Wu about her public lesson in the district * Interviews with Hu about helping Su and Lu prepare their presentations in the district * Interviews with Lu about her presentation in the district * Interviews with Su about her presentation in the district * Interviews with all participant teachers about their group activities and the district teaching competition in April * Interviews with all participant teachers about preparing and conducting the lessons when a supervising group from the district visited the school for two days * Interviews with Lu about her public lesion * Final interviews with all participant teachers * Interviews with Su about her participation in fourth and fifth teaching research groups, teaching across grades and participation in the district bi-weekly technology workshop * Interview with the school math director Jin	All interviews but one with the district specialist were audiotaped
Documents	* 2005-2006 school math instruction plan for the second semester * Textbooks, teacher manuals, student booklets, and some worksheets * Some journal articles they studies in group meetings * All lesson plans of Lu, Pu and Wu's public lessons	

Table A.1 (cont'd)

* Comments from the district colleagues on Wu's public lesson plan * Lesson plans of Lu's district presentation * Lesson plans of Su's district presentation * Lesson plans of first grade teachers for the district supervising group visit * Lu and Pu's notes of observations of the teaching competition * Previous lesson plans of all teachers except Zhang that were compiled in a book by the school * lessons plans of a unit created by fourth grade teachers (a difficult unit) * videotapes of their previous public lessons--Wu, Pu, Li, Lu, Su and Hu

Appendix B Ms. Wu's talk moves

categories	Mar. 22	Mar. 29
Demonstrate ideas	7. T: now do you know how many more are the red cubes than the yellow cube? (writing on board) 8. Ss: Two more 9. T: How do you know? Who wants to come to the front and tell us how you found that? 10. B1: I put the yellow cubes above and... and the red below. 11. T: Could you come over here to show us? (B was sticking yellow cubes in a line and red cubes below yellows, matching one yellow with one red) 12. T: Ok, can you tell how many more? 13. Ss: Two more. 14. T: Can you come over to show us the two more? 15. B1: (point to the more red) they are the two more red cubes.	11. T: How do you know the answer? You, please speak aloud. 12. G2: I count. 13. T: You counted. Can you tell us how you counted? 14. G2: Class Two has 8 persons. Class One has 6 persons. 15. T: How do you know that Class Two is 2 more than Class One? 16. G2: Because 8 is more than 6. 17. T: Do you mean that 8 is two more than 6? 18. G2: (nod and sit down) 19. T: Can anyone else tell us how you find the answer? 20. B1: Because...because the red and the yellow both have 4. And after the 4 red there are 2 left. (The red represents Class Two. The yellow represents Class One) 21. T: Do you want to use the red and yellow cubes to show your answer? Can you give it a try in front? (B1 is walking toward the blackboard) Let's see what he is

	going to do. (T helps the boy paste the magnet cubes on the board) (After Ms. P tting the six yellow cubes on the board, the boy said-) 22. B1: I want to make the red toward the yellow. 23. T: Can you point out the two more for us? 24. B1: The two more is here (circle the two with figures)
Use wait time	42. T: We solved this problem with cubes. Can you come up with other ways to solve the problem? 43. G3: I counted. 44. T: We already counted them. 45. B3: Direct calculation. 46. T: What do you mean? How can you do that? 47. B3: (no response and wait) 48. T: That doesn't matter if you have no idea now. Some said we can count. How many candidates does Class Two have? 63. T: Subtracting 6 means...(use a "remove" gesture) 64. Ss: Remove 6 persons.

		65. T: Ok. What does the 6 removed refer to? 66. Ss: Class One. 67. T: Don't hurry. Please use your head. And discuss with your partner. Ok? Start. (Ss discuss with their partners and T circulates the class for 30 seconds)
Revoice		52. T: You all know that 8 is two than 6. How do you know that? 53. G4: Because 8 takes away... 8 minus 6 equals 2. 54. T: You mean you use an operation (write down 8-6=2)?
Explain and justify thinking	48. T: Some of you did the same. But I also see some of you did differently. Do you have any question for him? 49. B3: Why do you circle the yellow cubes? (no response) 50. T: Do you want to ask if the circled yellow cubes include any red cubes? (no response from the boy) Let's help him. 51. T: Can you see any red cubes? No. How many red cubes are left? Two? 52. Ss: No. 53. T: What should we circle? 54. B5: Circle the red cubes, the	69. T: Who wants to come here and show your answer? (Ss raise hands and a girl is called on) (She cannot reach the cubes and T asks her which six she wants to circle. The girl says the six yellow) 70. T: Can you explain why you circle the six yellow cubes? 71. G5: Because Class Two is two more than Class One. So I think I should circle the yellow. 72. T: That's your

seven red cubes.	explanation. Does anyone have questions for her?
	73. B4: How do you know it is two more?
	(no response)
	74. T: Let's look at the 8 in the operation. What does it mean?
	75. Ss: The numbers of Class Two.
	76. T: Do the 8 candidates include any from Class One?
	77. Ss: No.
	78. T: Which six should we circle? Who does differently?
	79. G1: (use her figure to circle the six red and T helps her more the loop to cover the six red cubes)
	80. T: Can you explain your reason for this? Speak louder. We cannot hear you.
	81. G1: The 8 of Class Two subtracts the 6 of Class Two.

*Note: T refers to the teachers, Ss refers to students, G refers to a female student, and B refers to a male student.

Appendix C

Table C.1 The activities of the first grade TRG teachers in 2006 spring semester

Date	Activities
2.28	Weekly group meeting; Ms. Pu took on the task of conducting a public lesson
3.07	Weekly group meeting; Ms. Pu prepared her public lesson
3.13	Observing and reflecting upon Ms. Pu's rehearsal lesson
3.14	Weekly group meeting
3.15	First grade Bell team monthly meeting; Ms. Pu conducted the public lesson
3.16	First grade teachers, the principal and the school math TRG head observed and reflected upon Ms. Li's lesson
3.21	Joint meeting with the second grade math teachers-reflecting upon Ms. Pu's public lesson; Ms. Wu tried out the first rehearsal lesson that would be presented to the district
3.22	Ms. Wu tried out the second rehearsal lesson in front of her colleagues of the district TRG and colleagues of the school TRG
3.24	Ms. Wu tried out the second rehearsal lesson again with the district teaching research specialist
3.27	Ms. Wu tried out the lesson again
3.28	Weekly group meeting; Ms. Wu tried out the lesson again with the district teaching research specialist
3.29	District meeting for all the first grade math teachers; Ms. Wu conducted her lesson
4. 4,11, 18, 25	Weekly group meeting
4.10-13	Teaching competition in the district
4.19	First grade Bell team monthly meeting
5.09	Weekly group meeting
5.16	Weekly group meeting; prepare lessons for the district supervision visit
5.17	District meeting for all first grade math teachers
5.30	Weekly group meeting
6.06	Weekly group meeting
6.07	First grade Bell team monthly meeting
6.19-20	Guidance for teaching the second grade textbook in the fall organized by the city

Table C.2 The activities of the fourth grade TRG teachers in 2006 spring semester

2.27	Weekly group meeting; prepared the lesson case study presentations to the district
3.13	Weekly group meeting; continued to prepare the lesson case study presentations
3.09	Ms. Lu tried out the lesson for the district presentation
3.15	Fourth grade Bell team monthly meeting; rehearsed the lesson case study presentations with the district teaching research specialist
3.20	Weekly group meeting
3.23	Ms. Su attended the district technology workshop
3.24	Ms. Hu mentored two teachers from other schools to revise the lesson case study presentations
3.27	Weekly group meeting
3.29	District meeting for all fourth grade math teachers: lesson case study presentations
4. 3,10, 17, 24	Weekly group meeting
4.10-13	Teaching competition in the district
4.20-21	Ms. Lu observed lesson demonstration and reflection activity organized by the city
4.26	Fourth grade Bell team monthly meeting
5.10	District meeting for all fourth grade math teachers
5.11	Ms. Lu rehearsed the public lesson in another school that would be conducted in front of the fourth grade Bell team
5.15	Weekly group meeting
5.17	Fourth grade Bell team monthly meeting; Ms. Lu conducted the public lesson
5.23	Weekly group meeting
5.29	Observed Ms. Hu's lesson about tessellation; Weekly group meeting
6.05	Weekly group meeting
6.07	Fourth grade Bell team monthly meeting
6.24-25	Guidance for teaching the third grade textbook in the fall organized by the city

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