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TEACHER LEARNING THROUGH PARTICIPATION
IN STUDY GROUPS

presented by

HAN HAN THI

has been accepted towards fulfillment
of the requirements for the

Ph.D. degree in Curriculum, Teaching and
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TEACHER LEARNING THROUGH PARTICIPATION IN STUDY GROUPS

By

Han Han Thi

A DISSERTATION

**Submitted to
Michigan State University
In partial fulfillment of the requirements
For the degree of**

DOCTOR OF PHILOSOPHY

Curriculum, Teaching and Educational Policy

2008

ABSTRACT

TEACHER LEARNING THROUGH PARTICIPATION IN STUDY GROUPS

By

Han Han Thi

The purpose of this study is to investigate teachers' learning improvement through participation in study groups. In particular, this study examined how two second grade active participant teachers' classroom practice changed over time and how their changes were related to changes in their study group meetings, which they called Professional Learning Community (PLC) meetings.

Through narrative classroom observations, audiotape recordings of study group discussions and interviews, this study analyzed how two teachers changed over time with respect to two aspects of their practice: (a) their analysis of students' work and students' ideas, and (b) their use of teaching and learning materials.

Findings were reported in three points: (1) teacher's content learning goals, activities, and materials, (2) teacher designed student work and embedded assessments, and (3) teacher and student roles. Similarities and differences in each teacher's practice between 2003 and 2007 were presented.

This study holds implications for researchers and practitioners interested in strengthening teachers' practice through professional development. It reveals that participation in study groups has the power to change teacher knowledge and belief about their practice and teaching.

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2008

DEDICATION

This dissertation is dedicated to
my father U Maung Thi and my mother Daw Than Shin,
who always felt proud of my career
and
my husband Ko Myint San,
and
my two daughters, San Su Thi and Han Nwe San, and my son Nyan Lynn San
who enthusiastically supported my decision to pursue a doctoral degree and
gave me energy from a far away home country until I reached
my educational goal in the United States.

Thank you all.

ACKNOWLEDGEMENT

I would like to thank my committee members Gail Richmond, Lynn W. Paine, Christopher W. Wheeler, and Thomas Bird for their kind encouragement and thoughtful suggestions that helped shape my research.

I especially want to thank my program advisor and dissertation chair Charles (Andy) W. Anderson who guided me with relentless commitment to quality research and writing and also supported me academically and emotionally.

I also thank Tim Smith and Deb Smith, who gave me valuable advice for my study on this project and also the two teachers who were willing to participate in my study.

I thank Ilene Satchell who supported me with her commitment to improving my professional writing and editing and Robert Smith and Judy Mc Lane who encouraged me in many ways throughout my doctoral study years in the U.S.

A special thanks goes to Dr. Mary Thormann, who gave me great affirmation during my life long journey to MSU. I also thank Dr. Keith A. Camann who treated me at Olin Health Center until my health was strong enough to reach my goal. Finally, I thank my sister, Wah Wah Thi, for her support in my doctoral program.

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CHAPTER ONE: INTRODUCTION

As the impact of on-going professional development on teachers' learning improvement becomes more and more apparent, ways that professional development workshops help or support participant teachers or how teachers buy into the professional development workshop experience becomes an increasingly central question in teacher education.

The purpose of this study is to investigate teachers' improvement through participation in the project of Professional Inquiry Communities for the Reform of Urban Science Teaching (PI_CRUST). This project was conducted as partnership program collaboration with the MSU science education faculty and the Lansing District Schools. This study will examine change at the end of the project year 2007 compared to the beginning of the project year 2003. In particular, this study will investigate the two 2nd grade participant teachers' improvement. It will analyze their change over time in different contexts with respect to two aspects of their practice: (a) their analysis of students' work and students' ideas, and (b) their use of teaching and learning materials. This study will examine how two teachers' practice changed over time and how their change was related to changes in their study group meeting, which they called the Professional Learning Community (PLC) meeting.

In order to see the two individual teachers' changes over time, this study will investigate the pattern of their participation through their study group discourse and will consider, for instance, how they shared and responded to students' work, what they said about students' understanding; and what teaching materials

they brought to study group discussions. Comparison will be made between two different times, specifically 2003 and 2007.

Many factors, which affected the two teachers in my study, are related to changes in the study group meetings. These include the way the study group discussed content of subject matter related to benchmarks, patterns of participation, the nature of work participants shared, their ways of talking about the classroom, their usage of teaching materials, and their understanding of students' work. Among these factors, this study will focus on changes in the study group discussion in two particular areas: (a) understanding of students' work and (b) usage of teaching materials.

I recognize that there are many different contexts, in addition to study group membership, which might impact teachers' improvement, such as moving to a new building, working with new principals who may have different perspectives, changes in the grade level where they taught and developed their practices, and changes to their professional environment like the study group in which they participated and shared their teaching experiences for their own learning.

This study will not address all of the contexts listed above which might have affected two teachers' improvement. Instead, it will examine only the context of participation in one particular project, the PI_CRUST professional learning community. In other words, this study will focus on the context of teachers' learning through participation in the study group as a new professional environment. It is possible that changes, which occurred in the two teachers' practices were not identical. In addition to examining changes over time by

looking from 2004 to 2007, I seek to discover specific differences in those changes between the two different teachers. There may be contrast in changes of practice though both teachers participated in the same study group.

Research Framework and Questions

My study was framed by one guiding question: How did the teachers change over time with respect to two important aspects of their practice (a) analysis of students' work and students' ideas and (b) use of teaching and learning materials? These two aspects of practice were woven into my two research questions, which are introduced here and explained in detail in Chapter Two.

Question 1: How did Teacher K and Teacher J's classroom practice change with respect to three important points?

- A. Teacher's content learning goals, activities, and material
- B. Teacher designed student work and embedded assessments
- C. Teacher and student roles

Question 2: What can we learn from interview transcripts and study groups audiotapes about the causes of Teacher K and Teacher J's changes in practice?

- A. Teacher and group leader role change
- B. Study group participant collaboration
- C. Teacher content knowledge depth change

Study Groups

Knowing that my research would be heavily focused upon teachers' participation in a study group, I first turned to education literature to examine the study group phenomenon. In recent years professional study groups have been established in numerous public schools, so that today many teachers are able to regularly interact with their peers in settings intended to enhance professional growth. (Borko, 2004; Cohen, 1990; Wilson, 2002) Through its continual outpouring of research findings and analysis, education literature presents a multi-faceted exploration of the effect that membership in study groups can have upon teacher learning and teaching practice. Researchers propose that study groups offer teachers unique opportunities to learn their craft and that by participating in study groups, teachers might be able to better understand student thinking and learning, their own (teacher) thinking, subject area content, and approaches to teaching content, along with many issues related to changes in practice. Examination of this literature reveals discourse among researchers united in their belief that membership in study groups can strengthen teaching performance even as they find multiple reasons for this phenomenon.

As researchers discuss teacher growth through association, they use phrases such as *study groups*, *collegial communities*, and *professional learning communities*. All of these phrases synonymously refer to teacher gatherings occurring more or less regularly for the purpose of deepening members' understanding of teaching and learning. Therefore, as I consider researchers' findings reported in literature, I also use all three phrases interchangeably.

Conclusions Drawn from this Literature Review

This literature review examines research evidence of study group effect upon teacher participants. It specifically examines (1) study groups' ability and tendency to affect teachers' knowledge and reasoning and (2) study groups' ability and tendency to affect teachers' classroom practice. However, before these two factors can be examined, we must first consider a requisite feature of group influence upon members, i.e., participation. Study groups do not have life in themselves. Instead their power to impact teaching and learning lies in the willingness of participating teachers to carry concerns and ideas into group sessions and to transport new understandings back to their classrooms. Participation must be viewed as a necessary driving force. Therefore, as this literature review examines research regarding groups' capacity for increasing teachers' knowledge along with groups' impact upon teachers' practice, it does so in the context of evidence regarding group participation. This literature review does not presume at the outset that participation always results in improved skill and understanding. Instead it attempts to assimilate the participation factor in literature's findings regarding study group efficacy.

In my review of literature focused on teacher learning and practice impacted by study group participation, I will first examine ways in which study groups provide learning opportunities for teacher members. In the second section I will present challenges identified by literature in establishing and maintaining study groups that truly deepen teacher learning. In the third section, I will

investigate multiple strategies for helping group participants learn and develop best practice as reported in education literature.

Section 1: Study groups provide unique opportunities for teachers to learn

Researchers of teacher quality agree that study groups provide unique opportunities for teachers to learn, and their published discussions range widely across ways that such learning occurs. For example, in considering what and how teachers learn in study groups, Kazemi and Franke (2004) emphasize teachers' collective efforts to gain deeper understanding of their students' thinking, while Little (2001) highlights teachers' collaborative discourse in order to improve their practice. Both researchers use similar terms— "teachers' collective work" (Kazemi and Franke) and "teachers' collaborative work" (Little), but their approaches to understanding teachers' opportunities to learn in study groups are different. Kazemi and Franke consider how teachers learn through collective examination of students' work. Little emphasizes teachers' learning through shared discourse around their own classroom practice. Little's notion of professional discourse is echoed by Carroll (2005) who talks about teacher learning through interactive talk in a school-based mentor-teacher study group. Carroll emphasizes how mentor teachers interact and explore their collective mentoring experiences. The above three literature pieces illuminate the fact that regardless of the particular being examined when researchers observe study groups, group meetings are found to offer unique opportunities for teacher learning by providing venues in which interactive discourse among members can occur regularly.

Some researchers argue that what teachers learn and how they learn through teacher development groups can change their practice. (Cohen and others, 1990; Lin, 2002; Deglau, Ward, O'Sullivan, Bush, 2006) In contrast, Broko (2004) focuses less on such specifics and more on study groups' general potential for impacting teacher learning. Through this review process, I concluded that education literature identifies professional learning communities not only as venues for teachers' learning, but also as "communities of practice" (Grossman, Samuel and Stephen, 2001; McLaughlin and Talbert, 2001; Wenger, 1998). For example, professional learning community meetings sometimes encompass environments in which teachers conduct book studies, examine research findings, and explore education theory. However, due to their small, intimate settings they also encourage sharing of ideas. In other words, professional learning community meetings can offer participants comfortable settings in which they might reveal elements of their teaching practice and invite collegial critique and encouragement. Unlike stand-alone workshops or district-wide professional development days, communities, which often meet frequently and regularly, can provide a series of growth experiences for teachers.

Within literature's descriptions of teachers' learning study groups, I find multiple emphases such as (1) gaining deeper understanding of students' thinking (Kazemi and Franke, 2004), (2) collaborative discourse to improve teachers' practice (Little, 2001), (3) learning through interactive talk (Carroll, 2005), and (4) learning in a community of practice (Grossman et al., 1998). Particularly, Grossman and others (1998) focus on teachers' learning of new

pedagogical practices in the dual areas of problem analysis and improved pedagogy arising from deepened subject matter knowledge. I will discuss how those researchers describe teachers' learning opportunities in different contexts in the following section.

Related to teacher learning opportunities through the use of student works, I found that a number of publications support using student work. Although they use different terms such as "a tool for professional development" (Ball & Cohen, 1999; Little, 2002) as cited in Kazemi and Franke (2004), "a mediator of teacher learning" (Kazemi and Franke, 2004), and "a focus for teachers' collective inquiry" (Franke, et.al., 1998; Richardson ,1990), researchers unite in their belief that examination of student work potentially deepens teachers' understanding of practice.

Ball & Cohen (1999) and Little (2002) talk about the possibility of teachers learning by using student work as a tool for professional development, but there is no evidence in their literature to prove it. They support the idea that "the use of student work has the potential to influence professional discourse about teaching and learning, to engage teachers in a cycle of experimentation and reflection and to shift teachers' focus from one of general pedagogy to one that is particularly connected to their own students" (p. 204). Ball & Cohen (1999); Lin (2002); and Little (1999) also suggest that organizing teacher learning around the study of student work is one particular way in which professional development can be situated in practice. However, they do not explain how those opportunities are realized and whether actual student work was used by teachers whom they

studied. The study of Kazemi and Franke (2004) is one piece that describes the significant use of student work to direct teachers' learning trajectory as a group.

Kazemi and Franke (2004) indicate their strong belief that teacher learning opportunity occurs through "teachers' collective work in which they develop deeper understanding of their own students' mathematical thinking" (p. 203). Kazemi and Franke examined a study group consisting of ten elementary teachers who met monthly across the academic year of 1997-1998 at a small urban school. Their study focused on teachers' examination of student work in mathematics. Teachers examined student work as a group activity as well as a focus of teacher inquiry. Kazemi and Franke provide evidence of how these workgroup discussions centered on student work and described how teachers came to understand students' thinking. "Teachers proposed a similar mathematical problem to their students prior to each workgroup session and then discussed the student work those problems generated. For each meeting, teachers selected pieces of student work to share with the group. Teachers could comment on how they adapted the problem, how their students reacted to the problems, and specific ways in which their students attempted to solve it" (p.209). Teachers' participation centered on attending to the details of children's thinking. In their findings, they reported that, "teachers developed more detailed knowledge of their own students' mathematical thinking and began to articulate bench marks in their learning trajectories for their students and instructional trajectories to support their work" (P. 230). Thus, Kazemi and Franke show how teacher learning is evident when discussion is centered on student work.

In addition to the understanding of students' thinking, Kazemi and Franke (2004) talked about teachers' interaction with their students. Teachers found ways to interact with students about their strategies and to document those interactions for the purpose of sharing in the work group. Kazemi and Franke prove that participating teachers' engagement with student work shifts from one of uncertainty about students' thinking to one of active engagement with student strategies. They describe how they looked at student work related to problem types and strategies. Moreover, Kazemi and Franke provide dialogues that help us see how teachers ask detailed questions of each other related to student strategies and student thinking. By giving sufficient data such as the structure of the workgroup, the problems teachers proposed in the group and the distributions of kinds of exchanges in each of seven workgroup discussions, they help readers see how teachers attended to the details of student's mathematical thinking; however, they do not show us how teachers' learning produces changes in their classroom practice.

In addition to the use of student work in teacher learning, researchers indicate that teachers learn from each other through "professional discourse" (Little, 2001) or through "interactive talk" (Carroll, 2005). In both Little and Carroll's reports of study findings, they state that teachers learn through their talk and their interaction. However, the context of what teachers talk is different in these two studies. Little emphasizes teachers' discourse around classroom practice of a particular new reading project, while Carroll focuses on teachers' interactive talk related to the knowledge of mentoring practice. In Little's study

(2001), teachers share their daily classroom teaching practice in the process of a new reading project and interact with each other in collegial communities through professional discourse about their innovative practice. Carroll's report (2005) focused more on teachers' interactive talk about their mentoring practice with their interns as they engaged in thinking through their ideas collaboratively as a group.

Related to teacher learning through professional discourse, Little (2001) tells about how teachers learn through their interactions in the course of everyday work. Her study examined secondary school teachers' learning, in particular mathematics and English teachers from two high schools. She describes a component of teachers' classroom practice called "SSR" (Silent Sustained Reading) to enable readers to comprehend teacher learning opportunities in the context of ongoing daily work (p.930). In the "SSR" episode, the discourses of five English teachers from the group called "the Academic Literacy Group" were centered on what kinds of questions teachers raised, how teachers made decisions and reached agreement in their discussions, and how individual teachers presented their preferences regarding the SSR practice. Little's description of teachers' interactions gives us understanding of how teachers located their learning in relation to the group's collective project. Little makes an interesting point when she reminds her readers that although community members think they know what happens in classrooms, teachers actually do their work for the most part behind closed doors and out of sight of the community. Therefore teachers' professional study groups provide a unique

situation in which their largely unseen work is exposed to others. It happened that teachers whom Little studied were engaged in the process of developing a pilot course and collaboratively writing each week's curriculum. Although such work would not necessarily have involved teachers' explanations of how they functioned in their own classrooms, nevertheless planning for a pilot course did give them opportunity to state their own preferences for specific guidelines or practices. Little reminds her readers that teachers' work is often unseen, and she affirm the idea that participation in study groups draws teachers' views and practice into the open where others can examine them.

In addition, Little explained how teachers "learn from and in practice" (Ball & Cohen, 1999) through their interactions with one another and with the materials environment, and construct particular representations of practice. Teachers presented their practices and artifacts, lesson demonstrations and reviews of student work in the group and responded to each other regarding SSR practice. Thus, teacher-to-teacher interaction gave opportunities to develop both individual and collective practice.

With similarity to Little's idea of teachers learning through professional discourse, Carroll (2005) reports about teachers learning through interactive talk in a school-based mentor-teacher study group called Collaborating Teacher Study Group (CTSG). Five mentor teachers from an urban Midwestern elementary school met together regularly with a university instructor to investigate their collective experiences with mentoring in CTSG. "Participants in interactive talk have the potential of constructing joint knowledge" (Carroll, 2005

p.464). Individual participants engaged each other in new thinking and constructed joint knowledge about mentoring practice. Thus, Carroll supported the concept that study groups offer teachers learning opportunities by creating a venue in which interactive talk about collective mentoring practice can occur.

As mentioned above, teacher learning occurred through study group discourse when teachers used student work to understand student thinking, when participants collectively examined their mentoring practice experiences and when they shared issues related to daily work. In addition to those opportunities, teacher can deepen their subject matter knowledge through their study group community.

In addition to teachers' learning about their subject matter knowledge in study groups, this experience also helps participating teachers gain confidence and view themselves as effective teachers. For example, Pfaff (2000) found that study group interaction "helped them gain a stronger and clearer sense of themselves as readers [which led to] a stronger insight into the students as readers" (p. 5). Pfaff continues on to say that as teachers gained this insight, "study group sessions encouraged subtle changes in instructional planning and decision making" (p. 5). Through similar learning experiences during group sessions, teachers can make changes to their practice.

Broko (2004) points out that when teachers gather themselves into professional study groups for the purpose of improving their teaching practice, it is not always necessary for them to use materials developed expressly for that purpose. In other words, they do not have to rely upon curricula prepared by

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others. Borko briefly describes The National Writing Project and uses it as an example of teachers teaching their colleagues. As participants simultaneously practice writing and demonstrate their teaching practice, they reportedly “change their philosophies about teaching writing, and increase both the time spent on writing instruction and use of exemplary teaching practices” (p. 11). Broko thus provides a glimpse of the study group as a place where teachers can learn together by doing and sharing their work with colleagues.

Closing comment

Literature noted above gives evidence that educators are attempting to use study groups as tools for teacher professional growth. It establishes participation's affect upon knowledge acquisition and teaching practice. Through this review, I conclude that teachers benefit the most when they participate in their groups in two ways: (1) they contribute by bringing concerns and ideas to their meetings, and (2) they assimilate other members' contributions and apply them directly to their teaching practice.

Section II. Establishing and maintaining study groups that truly help teachers learn is a challenging task.

Researchers have determined that establishing and maintaining study groups that truly help teachers learn is a challenging task. This acknowledgement runs as a continual thread through teacher study group literature. In this section, I will present the challenges of (a) establishing study groups, and (b) maintaining study groups. Related to the challenges in establishing study groups, I will discuss the issue of organizational structure, the issue of leadership role, and the issue of time.

Regarding the challenges in maintaining study groups, I will present the issues of teachers' willingness to participate or to engage and teachers' conflict or tension.

A. Establishing study groups is a challenging task

A-1 Issue of organizational structure

Educational literature considers the challenges in professional learning communities in terms of organizational structure and productive, substantive use of that organization and time. (Morrossey, 2000) Organizational aspects of the study group have great influence upon the extent to which members continue their participation. (Arbaugh, 2003) During his study group research, Arbaugh identified four aspects of study group organization: (i) release time, (ii) requirements outside of study group sessions, (iii) frequency and length of study group meetings, and (iv) number of study group members (p. 154).

(i) Teachers whom Arbaugh studied said that release time was an important organizational characteristic of the study group. They were more likely to continue participating if they could do so during the school day as opposed to arriving early or staying late to attend meetings. I will discuss about time issue in the section A-3.

(ii) Arbaugh found that some participant teachers preferred having time to complete their reflections and read articles during study group meetings. Some of the teachers said they could read and write outside of the study group meeting, but teachers opposed to outside work spoke loudly regarding this issue. "Study group "homework" was not at the top of their priority list, often because of other school responsibilities." (p. 156)

(iii) Frequency of study group meetings is one factor to be considered when the study group is established. Most of the participant teachers agreed to meet once every two weeks. Arbaugh noted that teachers in his study also indicated that meeting less often would lessen the connections from one study group session to another.

(iv) Number of study group members affects teachers learning in the study group. Having too many members would lead to a group where individual contributions would be lessened. However, too few members may also cause a lack of diverse experiences and ideas. (Arbaugh, 2003)

Little (1988) suggests that groups can provide effective professional development if they are structured in such a way that they ensure “collaboration adequate to produce shared understanding, shared investment, thoughtful development and selected ideas” (cited in Wilson & Berne, 1999, p.175). Wilson and Berne explain Little’s proposal that in order to obtain such results, learning groups should meet regularly and for time periods sufficient for meaningful work. Little also feels that group meetings are most useful when their atmosphere is conducive to exchanges of ideas among participants. However, Wilson and Berne are quick to point out that Little means that such idea exchanges need to be centered on problems that matter to the participants, that is problems that teachers see in their classrooms. Finally, Wilson and Berne conclude that Little recognizes study groups as places where “professional habits and norms of collegiality and experimentation” (cited in Wilson and Berne, 1999, p. 175) can be developed. In their examination of research, Wilson and Berne (1999),

presented five organizational themes of network groups conducted by Lieberman and Grolnick's (1996). One of the five organizational themes concerned important qualitative features of the network communities.

When DuFour (2003) explains how professional learning communities should be built, he emphasizes the importance of structuring groups so that they encourage individual members to seek and develop innovative strategies for achieving the purpose of the parent organization. DuFour argued that the most effective strategy of the study group is one that he calls "loose and tight, a strategy that establishes a clear priority and parameters to provide each school and department with the autonomy to chart the course for achieving the objectives" (p.2). Under this concept, district and building leaders maintain tight control of groups' purpose for existence, frequency of meetings, attendance requirements, and reporting out obligations. However, leaders give freedom to participants to design their meeting structure and to find their way to meet stated goals and objectives. The concept of the professional learning community should be the focused purpose and big ideas that should drive school districts. (DuFour, 2003) DuFour addressed how "collaborative teams are most effective when members have a clear sense of purpose, specific goals and structured activities that give directions to their work" (P.5).

DuFour explains, however, that simply setting aside time and space in which teachers might meet by no means ensures that they will begin to think alike. He states that helping teachers find a single focus is crucial, and he recommends that this focus be "making a positive impact on student learning (p.

5). He suggests that one way to quickly establish a single focus is to link student learning to standards, pointing out that those standards may be national, state, or district. He then proposes that group participants might solidify their image of student learning by agreeing upon evidence, i.e., is by creating assessments to be shared by everyone in the group. As he concludes, it follows naturally that as teachers collectively design assessments, they will also define proficiency evidence. DuFour then says that group participants' collective work to identify standards, create assessments, and determine proficiency levels will culminate at some later time when they return to the table to examine student work and assessment results. DuFour suggests that such moments do not spell an end to the group or a completion of objectives. Instead, the group will ideally begin the cycle all over again with new standards, assessments, and so forth.

A-2 Issue of leadership role

Researchers have found that before teachers begin to participate in study groups, leaders must lay the groundwork by establishing each group's purpose, mode of operation, rules of behavior, and reporting system. Because little guidance is available for those who would lead study groups and due to the inherent tension between developing and sustaining inquiry into practice, group leaders are challenged when they attempt to promote professional development around mentoring practice. (Wilson & Berne, 1999) A skilled leader can build the collective capacity of a staff and, therefore, get better results when they gather together in study group sessions. (Arbaugh, 2003) Wilson & Berne (1999) examined one of Lieberman and Grolnick's (1996) organizational themes, which

concerned the facilitative leadership that was essential to teachers' networks. "Facilitating networks appear to be about establishing connections, forming groups, finding places to meet, and brokering resources and people." (P.190)

A-3 Issue of time

In his examination of study group effectiveness, Vandeweghe (2006) found that time set aside for meetings was critical to their eventual success. "Time matters means time to meet without interruption, time to observe and learn from students, and time to reflect upon practice" (p. 286). Teachers who Arbaugh (2003) studied characterized release time as being an important organizational characteristic of the study group. "Release time is very important for those teachers because they lead varied and busy lives. One teacher in this project described the release time as being "helpful" and another teacher thought the release time, after-school meeting was a "mixed bag" because of various responsibilities" (p.155).

Abdal-Haqq (1995) (as cited in Wilson and Berne, 1999) said that groups must be allowed to provide adequate time for follow-up support to teachers. Groups that have only enough time to identify challenges being faced by members but not adequate time for problem solving will only frustrate participants. Ideally, group sessions last long enough so that members can begin by following up on issues identified in the previous meeting, continue into identification of new student and teacher needs, collaboratively pursue solutions, and collectively write a brief summary of the sessions' conclusions.

B. Maintaining study groups is a challenging task

Grossman et al. (2001) argue that it is very difficult to attain and sustain teacher communities, yet this task remains critical to school health. We cannot expect teachers to create a vigorous community of learners among students if they have no parallel community in which to nourish themselves. After study groups are established, leaders must turn their attention to sustainability. Leaders face the challenging task of maintaining participants' enthusiasm and unwavering dedication to their groups' objectives. Research literature identifies two components of group sustainability—engagement and tension among participants.

B-1 Issue of teachers' willingness to engage

Researchers agree that long term group sustainability is strongly influenced by the extent to which teachers actively buy into their group's purpose. Teachers need to view their group as supportive of their career's noble purpose that is teaching and learning. Groups that appear to offer friendly collegiality but little definitive professional guidance may falter over time. This is not to suggest that collegiality is not important to a group's sustainability. Collegiality is an important asset in a well functioning group, but members maintain group loyalty for longer periods if during meetings they are united around a broad school mission rather than only around classroom practice. (McLaughlin and Talbert, 2001 Chap. 5)

In addition to adherence to their group's mission, long term maintenance also depends upon participants' opportunity to comfortably interact with their

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fellow attendees. Abdal-Hagg (1995) named peer interaction as a characteristic of the effective study group. Little (1988) determined that such interaction needed to go beyond training and to carry forward into implementation. In other words, teachers need to view their group meetings as places where they can not only learn about teaching, but also explore methods by which new approaches can be implemented. If the group is to remain valuable in the minds of its members, teachers must view group sessions as the place to when they want to investigate implementation. This does not diminish the importance of professional conferences and workshops, and it does not devalue informal conversations among teachers. Nevertheless, groups are more likely to be self-sustaining if members elevate them to a position at least equal to all other sources of professional growth.

In an interesting sidebar to consideration of study group membership benefits, Vandeweghe (2006) notes that through the completion of much study of professional development groups, researchers studying groups' impact upon teachers have illuminated a reciprocal, beneficial relationship between groups and individual members. This reciprocity occurs in the context of teacher professionalism. In order for teachers to successfully nurture their group, "Many, though not all, teachers must have a natural inclination to learn more about teaching and learning and feel professionally obligated to do so" (p. 286). Such teachers, feeling professionally obligated to learn, feed their communities as they engage with one another. "Genuine collaboration establishes and maintains a broad-based learning community"(p. 286). As teachers who are participating in

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study groups develop their capacity for learning through sharing with colleagues, growth occurs for both individual group members and for the group as a whole. Grossman et al. (2001) argue that “community is difficult to attain and even harder to sustain” (p. 993). “They contend that teachers will always need to find ways to stay abreast of developments in the subjects they teach” (p.994) It is through meeting this basic teacher need that professional learning communities find their best hope for sustainability. Wilson and Berne (1999) stated that being part of a professional group could hold teacher’s commitment to learning and changing their practice.

B-2 Issue of teachers’ conflict (tension)

One of the challenges in community formation and maintenance arises from diverse perspectives within a social group (Grossman, 2001). Wilson & Berne (1999) found that admitting that one’s practice is less than perfect is an act of vulnerability that depends on group trust and mutual respect. “Trust and respect, in a profession beleaguered by consistent criticism, take time to develop” (p.188) Educational literature abounds with references to conflict among teachers as it discusses complex conceptions of teacher professional community, which take into account dilemmas, tensions, and challenges involved in building teacher communities that impact school reform and teacher norms and practices (Achinstein, 2002; Hargreaves, 1994; Lima, 2001; Little & McLaughlin, 1993; Louis & Kruse, 1995; Merz & Furman, 1997; Westheimer, 1998)

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Some researchers identify tensions between individual, subgroup, and collective autonomy as they explain how teachers engaged in study groups struggle with collaboration, how teachers in community manage conflicts, suppress or embrace their differences, and ultimately how that defines the community borders and the potential for organizational learning and change. Literature affirms that when group participants are talking, differences will naturally arise. This is to be recognized as normal and should not always be considered alarming. When people express different views, they can actually teach each other new ideas. Everyone involved can grow from this experience.

In their examination of research, Wilson and Berne (1999) reviewed Lieberman and Grolnick (1996) who noted several tensions within network groups: negotiating between the network's overarching purposes and its daily 'work,' balancing outsider and insider knowledge and expertise, creating structure that allows for centralization and decentralization, dealing with the increased formalization that comes with the network growth, and making decisions about membership, both inclusion and exclusion. As teachers successfully negotiate these tensions, networks provide multiple opportunities for teachers to learn. (cited in Wilson and Berne, p.191)

As the above list indicates, multiple tensions among members might arise during group meetings. In so doing, tension offers teachers opportunity to deepen their sensitivity to one another and enhance their professional behavior. Nevertheless, tension among members might also destabilize the group and threaten its sustainability.

Achinstein (2002) asserts that tension might erupt not only from discourse, but also from group actions. "When teachers enact collaborative reforms in the name of community, what emerges is often conflict. The conflict is not only central to community, but how teachers manage conflicts, whether they suppress or embrace their differences, defines the community borders and ultimately the potential for organizational learning and change" (P. 421).

Achinstein (2002) suggests that teachers who experience conflict in their learning group might actually thrive in that environment. She found that among participants whom she studied, "community and conflict formed an unexpected marriage (p. 450). As teachers disagreed on matters of practice, they redefined "the boundaries of the communities" (p. 450) and re-determined the role that each participant would allow the community to play in his/her individual classroom practice. Achinstein does not view conflict as solely negative. Instead, she points out that questioning beliefs and considering change can be positive processes. She also labels leaders' hope that group members will always work in smooth unity as *naïve* and suggests instead that educators should examine further the issue of conflict among group members with the goal of learning more about how conflict's potential for group effectiveness might be realized.

Closing comment

Education literature reviewed in this section highlights challenges found in establishing and maintaining professional learning communities and identifies multiple responses to such challenges. It approaches study group challenges analytically, attempting to both clarify issues and suggest solutions. Therefore,

literature identified in this section will be helpful to leaders whose initial enthusiasm needs a reality check, to those who have launched groups and are puzzled by mixed results, and finally to those who are ready to settle into the long process of making their study groups highly effective.

Literature reviewed in this section highlights the professional learning community during the time when members have gathered in one place and are actively sharing ideas through verbal exchanges. In other words, actual meeting times are examined by this literature more than results that might be carried back to classrooms. Recognizing that idea implementation in classrooms begins with strong idea planting during group sessions, education leaders will find this literature especially useful.

Section III. Researchers have explored multiple strategies for helping teachers learn in study groups.

Examination of learning group literature reveals variety and complexity both in ways that educators fit group learning into their professional development plan and ways that they structure group membership and function. Loucks-Horsley, Love, Stiles, Mundry, Hewson (2003) examined teacher learning strategies and reported that a professional development program can be made up of multiple strategies offered simultaneously to different groups of teachers to meet their different needs or accommodate varied learning styles. In other words a study group might correctly be viewed as just one component, albeit an important component, of a school's professional development strategy. One unique understanding about professional learning communities that is gleaned

from examination of educational literature is that multiple teacher professional development needs can be met within the venue of collegial teacher study teams. Therefore, we see that study groups might be simultaneously presented as a professional development tool standing alone and separate from others while also being presented as vessels within which additional teacher learning can occur. For example, Loucks-Horsley et al. (2003) described “18 different teacher learning strategies clustered around six categories: aligning and implementing curriculum, collaborative structures, examining teaching and learning, immersion experiences, practicing teaching, and vehicles and mechanisms” (P. 11). All of these teacher learning strategies, which share common underlying assumptions about teaching, learning, and professional development, might be aptly addressed during study group sessions. Louks-Horsley, et al do not suggest that study groups are necessarily superior to other means of growing teachers’ professional capacity. When addressing forms of collaborative structure, they identify the study group as one of three professional development strategies: “partnerships, professional networks, and study groups” (P.138).

Having recognized study groups’ ability to provide teachers with unique learning opportunities as well as challenges related to effective study group design, researchers have also explored multiple strategies for helping teachers learn within study groups. I will examine the literature on those strategies as follows:

A. Collaborative work

B. Engagement/ participation/interaction

C. Development of professional knowledge

A. Collaborative work

Collaboration is a goal common to professional learning. “The collaboration strategies provide a structure through which individuals come together to pursue a variety of different kinds of learning that is dependent on collaboration with others” (Loucks-Horsley et al., 2003, P. 138). Unlike other collaborative strategies such as case discussion or lesson study that have a specific goal or procedure, study groups can come together around any topic and are, in fact, often the venue for other professional development strategies, such as when a study group focuses on examining student work. (Loucks-Horsley et al., 2003)

“Study groups are collegial, collaborative groups of problem solvers who convene to mutually examine issues of teaching and learning” (Loucks-Horsley et al., 2003 P.153). Regardless of the topic or issue being addressed, study groups provide a forum in which teachers can be inquirers and ask questions that matter to them, and are based on improving student learning, over a period of time, and in a collaborative and supportive environment. (Loucks-Horsley et al., 2003)

One such strategy revolves around encouraging teachers to view themselves as contributors to a collective effort. Kazemi and Franke (2004) describe teachers’ collective work in which they developed deeper understanding of their students’ mathematical thinking in a group that met for an entire year. The workgroup discussions centered on students’ work. Kazemi and Franke

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focused their discussions on the significance of the use of student work while describing the transformation of participation that occurred among participating teachers. Kazemi and Franke's study illuminates the advantages of centering collective work around students' work and establishing students' work as the centerpiece of group discussions. They found that teachers attempted to elicit their students' thinking and they noticed sophisticated reasoning in their students' work. Teachers found ways to interact with students about their strategies and to document those interactions for the purpose of sharing with their group.

Similarly to Kazemi and Franke (2004) but focusing even more on participants' interaction, Little (2002) investigated communities of practice by presenting a segment of interaction from a teacher work group. This particular group consisted of secondary school teachers who taught mathematics and English in two high schools. Little found that through interaction, teachers talk with one another and with others, and they work with and on the material artifacts of teaching and learning such as instructional materials, lesson plans, products of student works, tests and assessment. By working collectively, teachers would strengthen the knowledge and performance of individual teachers and would pool their expertise and experience to find solutions to common problems.

The work of Joyce (2005) offers one response to those who question study groups' potential or search for substantive answers to questions about study group structure. She views a group as a cooperative, inquiry-oriented training model with potential for helping teachers develop their professional skills. As an example, she described an ideal teacher-led study group in which teacher

leaders practiced new teaching strategies and curricula in their own classroom with other members observing them. With other members' feedback, they modified and adjusted their methods. They later modeled successful practices in workshops for other district teachers.

In a work written some years before Joyce's (2005) research, DuFour & Eaker (1998) also identified study groups as ideal sites for teacher collaboration. They recognized groups' inherent ability to foster mutual cooperation, emotional support, personal growth and a synergy of efforts for teachers participating in a professional learning community. DuFour (2003) says that collaborative teams as ideal places are most effective when members have a clear sense of purpose, specific goals and structured activities that give direction to their work. In such teams, members use collaborative time to engage in dialogue and processes that have a positive impact on student learning.

B. Engagement/ Participation/ Interaction

While some literature focuses on study groups' structure, membership, and intra-group function, other literature searches for bridges between study group sessions and participants' classroom practice. One such piece is offered by Pfaff (2000) who notes that it isn't simply group membership that affects practice but that it is through the process of engaging in professional discourse that teachers strengthen their classroom performance.

Literature considers how interacting in groups helps classroom performance. Pfaff (2000) reported that "changes of teachers' perceptions occurred in their teaching performance as a result of their participation in the

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study group sessions” (p.3). One example is that “study group participants reported that their interactive experiences with professional reading and recreational reading helped them gain a stronger and clear sense of themselves as readers as well as develop a stronger insight into the students as readers” (p.5). Moreover, “study group participants noted that the study group sessions encouraged subtle changes in instructional planning and decision making [by gaining a] keener sense of the importance of addressing students’ interests along with their instructional needs” (p. 5). He found that teachers who engaged in ongoing professional study group activities were more likely to gain or sustain a sense of security and confidence that encouraged them to transfer the content of their study group sessions into classroom practices. (Pfaff, 2000)

Further indication of transference from group discourse to classroom practice is provided by Deglau, Ward, O’Sullivan, Bush (2006) who conducted research on the nature of discourse among teachers as they engaged in a professional development activity. In the study group, all participants engage in reflection and learning and develop a common language and vision of science and mathematics education. (Loucks-Horsley et al., 2003) “Study group requires the participation of teachers who are committed to reflection on their work and taking initiative for their own learning” (P.158).

McLaughlin & Talbert (2001) offer a definitive designation of study groups as not simply sites for member interaction. Instead, they view groups as a cornerstone of teaching practice, one that should be deeply embedded in the process of building teaching practice. “In the communities of practice, teachers

are mutually engaged in teaching; they jointly develop their practice; and they share their repertoire of resources and history” (P. 41). According to McLaughlin and Talbert, member engagement and participation do not merely supplement teacher development. Instead a series of group meetings becomes a series of events in which participants lay down the building blocks of their practice.

Wenger (1998) considers how such application of group experience to individual practice can occur, as he explains that learning is a process of social participation and that learning by belonging to the community happens when participants launch into engagement, that is, active involvement. He says that members learn simply by belonging to the community. DuFour (2003) extends Wenger’s concept as he promotes the necessity for study group members to actively establish team engagement and to situate shared knowledge in learning communities through actively sharing knowledge, constructing consensus, engaging in periodic review, and focusing collective effort upon shared objectives.

Carroll (2005) supports others’ view of professional learning communities as ideal sites for teacher engagement, pointing out that teachers can learn through interactive talk. He substantiates his findings with a detailed examination of group participation as he considers the nature of interactive talk and its relationship to professional learning, study group materials, analytic tasks developed from artifacts of practice, and inquiry-oriented discourse in the study group context. Carroll found that participant teachers (mentors) invited each other in the discussion to consider one’s conjecture and implicit suggestions

about practice, thus engaging them in thinking about these ideas. For example, by putting individual teacher's ideas on the table, all participants engaged in considering a specific example about mentoring practice and helped individual teacher to clarify and articulate a powerful underlying principle about mentoring.

Paul Cobb, Kay McClain, Teruni de Silva Lamberg, and Chrystal Dean (2003) described their ongoing collaboration within a group of teachers in an urban school district to situate teachers' instructional practices within the institutional settings of the schools and school district in which they work. Related to the members' participation in the practices of a community, Cobb et al. illuminated how members of different communities engaged in activities together. Through the collaboration, teachers were better prepared to discern the mathematical intent of the nonstandard problems in the textbooks within a district. Moreover, Cobb et al. highlighted another strategy of collaboration in which members, named as "brokers" (Cobb et al. 2003), who are at least peripheral members of two or more communities, can bridge between the activities of different communities by facilitating the translation, coordination, and alignment of perspectives and meanings. Cobb also talked about other strategy, termed as "boundary objects" that have been incorporated into the practices of two or more communities, which can serve as tools for communication between the members of different communities.

C. Development of professional knowledge and practice

Educational literature also examines study groups' role in the development of individual teachers' professional knowledge. Geert (2006) finds that groups

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provide stimulating context in which teachers may develop their own professional identity. McLaughlin and Talbert (2001) identify “teachers’ learning communities as a strategy to build teachers’ capacity for effective classroom teaching” (P. 135) and suggest that they be respected as strategies for generating and sharing knowledge about practice. They find that “teachers in the school communities construct their practice around concepts of the “good” class, the “good” student and good educational futures” (McLaughlin & Talbert , 2001 P. 42). While observing one study group, they noted that teachers brought back “knowledge resources from district and out-of-district professional activities to the community. The department chair gave priority for time to share each others’ writings and discuss new projects and just talk” (McLaughlin & Talbert (2001, P. 96).

Jan, Douwe, and Nico (2000) agree that teacher learning communities are powerful strategies for developing teachers’ practical knowledge because during group sessions, participants engage in learning through networking, peer coaching, collaborative action research, and the use of real cases drawn from classroom experience to examine student learning.

Loucks-Horsley et al., (2003) suggest that study groups heavily influence teachers’ practice when members consciously reflect on students’ thinking, curriculum content, and their own teaching practices. They suggest that study groups are best organized around a specific topic that reflects issues of importance to the participants. These topics might range from school-based concerns to curriculum and instructional issues. For example, they observed grade-level teachers form a study group to learn more about assessing their

students' understanding of science concepts. Within such study groups, teachers are encouraged to go deeper into their thinking about the issues as they question and reflect on their practices and their students' learning.

Closing comment

It seems to me that any review of literature focused on group learning must remind readers that teacher professional growth is a complex area of study. Readers will note that this literature highlights study groups' ability to help participants build bridges between learning and doing. As members discuss student needs and decide upon solutions during meetings, they also encourage each other to carry new knowledge and ideas back to their classrooms and to put new ideas into practice. As readers examine this literature further, they will see that group members are also encouraged to carry classroom analysis back to later meetings, so group engagement develops into a circular pattern that continues as long as the group endures. Overall, literature presents professional learning communities as just one among many tools for teachers' growth in knowledge and skill. Furthermore, this review makes it clear that there are many different ways that study groups might function.

Conclusion

I began this literature review with the intention to learn about study groups as opportunities for teacher learning. I discovered that literature collectively describes what and how teachers learn in their study groups, but the focus of such literature varies, and evidence of how teachers really learn or how teachers

improve their practice and make changes through professional learning community participation is limited. Although I recognize researchers' attention to the ever-increasing presence of study groups in America's schools, I also acknowledge the need for additional research focused upon groups' function and efficacy.

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CHAPTER TWO: METHODOLOGY

In this section, I will describe my research framework built upon two research questions, the data sources I used, and the focus of my analysis. First, however, I will explain the life experience that led to this research and my role as researcher of my specific research questions.

Life experience leads to my role as researcher

Prior to my admission into the Teacher Education doctoral program at Michigan State University, I completed a Bachelor's degree in teacher education in Myanmar, my country of birth, and began teaching middle and high school English and physics after a very short student teaching experience. Because I won the 'best teacher' award three times and entire classes passed their exams completely, I thought that I was a successful teacher. I never reflected about what my teaching strategy was. I just recalled how my old teachers, whom I held up as models, had taught me. In the same classroom where I had once sat as a student, I stood on the other side of the table and followed the example set by my former teachers. I now question how much my vision of teaching changed when I simply moved from the student side of the table to the teacher side.

After three years of teaching experience, I completed a master's program specializing in the teacher preparation curriculum at the Institute of Education in Myanmar where printed materials and technology were severely limited. We were not trained as researchers, only as careful listeners. My thesis seemed less like a report of research findings and more like a collection of curriculum

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descriptions. Due to the political situation in my country, universities were closed for years and libraries were far away from me, and it took four years to attain my masters degree. Moreover, because of restrictions inherent in the centralized education system, the words in my thesis were just words on the page to read, but not words to speak.

During subsequent years, my three children were born. I was then unable to give as much attention to my teaching and eventually began to feel like a dull knife. I began to wonder if experienced teachers realize whether or not they are continuing to grow professionally. After I became a curriculum developer, I discovered that student teachers felt like newborn babies in their field without sufficient content knowledge and especially practical experience. Teacher educators also felt overloaded and discouraged without professional and financial incentives to provide motivation. While viewing this suffering, my need to find answers grew. I wanted to learn how pre-service teacher preparation programs function in developing and more economically advanced countries and how an effective induction program might look. My need to know grew in intensity until it led me to this doctoral program.

At MSU my interest in research grew until In the fall of 2003, I became a research assistant and was asked to attend, record, and transcribe bi-weekly meetings of the PI_CRUST project, Professional Inquiry Communities for the Reform of Urban Science Teaching. As months passed and I observed many discussions, I became intrigued by the possibilities for the study group as a component of professional development. I especially noted the active

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participation of two teachers who later became study subjects and whom I refer to as Teacher J and Teacher K. I launched my research of the PI_CRUST study group efficacy as a lens through which I might contribute to the understanding of teachers' professional development, whether that be in the United States or in my home country, Myanmar.

My study was framed by one guiding question: How did the teachers change over time with respect to two important aspects of their practice (a) analysis of students' work and students' ideas and (b) use of teaching and learning materials? These two aspects of practice were woven into my two research questions, which follow:

Question 1: How did Teacher K and Teacher J's classroom practice change with respect to three important points?

A. Teacher's content learning goals, activities, and material:

- Both teachers changed the nature of their goals as well as the activities and materials they used to achieve those goals.
- The knowledge they taught as well as the activities and materials they used changed from naming and listing facts to attribute and value discovery and description.

B. Teacher designed student work and embedded assessments

- Teachers designed student work so that it shifted from free expression of their ideas to engagement in specific scientific practice designed to help students recognize the attributes and values of sound

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- Teachers designed activities that allowed students to practice the process of finding patterns and describing attributes and values.
- These activities also allowed teachers to observe students' learning performances and respond with immediate, specific feedback

C. Teacher and student roles

- The teachers' roles shifted from encouraging students as they did activities to active coaching of specific scientific practices
- The students' roles shifted from reciting or drawing objects with which they were familiar to practicing the scientific process of attribute and value discovery and description.

Question 2: What can we learn from interview transcripts and study groups audiotapes about the causes of Teacher K and Teacher J's changes in practice?

- Teacher and group leader role change
- Group participants collaboration
- Teacher content knowledge depth change

Question One's sub-points A, B, and C grew out of my attendance at PI_CRUST meetings. As I listened to the group's discussions and observed Teacher J and Teacher K's inquiries and contributions, I realized that their development fell into the categories indicated above and determined that these were areas in which I would want to gather data.

Participant selection

Two participant teachers out of four were selected from the 2nd grade study group. The reason I chose these two participants is that those two teachers

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were regular and active participants throughout the five-year long project. They regularly attended the bi-weekly 2nd grade professional learning community (PLC 2) meetings. They participated enthusiastically in the study group and they were experienced teachers in the same urban school district.

Data sources

Data for this study was gathered through one primary sources and two secondary sources.

Primary data source

My primary data source included four videotapes. The first two were recorded in 2003, and the second two were recorded in 2007. During both 2003 and 2007, Teacher K and Teacher J were videotaped. The 2003 video tapings occurred before I joined the PI_CRUST project. Therefore, these two tapings were not made by me. I used these tapes as data that existed prior to the beginning of my research. In 2007, I was functioning as the researcher and did observe Teacher K and Teacher J and videotape them. The events that I witnessed while I observed and videotaped intrigued me and led to my decision to draw upon these tapes as primary data sources.

Secondary data sources

Interviews with two 2nd grade participant teachers, Teacher K and Teacher J, were used as a secondary data source in order to support the primary data sources noted above. Another secondary source was multiple PI_CRUST study group meetings recorded on audiotapes.

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Data analysis

My data was gathered as a means of understanding my two research questions: (1) How did Teacher K's and Teacher J's classroom practice change with respect to three important points and (2) What can we learn from interviews and study groups audiotapes about the causes of Teacher K's and Teacher J's changes in practice?

In order to answer research question one, I examined two teachers' classroom practice with a focus upon changes over time from 2003 to 2007. I looked for specific indications of how the two teachers planned and carried out their lessons. I especially noted their implementation of activities, their use of teaching materials, the work they assigned to students, and how well this helped them reach their content goals.

The data that I used to answer research question 2 was gathered through interviews and study group meeting audiotapes. As I listened to the tapes and examined interview transcripts, I searched for evidence of the causes of Teacher K's and Teacher J's changes in practice from 2003 to 2007. I studied ways that these two teachers participated in their study group discussions and what their responses to interview questions revealed about how they incorporated their study group experience into their lesson planning.

The following figure provides an overview of how I analyzed my data in order to answer two research questions.

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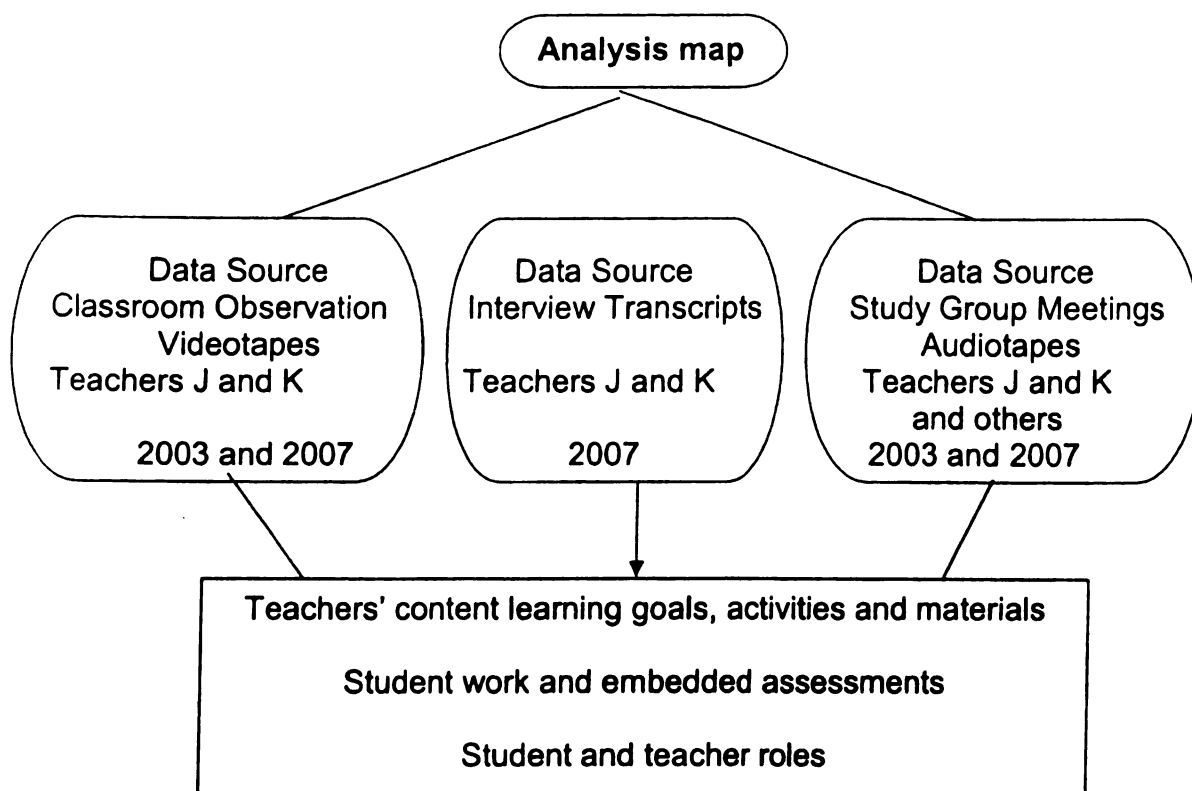
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Figure 1: Analysis map



As Figure 1 indicates, I drew from all three data sources to illuminate my three focus areas. Data from both Teacher J and Teacher K were available to me through every source, and both observation videotapes and study group audio tapes yielded data from more than one year. Interview transcripts from 2003 are not available to this research, since I did not join the PI_CRUST project until 2005. Nevertheless, both Teacher K and Teacher J gave of their time generously and generated rich interview data.

During the analysis process, I noted a connection between teacher behavior seen on classroom observation videotape and the self-evaluation remarks that they made during interviews. They recognized growth in their

performance. I found the study group meeting audiotapes to be a third growth indicator as I listened to their increased contribution to study group sessions.

My analysis is recorded in the following chapters. Chapters 3 and 4 report observable teaching practice by Teacher K and Teacher J respectively as it was seen in 2003 and 2007. Change from an ask-and-tell format to hands-on experiments marked both teachers' work. Chapter 5 explores why and how membership in the PI_CRUST influenced both teachers' teaching practice, noting the positive influence of transference of leadership to teachers, member collaboration, and the exchange of ideas in a comfortable, sharing atmosphere. Chapter 6 concludes this research report, situating it among the body of professional development research, recognizing its limitations, and suggesting the need for additional study.

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CHAPTER THREE: CASE OF TEACHER K

Overview: Lesson Background

Teacher K was an experienced teacher who had 17 years teaching experiences in the second grade level. She had been teaching science in the same building in an urban setting throughout her teaching career. She was also a five-year long active participant in the project of Professional Inquiries for the Communities of Reform in Urban Science Teaching. She was a very confident teacher and maintained good control of her classroom . Her students eagerly participated in the activities, which she planned for them. Throughout my observation, I saw significant changes in how she used scientific knowledge and practice to engage her students.

In 2003, while I observed and videotaped Teacher K's classroom teaching, she taught a science lesson about guppies to a class of over 20 second grade students. In 2007 I observed and videotaped her as she taught a unit about sound. There were about 25 students in her room that year. Her classroom was very structured both in 2003 and 2007. She had a white board, charts and pictures on the wall, kits and books, electronic media and enough space for the whole group as well as small group activities.

2003 Lesson

1. Content learning goals, activities, and materials

Teacher K's goal was to discover what her students knew about guppies and determine the level of their prior knowledge. She wanted to review students' knowledge of fish in general and guppies in particular, emphasizing

their body parts, survival needs, and where they live. She also wanted to provide her students with new facts about guppies, and she wanted them to observe guppies and record guppy behavior by creating drawings.

Teacher K used both printed text and hands-on objects to teach her lesson. She also used her white board as a way to draw all of her students' attention to one place. She created a highly interactive lesson as her students said details about guppies and she wrote them on the white board. She usually responded to students by adding facts to the list. At another time, when she wanted to draw facts from text, she directed her students' eyes toward their textbooks. Later, when Teacher K wanted to create opportunities for small group cooperative learning, she relied upon hands-on materials. Finally, at the end of her lesson, she returned her students to individual work by providing drawing paper and instructing her students to draw what they have seen as they watched two guppies in a small fish tank.

2. Student work and embedded assessment

During this lesson, Teacher K provided students many opportunities to interact with her and with each other. First she asked her students to volunteer facts about guppies that they knew. Teacher K called upon approximately 16 students and asked them what they already knew about guppies. As they responded, she wrote their ideas on the white board. She often asked her class if they agreed with one's answer or what she had just written, and students indicated their agreement or disagreement with stated

facts. She also invited them to raise questions to indicate what they wanted to know more about guppies. In addition to this interaction with their teacher, students had many opportunities to interact with their peers as they worked together in small group activities. As they examined the fish, they shared their observations verbally. Following their teacher's directions, after observing two guppies in a aquarium, students drew guppy's movements and especially noted the way that guppies turn.

One of Teacher K's teaching strategy was to give students work to do within the context of her lesson. Because her students were observing live fish swimming in a fish tank, they were required to actively pursue knowledge through observation of guppies in their natural habitat. It was not easy for them to observe a swimming guppy through the view of magnifying glasses. Near the end of the lesson, when Teacher K asked her students to pay attention to a guppy's motion, she facilitated their work by repeatedly asking questions to redirect their attention to the task.

3. Teacher and students' roles

The teacher's first role in this lesson was to solicit information from students about guppies and to record it in a way that would facilitate the second part of her lesson. As she recorded facts on her white board, she put them in a KWL table . In column 'K' (what they have knew already), she listed facts based on students' answers about what guppies need and where they live. She also made a list of questions in the column 'W' (what we want to

know) when the students were raising questions about what more they wanted to know about guppies. In this way, Teacher K helped her students sort and categorize their knowledge, and she modeled one type of organizer.

Teacher K also showed her students how to prepare for small group work and how to gather into working teams. She gave directions by reading instructions from the students' textbook. For the small group activity, she organized them into groups of four and assigned duties to all. Overall, Teacher K seemed to recognize that organizing the content and activities was her responsibility, and this was her observable behavior. Although the observation allowed students to learn more about guppies, it did not provide deeper ideas about the structure and function of guppies.

In this 2003 lesson, the students' role was to observe, record, and contribute points to the lesson. They were to provide facts about guppies either by contributing prior knowledge or by learning new facts through observation. After forming into groups of four, some students who were assigned roles as manager and messenger took the responsibility of taking a fish tank and magnifying glass to their group. Students who were assigned as trackers took the responsibility of reading the instructions for their small group. Students took turns observing guppies in a small aquarium as pair work. They then made observations and drew the pictures of how guppies moved and turned.

2003 Story of the Lesson

Teacher K began the class by arranging small groups, which had four people in each group. She praised one particular group who were doing an excellent job in grouping and waiting for directions quietly. She introduced guppies, which she brought from the library this morning, as visitors in the classroom. She announced that today students would be observing guppies, which were a kind of fish.

As Teacher K drew a KWL table on the board, she described its purpose. She asked, "What do we already know about fish or guppies in particular?" Then, she wrote "K" in the first column of the KWL table. She called on a student named Amy to give the answer to her question, "What do we know already?" She repeated Amy's answer of "Guppies live in water" and wrote the words "live in water" in the "K" column. She asked the class whether they agreed with Amy's answer.

Then, she called another student's name, Brian, and asked him, "What else do we know about guppies?" She repeated Brian's answer of "They need to breathe" and asked the class whether they agreed, and then, she wrote the answer "need to breathe" in the "K" column.

During the first half of the lesson, Teacher K repeatedly asked the same question to thirteen individual students to find out what they knew about guppies. Although she phrased her question in different ways (see highlighted questions below), she was basically asking the same thing. Occasionally,

after one student answered she asked other students whether he/she agreed.

As the following quotes indicate, all of the students agreed with stated facts.

T: If we do KWL, I know you guys are already good at these. What do we already know about fish or guppies in particular? (Teacher K wrote "K" on board) Amy, What do we know already?

Amy: we know that...

T: wait a minute. Somebody is not ready to listen yet.

Amy: Guppies live in water.

T: Guppies live in water. (Teacher writes 'live in water') Does everybody agree with that?

Ss: Yes.

T: What else do we know about guppies? (points to one student)

Brian!

Brian: They need to breathe.

T: They need to breathe. Do you agree with that?

Ss: Yesss. (teacher writes 'need to breathe' on paper, on board)

T: Ambra, what else do we know about guppies?

Ambra: they need to eat.

(Teacher writes 'need to eat' on sheet/board)

T: Anybody know about guppies, Gail?

Gail: They have gills.

T: Does everybody agree with that? (teacher writes 'have gills')

Ss: Yes.

T: Andy

T: They have.... Say again. Say it. (student's voice is low) They have fins. One is a fin and two and more are 'fins'. Evian, what do you know about guppies?

Evian: They need water.

T: They live in water. You say they need water, for what?

Evian: to drink

T: live in water... need...in...water to drink (write 'need water to drink') Everybody agree with that?

Ss: Yes

T: Dian, what do you know about guppies?

Dian: ()

T: Think about it. I'll come back to you when you remember. Kathy?

Kathy: They ...uhh... they have scales.

(Teacher writes 'have scales') Salina?

Salina: they have eyes.

(Teacher writes 'have eyes') Can I start a list here?

T: Connie?

Connie: They don't have eyes' lids.

T: They don't have eyes' lids. Do we know that?

Ss: Yes

T: we're going to do some observations today. So, this would be...(write 'W'), Connie, can we put it here? Are you sure 'they don't' or you're sure they don't? Listen to Connie. You guys learnt at library. What do you lean today?

S: they can't close their eyes.

T: so, I'll put this here, we have already knew?

S: yes

T: They don't have...

S: eyes' lids

T: What book are you guys reading?

S: We didn't. She said...

S: They hide shelter (teacher writes it)

T: Dian, do you remember what do you want to say about guppies?

Dian: (low voice)

T: They don't have legs.

S: no legs

T: They have scales and eyes. They don't have...

Ss: legs (Teacher writes 'legs')

T: Jerica, They have scales and eyes. I'm going to squeeze here. And, tails. Alisa?

Alisa: they need food

T: They need to drink. They need to eat. I'm going to say here, they need food. Connie?

Connie: they're little

T: are they? Compare to what? So, what if, what's about baby guppy? Are they little compare to baby guppy? So, she's saying that 'little'. Are they little fish? So, they're small or little kind of fish. (Write 'small (little) fish')...Andy, do you want to share something you know about guppy? ... Anybody has something to share that is not already up here? Jenny, what do you want to share?

Jenny: They need space.

T: They need...to eat, they need to breath, they need water to drink, and they need shelter...and space, for what?

Jenny: to live

T: OK.

Comment: As a goal for the lesson, Teacher K was trying to discover her students' prior knowledge about guppies before she began the guppy observation. In order to determine her students' understanding, she spent time asking questions and listing students' answers in a KWL table. As the students talked, Teacher K collected their statements about guppies and

categorized them as to what guppies need, where they live, and what body parts they have. She also made sure that students understood all those facts clearly. In some cases, Teacher K responded to students with ambiguous feedback. It seemed that she had no alternate plan ready based on student responses.

One interesting interaction between the teacher and students occurred when a student named Andrew asked whether or not guppies have bones. Teacher K entered Andrew's question in the "W" column (What we want to know) of the KWL table.

T: Andrew, you thought of something?

Andrew: they do not have bones.

T: They don't have bones? Do we think they do or do we know they don't?

S: shark doesn't have single bone.

T: Ok. Are those sharks ... Have you ever heard that fish at dinner has no bone in it?

Ss: yes

T: Hmmm?

S: they just have(low voice)

T: So, Andrew tells us that they don't have bones.

S: they still have bones

T: We are not able to find out it today to look at whether they have bones or not (write 'bones?' in the second column of "K") But, here is a question of we want to know about guppies have bones.

S: they do

T: we don't know!! You're telling us that sharks have bone. We know that guppies aren't shark.

Ss: yes... S: guppies are fish.

T: what are sharks?

S: fish

At that time, another student, Connie, said that guppies are reptiles. Teacher K asked if someone could tell what a reptile is. This led to the following exchange.

Connie: guppies are reptiles.

T: guppies are what?

Connie: reptiles

T: Ok. Tell me what reptile is?

Connie: They are animals that have scales and bones...

T: reptile has scales...

S: no...

T: she talks about...ok...what else about reptile? Who did the reptile poster? Galliam, what do you know about reptile?

Galliam: they live on land.

T: OK. What tells us about guppies?

G: They are not reptiles. Reptiles...(low voice)

T: The reptile lives in water, Galliam?

Galliam: Well...like they stay there for a while

T: OK...he's saying about reptiles, not amphibians. We get to figure that one out.

T: Raise your hands. How many of you think that guppies are reptiles? () I have a couple of people. Are...guppies...reptiles?

(Write 'are guppies reptiles' in the "W" column)

Comment: Here, Teacher K started switching to column "W" (What do we WANT to know) when student raised questions and others responded with what they thought they knew. Regarding the student's confusion with guppies and reptiles, Teacher K did not explicitly explain to students what a reptile is but left that question as "what we want to know". She neither responded to her students with an explanation nor did she ask her other students whether they knew what a reptile is.

Moving to the next column, Teacher K pointed out some questions that students had already generated to find out what they wanted to know. Then she continued asking the question, "What else do we want to know" to a few students. Students raised questions like "Do they have teeth?" and "What kind of food do they eat?" At that point, Teacher K asked her students whether some questions may or may not be able to be answered today but she did not ask "why" when students said "No". Then, she continued asking a student named Eva and recorded on the board Eva's question of "Do they live in the ocean?".

Teacher K then told her students that they were off to a good start toward finding answers of their questions. She also mentioned that students thought they knew some answers but those answers may not be true about guppies and she had to move some questions from column K to column W to check it out.

After Teacher K finished questioning her students, she moved on to the next part of her lesson. Her role in this activity was to organize her students into groups of four as two student pairs and to assign duties to the students. In each group, she had one student be the manager, another the messenger and the rest to be the trackers. She did not demonstrate what she wanted her students to do. She merely read directions for finding out about guppies from the book.

Teacher K began this part of her lesson by telling her students to turn to a particular page in the Animal book to find out about guppies. She read a long list of instructions that prepared them for the activity to come. There were focus questions that told students what they were supposed to observe. For example, questions asked why guppies look different, what part guppies use to move from place to place, what other guppies' parts can be seen, and what those other parts do. She spent about 12 minutes carefully explaining what the children were about to do and gave many instructions about what the students were to observe, including two parts: (i) directions for finding about guppies, and (ii) check for understanding.

Then, Teacher K explained the first part of the activity. Students were to slowly put a pop stick into the tank, observing what guppies do, and writing about what they observed. Here, she spent time reminding students not to poke

the fish with the stick. She continued explaining the second step of the activity in which students were supposed to drop just a pinch of fish food into the tank and observe what guppies were doing. For the second part of "check for understanding," she asked students to answer the focus questions such as do you have male or female guppy? How do you know? What do you notice?

Comment: As Teacher K read the list of things that the students were to observe, her students did not respond. They asked no questions. She explained that it would be impossible for them to answer all of the questions found in the textbook. For example, one question asked whether two female guppies would fight. But, there was no way for her students to know whether they were male or female. Regarding the question of male or female, Teacher K asked students to recall what they have learned about guppies in the zoo. One student answered that females are smaller than males. The following is the conversation between Teacher K and the student.

T: Think about what you learned about animals when we were in the zoo. Think about what you learned about males and females when we were in the zoo. And, you see a picture. What do you know about a male and female guppy in the picture?

T: Htai, what do you notice?

S: Female is smaller than male.

T: For guppis, generally speaking, I can have a newborn male guppy that is smaller than older female, but these are all about the same age. So, you'll be ok using that generalization.

In responding to the student's answer, Teacher K generalized the size of males and females rather than providing knowledge about the differences in male and female size. The example of comparing the size of a newborn male guppy with the older female was not clear enough to provide the facts about male

and female guppies. It seemed that Teacher K might not have enough knowledge to provide a clear explanation and thus, responded to a student's answer with a generalization.

To check for student understanding, Teacher K continued reading the focus questions as followed:

T: Which part does guppy use to move forward? Which part does guppy use to TURN? You have to look closely to tell which part of body the guppy is using when it makes to turn. Don't you?

T: Does guppy move ever backward? If it does, how? Does guppy stop eating if it is full? Will two male guppies fight if you put together? We talked about some animals at the zoo, they have to beat by themselves. Would two female fight if you put them together? How do adult guppy take care of baby guppy? Do adult guppy hurt baby guppy? What will happen if you out little gold fish in the tank with guppy?

Ss: they eat

T: Don't tell me. You have to write down. What do you think it's going to happen if we did that?

It seemed that teacher just read a lot of questions from the book without analyzing the questions whether they can be answered through the observation of two guppies in the tank for each group. Especially for the question of whether two male guppies fight if they are put together, student may not have answers while they even could not differentiate the male and female, and the adult guppy and the baby guppy.

Comment: Sometimes, Teacher K gave more information than her students needed. For example, she asked a number of questions that were impossible for her students to answer. It seemed that Teacher K relied unnecessarily upon the written text in the science book and that her prior planning did not involve eliminating extraneous materials.

2007 Lesson

1. Content learning goals, activities, and materials

In 2007, teacher K's goal was to discover what her students knew about sound. She wanted to review not only her students' knowledge of sound in general but also their knowledge about the attribute of volume and pitch of sound along with the values of "loud and soft" in volume and "high and low" in pitch. She wanted to provide more scientific understanding about sound by relating the attributes and values to ways of making and changing volume and pitch. She also wanted her students to discover the pattern of "longer length makes lower pitch" through their observations. And, she wanted her students to describe how pitch can be changed and to predict and observe and then describe the pattern of changing pitch with their drawings.

Through my observation, I found that Teacher K used materials differently in 2007 than she had in 2003. Most of her 2003 lesson was associated with reading and writing by using the printed text and listing facts from the book. Although she was using hands-on objects and papers for her students' drawings, her instructions on drawing the guppy's behavior were vague and unclear and did not help her students focus on what they were supposed to observe. In contrast with the 2003 lesson, in which the lesson was mostly observation and description Teacher K's 2007 lesson was much more directed to a specific observations. Moreover, her language was more related to the observations in 2007. In 2003, she stated facts from the book and did the observation of the guppies. But, she did not make a good connection between the observation and

the facts from the book. In 2007, she spent a lot of time on language, which was closely tied to the sound they were hearing and the observation of the instrument they were using to make sound.

2. Student work and embedded assessment

During the 2007 lesson, teacher K provided students more opportunities to engage in activities and encouraged students to have more discussions through various experiments. When she reviewed her students' key knowledge about sound, she asked questions to discover her students' prior knowledge about sound and highlighted words on the board that were related to the observations. She provided various experiments so students could explore the idea of making changes in volume and pitch by using three different instruments until the students understood the concept. For the activity, she gave more specific instructions about what students were supposed to observe and she related the language from the discussion to the activity. During the activity, she monitored her students, which allowed her to check her students' understanding.

In 2003, Teacher K was writing the statement and indicating whether students agreed or disagreed, but there was no teacher evaluation of the students' work. Students shared their observations but again no evaluation from teacher was included. In 2007 she had a very clear goal in mind in terms of the description of sound's attributes and values. She asked questions to check how well the students were achieving that goal. She gave more emphasis to certain parts of the lesson when her students had trouble completing the activity. During

the 2007 activity, she functioned more as a coach during their observations, while in 2003 she focused more on monitoring classroom management.

3. Student and teacher roles

The teacher's role in this lesson was not only to solicit information from students about sound but also to analyze the students' reasoning about the changes of sounds. She created the activities, which allowed students to explore the idea of making changes of volume and pitch. When she provided the experiments that allowed students to hear the changes of pitch, she used three different materials including a thumb pluck, stretchy strummer, and rubber band. She began the experiment by asking how we change the volume on this instrument. Students volunteered the answer and also raised the question with "what if?" Students asked to experiment with their new idea of moving the block to see the different volume. Teacher K emphasized the correct scientific terms of "soft" and "hard" for the volume change and "high" and "low" for the pitch change. During the activity in 2007, she focused on coaching her students' performance in the small group activity.

In 2007, the students' role was to engage more in experimenting with the different materials (such as stretchy strummer, thumb pluck, and rubber band) to see how we can produce different volumes of sound and different levels of pitch. Teacher K added explanations as needed when students were doing experiments. Students were allowed to raise more "what if" questions and to explore their ideas by using the materials, which were available to them.

Assigning students to take their responsibilities was the same in 2003 and 2007. During the activity in 2007, students were more engaged in the activity of changing pitch by using a wind chime. Students were encouraged to predict their observation before finding out about the effect of changing length to the change of pitch.

Story of the Lesson in 2007

Teacher K began the class by telling her students to set up small groups and counting three students to be in one group. Students moved their desks to make a group. Then, she began the lesson by saying, "Why don't you tell me what you have learned so far about sound." She called on a student named Kristin to give her answer. Kristin said "loud and soft". Then, Teacher K followed Kristin's answer by asking Kristin "What is it called?" Kristin answered "pitch" but corrected herself with the right answer "volume". Teacher K wrote the word "volume" on the board as her goal to teach about volume to her students. After highlighting the word "volume," she asked her students "what else do we know about sound?" One volunteered student answered "sound can change". Teacher K added an explanation to the student answer about sound changes and highlighted the words "change the loudness and softness". Then teacher used the leading questions to initiate the conversation about change of pitch by following up on the questions about the description of pitch and the way of changing pitch. Then, she wrote the words "high" "low" and "pitch" on board.

Comment: *Related to content learning goal: Teacher K set up an attribute-value framework for describing sounds, as opposed to listing facts as she did with the guppies. As embedded student work, she not only wrote down what students said; she used their contributions, but altered them so that they fit into a scientific framework.*

After teacher K asked about the pitch, she continued asking her students what else they have already known about sound. A student named Brian answered “vibration”. Then the conversation began about vibration and included the definition of vibration and how vibration can make a sound and how sound vibrates.

At one point, the discussion switched to sound starter as students started talking about making a vibration of sound by hitting an object. Teacher K talked about the science term of “hit” to the class and wrote the words “sound starter is a striker” on the board. Then she asked for another names of sound starters and students answered “pluck” and “a rub”. So Teacher K started with observations and patterns—how to describe sounds—and then she moved to causes and explanations—sound starters and vibrations.

Then, Teacher K used the word ‘pluck’ as a sound starter and asked students how they might change the volume by using the starter on a particular instrument. Next, she began the first experiment by using an instrument called a stretchy strummer. The stretchy strummer was constructed with a bunch of rubber bands around a tray and putting a block between the rubber band and the tray. The block can be moved under the rubber rings. During the experiment,

students explored their different ideas about how the volume can be changed.

Teacher K responded to her students' ideas by doing the experiment as students described. The interaction between teacher and students can be seen in the following episode 1a.

Episode 1a: Experiment with stretchy strummer

T: Ok. It's a pluck. So, if we have a pluck, how do we change the volume on this instrument, sound system? How do we change them?

Boy: volume

T: volume. From loud to soft or soft to loud

Boy: I think if you take out the pluck and pluck in again

T: If I take out the block and pluck in. Just listen to it as I have here. (blin..blin...blin...) How am I going to change the volume?

Boy: lower

T: You say lower but I could not do it lower. That's still the same.

So, how do I change it?

Boy: What if you go slow?

T: He's looking for slow, not lower. What would that work it?

Girl: high

T: high? When I hold it higher, can I change the volume? (Teacher holds the instrument high up.) Change the volume... How would I change the volume?

Boy: move the block

T: Move the block? The volume changed? What change?

S: the pitch

T: the pitch changed. I'm going to back the block here. How am I going to change volume?

T: Britney!

Britney: ()

T: help her out

Girl: just do like that...Did you do like this and change the volume?

A kind of damp it...change the volume I say.

T: Ok. Give me a clear one. If you can't hear me when I'm doing this, you tell me to make it louder, what am I going to do? Phisela...

P: (low voice)

T: Ok. I changed it here. Listen to the sound. If I move my block, did I change volume? (Plun,plun,plun) I'm trying to be consistent with my finger. How would I change the volume?

S: with your finger

T: With my finger? If I do like this...Anthony is saying if I move the pluck and start it, he said move it further out before I go to the

pluck. What I am doing? If I move it further out, did that change the volume? Yes, but what did I do???

S: you made it high

T: I made the volume louder. How did I do that? He said move my finger out before I let go of it. That's what I did. I did it make louder, didn't it?

S: you move the block.

T: I didn't move the block. The block stays the same. I'm pulling it instead of...I'm plucking it but instead of doing it softly, I did it

S: hardly

T: who said lower or higher? It's not lower or higher. It's softer or harder. Listen to this volume. I'm not moving the block. Listen to this one. Can you hear that?

Ss: No

T: so, what would I have to do? I'm going to apply more pressure. I'm going to do it...harder. Now, listen. Can you hear that? Amy, are you able to hear that? Ok. A little problem with volume. What about pitch?

Comment: *At this point, Teacher K realized immediately that her students had a problem with volume change with this particular instrument. As she heard the students' answers about 'high and low' which was supposed to indicate the pitch, she made a decision to give her students opportunities to talk about pitch.*

Teacher K was aware of the students' confusion between volume and pitch when she used materials that were intended to help her reach her goal for this lesson.

During the above interaction with her students, Teacher K realized that they had trouble understanding the difference between changing volume and changing

pitch. She spent more time and emphasis on the problem when her students had trouble with their idea. Through experiments, she provided many opportunities for

her students to figure out ways to change volume. She and the students engaged in different kinds of experiments, and observed together how volume or pitch can

be changed. As we can see in the above examples, Teacher K and her students

tried to recognize sound changes by moving the block or striking slowly. She also incorporated scientific language when she taught “hard, soft” for volume change and “high, low” for pitch change.

Teacher K continued using the same stretchy strummer instrument and doing another experiment about changing pitch. She closely interacted with her students during the experiment. In the following episode (1b), this interaction, which revealed scientific knowledge about pitch changes, can be seen.

Episode 1b: Experiment with stretchy strummer

T: Here my pitch. Listen to that. How am I going to change pitch?

S: move it up

T: Ok. I move it up. Now, does my pitch change? Yes, it changes. Did it go from...what? How did I change? Listen tot his sound and (move the block up) listen to this sound. The pitch...from what to what?

Ss: low to high

T: Shuuuu (point to another girl)

S: high to low

T: Ok. Listen it. Let see everybody agree. Here is my pitch. Listen to it (pliin, plin, plin). (Move the block up and pluck again) How did I change it? Start it off high and make it low. Look at my string. When it is high pitch, look at my rubber band. Is it long or short compare to the lower pitch?

Ss: short

T: Ok. If I have a shorter string, it makes a ...?

Ss: high

T: high pitch. If I have a long string, it makes a ...?

Ss; low

T: low pitch. Do you think it applies to others that we learned about? Should we try and see?

Comment: The above episode gives evidence that Teacher K strengthened her students' ability to reason and increase their scientific knowledge through their interactive practice. Through participation her students increased their knowledge about changing pitch. Then, she encouraged her students to apply their findings

to the second experiment. At this point, as the above bolded words indicate, she modeled for her students, reminding them that learning can occur through the application of knowledge.

As teacher K realized that her students had a problem with volume change in the first experiment with the stretchy strummer instrument, she provided the second experiment by using another instrument called a thumb pluck. A thumb pluck is a wooden flat stick, which can produce a sound by striking. To demonstrate, she put a part of the thumb pluck on the table edge and plucked another part that was off the table, in the air. First, she let students listen to the sound to identify the volume. Then, she asked her students how she might change the volume. Students proposed different ideas such as 'make it shorter' or 'make it softer'. So, Teacher K moved the block and made a pluck. Then she asked her students to listen to the volume level. Similarly, she plucked both softly and firmly and then let students evaluate the volume change. After experimenting with two different activities, the students could finally identify the volume change from soft to loud or loud to soft by plucking softly or firmly.

At that point Teacher K pointed out that the pitch was the same while the volume changed. Then, she switched to the activity of changing pitch with the same instrument. To discover the students' reasoning she asked her students for their ideas about how she could make a change of pitch. She was striking a couple of times by moving the pluck as her students proposed their ideas of "push it in" or "push it out." When students realized the change of pitch from high to low, she added her explanation of how she made a high pitch by shortening

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the length of the stick. Then she discussed the findings by comparing this result with that of the first experiment. She highlighted the pattern of “longer, lower” as a common concept in changing pitch. The interaction of teacher and students in the second experiment can be seen in the following episodes 2.

Comment: Note how she is being systematic in moving from observations, with attention to students using appropriate words to describe the words that they hear, to patterns and causes—how changes in the way the sound is made are related to changes in the sound.

Episode 2: Experiment with thumb pluck

T: Let's try. How about thumb pluck?

First of all, tell me how would I change the volume. If you can't hear me...if I make this sound...let me put it down here. So, everybody can hear it. Listen carefully. (Teacher makes a pluck) If I want to change the volume, what would I have to do?

S: make shorter

T: I'm changing the volume. Now, just listen

S: make softer

T: I make it softer. Did I change the volume? Here is harder but the pitch is the same. Now, the second change will be changing the pitch. How am I going to change the pitch on this? Let do with one. Listen it. How did I change the pitch?

S: push it in

T: Ok. I push it in. Did that change the pitch?

Ss: Yes

It make it higher or lower?

Ss: higher

T: so, how I can make it lower?

Ss: push it out. Let's listen. Did it work?

T: so, what do we know about this sound system. If I'm going to make high pitch sound, I push it in. I make the length of the stick shorter. If I want to make a lower pitch, I put it what?

S: make it longer.

T: Is that the same with the stretchy strummer?

Ss: No

T: When I made a low sound with stretchy strummer, did I have more length or less length of the rubber band?

Ss: more

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T: Did I have to make a more length here (thumb pluck) to make a lower sound? Or less

Ss: more

T: So...Is that something they have been in common? LONGER, LOWER (stretchy strummer); LONGER, LOWER (thumb pluck). Do you think it works for all level?

Ss: Yes

Comment: *In the above episode, we can see two patterns of (i) how Teacher K and her students played their roles while participating with material, and (ii) how she related student work to the content in order to use a big idea. In the first pattern, she played the provider role by providing many opportunities for her students. Students played the producer role as they figured out the result of changing the length of the stick relates to the change of pitch. In the second pattern, Teacher K clearly stated the big idea in relation with the content and her student work. She also generalized the 'longer, lower' pattern to identify the pitch.*

As another application of identifying pitch, Teacher K provided the third experiment called 'rattling ruler' by using a ruler. She adjusted the length of the ruler and made a strike using the same procedure as she had when striking the thumb pluck. She tried to prove that the common concept of 'longer, lower' could be applied to other materials. Then she gave students the experimental role of constructing a sound system and testing out their learning about pitch with a wind chime activity. During the instruction part of this activity, she asked students to turn to a particular page in Lesson Seven of their science book. She asked her students whether they knew about wind chime before and then conducted a discussion about the sound starter of wind chime and how wind chime makes a

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sound. Then she read a few questions from the book to begin an investigation into how the two different lengths of wind chime affects the change of pitch.

For the distribution of materials, Teacher K called students who were assigned as managers to take the tray with supplies to the groups. Supplies included four nails of different lengths. Three longer nails were black, purple and green and they were also different in length. The shortest nail is the striking nail. She asked her students to use their own writing instruments and put their names on it. After distributing the supplies, she asked her students to make their own predictions by drawing pictures of the order of three nails before they started the construction of Nail Child. She gave clear instructions explaining that her students were supposed to draw pictures showing their predictions. Her instructions for the prediction can be seen in the following.

T: If you look at the supplies on your table, those are the things you are going to use to make a Nail chine. But you have to do some predicting before you may start constructing. So, go on. Look at number one. If you make a wind chine, please, I need your eyes here. When you're drawing the pictures, it said I think the order might look like this because if you are putting...(grabbing nails from the tray) if you look at the nails, you have one with the black, one with the green and one with the purple. These are the nails you are going to place in there. If you are putting these three nails in order, and we are going from ... low pitch to high pitch... what were you picture look like of this? When you draw a picture, I want you to draw a picture from this side, looking at right here, the nails on it. I want to see a different length. I need to do from low to high, what order would your nails be? Draw me a picture. You can draw at the top of it. Just keep in mind that if you look at this side, the straight line but I want to know the order of the nail...it's going to be like this. Remember, we're going to low to high. I put "L" here. So, draw me the order of the nails if you are going to make a low pitch to high pitch. It does not matter to me if you start the right or the left. Draw me a picture what's gonna to be look like.

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When students were drawing their predictions, Teacher K was monitoring individual student work to determine whether they were following her directions. Once students finished their drawings, she read the instructions for the first step from the book and gave her demonstrations. She demonstrated clearly how students should draw a line on the Styrofoam to mark where they were supposed to place three nails in order. She also reminded students not to press too hard on the Styrofoam when they drew the line. Then, she showed how to make a line three centimeters apart. She asked students to look at the centimeter side of the ruler and counted one, two, and three and drew a line. She directed them to draw another line at every three centimeters.

When she finished her demonstration of the first step, she assigned certain students to be trackers. They were supposed to draw a line. As a second step, she assigned other students as messengers who made lines every three centimeters. When all groups finished drawing three lines, she directed students to put three nails at each mark on the Styrofoam as a third step. After monitoring the groups for the third step, she asked for her students' attention while she gave instructions about tapping three nails in order to test the pitch from high to low. She asked students to check whether their predictions were right according to their findings. During the activity, Teacher K was coaching her students in each group. Her demonstration and coaching can be seen in the following episode 3.

Episode 3: Experiment of Nail Chime with prediction

Now, it's ready. They're going to look at these nails. They move pretty good. They wiggle. Now, take the tapping nail and it's going to tap. (tin, tin, tin...)
Do they have an order from low pitch to high pitch?

Ss: No

T: If it is not, what are you going to do?

S: take it out

T: It's easy to take it out this time. Let's try it in different way. Now, listen. (tapping nails) It is on order for high to low pitch?

Ss; Yes.

T: You have to keep trying. You know what? You make a prediction on your paper. So, go ahead and put it on your paper if your prediction is right.

(Teacher walks around and reminds students to draw for number two)

T: Once you have an order for low to high, you need to draw what is look like. Whether you prediction matches or not, you need to draw to know the facts whether it is in order. You need to draw. Do you think it is the right one? Does it low to high? Like this? This is the way. Ok, give me the tapping nail. This is in order for low to high pitch?

Ss: No

T: So, put it in order for low to high pitch. (Student puts nails in order) Which one is the lowest pitch? Here, listen. (tap the nails)

S: that's the lowest (point to the longer nail) (another student changes the order)

T: Now, listen. (tapping) Does it in order for low to high now?

S: yes

T: We start it here with low (longer nail). So, on your paper, you're going to get what?

T: Ok, go ahead and draw.

Comment: *Teacher K used the materials effectively according to her lesson goal of providing scientific knowledge about pitch. She participated in the activity in a facilitator role while students figured out the order of nails in order to hear the pitch form high to low. She was coaching her students rather than monitoring their work. At this point, the difference can be seen between these predictions and the predictions that the students made about guppies, which were basically guesses. She had worked hard to establish the longer-lower pattern, and now she expected her students to use that pattern as they make predictions. She set up the experiment by changing the order alternately, so she could look to see*

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how the students were arranging the nails and thus visually monitor their predictions and understanding.

Overall, Teacher K interacted closely with students by responding to her students’ ideas and following with an experiment. She provided a series of experiments to her students to increase their scientific understanding and reasoning ability.

Similarities and differences in 2003 and 2007

1. Content learning, activities, and materials

Table1:
When studying 2003 and 2007 data, multiple differences can be seen in the way that Teacher K handled content learning, activities, and materials:

	2003	2007
Identification of students prior knowledge	Identified prior knowledge by reviewing facts	Identified prior knowledge during experiments
New knowledge	Provided more facts	Provided more conceptual scientific understanding
Knowledge – practice relationship	Knowledge was not related to practice	Knowledge was applied to practice
	No materials used during review of prior knowledge	Three materials: stretchy strummer, thumb pluck and rubber band were used while identifying prior knowledge
Material use	2 guppies available for observation	Adequate supplies to engage all students at once
	Materials inadequate to answer questions (male and female guppies needed)	Materials were adequate to allow students to answer questions (four nails of four different colors and different lengths)

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2. Student work and embedded assessment

Table2:

Differences can also be seen when student work and embedded assessment are examined.

	2003	2007
Teacher's response to students' ideas	No explanation followed student responses	Responses to students contained explanations
Teacher – student communication	One-way communication with questions and answers	Interactive conversations around students' ideas
Instructions given to students	All instructions came from the textbook	Instructions were given by the teacher and included demonstrations
Number of activities	One activity	Three experiments before the activity
Monitoring vs. coaching	Monitoring during the activity	Coaching during activities

3. Student and Teacher Role

Table3: The distinct differences in the teacher's role between 2003 and 2007

	2003	2007
Student participation opportunity	Student participation was likely restricted	Many opportunities were given to students to participate in experiments
Use of time	Time for science was limited. Pre-activity work consumed much time and little was available for the observation	Teacher K adjusted her science time to allow all students adequate time to experiment and discover patterns
Conceptual understanding	More time given to facts and reading instructions; little time given to conceptual understanding	More time devoted to conceptual understanding through experimentation

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Although there are many differences between 2003 and 2007, similarities can also be seen when examining classroom management and structure. In both years, Teacher K's classroom was very structured with tables and chairs for either whole group or small work. Reading and writing materials such as a whiteboard, charts, graphs, and science books were set up appropriately. Her ability to organize her students into various groups was very evident during both years. By 2003 she was already committed to moving beyond the textbook and helping her students learn through group activities.

CHAPTER FOUR: CASE OF TEACHER J

Overview (Background of the lesson)

Teacher J was an experienced teacher who had eleven years teaching experience in the first and second grade level in addition to five years in pre-school level and one and a half years in substitute teaching. He had been teaching science in different buildings in urban settings throughout his career. He was also a five-year long active participant in the project Professional Inquiries for the Communities of Reform Urban Science Teaching. He participated in two different grade level study groups such as 1st and 2nd grade. He was a very enthusiastic and creative teacher. He developed his own materials as a means of providing his students many opportunities to learn through his creative activities. He was also a kind of teacher who seeks different learning environments for his students' learning and his own practice. Throughout my observation, I can see the significant changes in how he engaged his students and used scientific knowledge and practice.

When I observed and videotaped Teacher J's classroom teaching in 2003, he taught a science lesson about "Materials". There were over 20 first grade students in the classroom. When I observed his teaching in 2007, I was in his classroom and recorded the videotape of his teaching about sound. The students in 2007 were the combination of both first and second grade. His classroom structure was organized for both whole group and small group activities and created a place for group discussion in a corner of the room. His classroom is decorated with charts, graphs, tables, and labels on the wall and hanging from

the ceiling related to the units. He used an overhead projector occasionally to provide information to his students visually. In addition, he used other electronic media and science kits as necessary.

2003 Lesson

1. Content learning goals, activities, and materials

In 2003, Teacher J's goal was to discover what his first grade students learned and observed about materials with which items in the class were made. He wanted his students to identify the four different kinds of materials such as metal, wood, glass, and cardboard. Particularly, he wanted his students to gain knowledge about the properties of materials and to analyze properties of materials they showed in their drawings of slides. He planned to cover two content goals, which included two dimensions of materials such as the shape and the properties of materials.

Teacher J used various kinds of materials from the class to provide lots of examples to increase students' knowledge about four different materials in the lesson. But, he only focused on the names of the materials. He emphasized neither the shape of the materials nor the properties of the different materials. He created two different activities to teach the lesson. In the first activity of labeling the materials, he did not provide enough knowledge and explanation about the materials to link the second activity where kids needed to identify the properties of different material. In the second activity, students needed to draw the shape of the materials as the background of the materials. In that case, his

choices of examples in the first activity were not really helping students to identify and describe the shape of the materials when they described the objects. There was really a mismatch between the tasks of drawing a slide with the goal of identifying the material that it was made of. There was no discussion following the activity.

2. Student work and embedded assessment

During this lesson, Teacher J provided students many opportunities to interact with the himself and with each other. Students were asked to describe the names of materials. He pointed out the materials in the class and his students volunteered the kinds of materials that they knew. He wrote four different names on papers and stuck those papers on particular materials in the class. Then, students were asked to chose one material and write down the name of that material. Students were reminded repeatedly about the correct spelling of the names of material. Teacher J asked students to make a good slide but he did not explain what good slide means.

Students worked at their seats individually and drew the pictures of materials with which they wanted to make a slide. When a student made the mistake, Teacher J did not identify and analyze the mistake to help that student to clarify his/her answers. For example, he explained that, "You're close. Paper is like a cardboard in a lot of ways." In that case, he responded to the student positively but he did not provide a thorough explanation of the similarities and differences of paper and cardboard to help students understand the concept of thick or thin

and strong or weak. There were no discussions on students' work in the first activity and he shifted to the next task of evaluating their own slides by giving the smiling face/ funny face and sad face based on their drawings with the material they chose. Teacher J used the question to answer whether their slides have problems if it rains or if it is windy. He also established the question of "How it works?" to make sure whether students understood the material that they included when they drew their slide. In both cases, Teacher J's questions did not lead to the expected answers about why a slide is not made of a particular material like cardboard or glass. He appraised students' work and tried to make students feel pleased with their drawing. He did not really evaluate the student work to know how well they achieved the learning goal.

3. Student and teacher roles

The teacher's role in this lesson was to solicit the knowledge that his students had learned about materials. He used a traditional teaching approach and communicated with students by the question and answer method. He gave examples of materials by pointing out things in the class and asking students questions so they could give answers. He controlled the activities and directed students individually about what they should do. He monitored the individual work during the activity and encouraged their work with his positive appraisal.

The students' role in this lesson was to work individually and evaluate their work by drawing a happy and sad face. They gave the name of materials as their teacher pointed things out in the class while he reviewed their prior knowledge.

They were asked to choose one kind of material and draw a slide as their role of designer. Then, they had to think whether their slides would have a problem if it rained or if it was windy. And, they had to draw the happy or sad face based on their evaluation of whether their slides were good and would not have a problem in the rain and wind. While Teacher J monitored their drawings, students explained what they were drawing.

The story of the lesson in 2003

Teacher J began the class talking to his students about things we build such as wood, plastic, metal and glass. He told his students, "I'm going to teach you first all the stuff that we use to make things, stuff around us. This would start with the letter that says *M*." Then he wrote the letter 'Materials' on the board and asked his students to pronounce the word materials. He gave the example that this chalkboard is made out of a material what is called slate. And, he wanted his students to look at the black cabinet and asked them the question, "What is it made of?" Students answered "metal." Then he said, "We use a lots of materials in this room." And, he pointed the chair out and asked his students, "What material is it?" Students answered "plastic." Thus, Teacher J highlighted the different materials of metal, plastic, wood, and glass in the class as you can see in the following conversations.

Teacher J: see that black cabinet. What is it made of?

Ss: metal

T: we use a lot of materials in this room. You know what...no...this is better. Right here. What material is it?

S: plastic

S: plastic

T: plastic. So, we use lots of materials just in this class.

S: those are made of plastic.

T: yes, you're right. Those are made of plastic. So, you already know lots of things about materials. Actually some more... let me see a couple of people are listening...great job. What material is this made out of?

Ss: wood

T: wood. What's material is a window made out of?

Ss: glass

T: glass. What about the door?

Ss: wood

After introducing the four different kinds of materials, Teacher J told his students that they were going to draw a slide with their choices of one out of four materials and figure out whether it would be a good slide. He provided the idea of drawing the picture of a slide by asking the question, "What are the slides made out of in our playground?" Students answered "plastic." Then he asked students to make a new kind of slide today. He encouraged them to draw a slide as a role of designer. He wrote the word "Wood" on a piece of paper and asked students to point out the things made of wood. When the students pointed out the door, he stuck that paper with the word "wood" on the door. In the same way, he wrote the name of the material "metal" and stuck it when students pointed the cabinet, which was made of metal. Then he wrote the word "cardboard" and asked them to show the object made of cardboard. When one student pointed out the object made of paper, he responded, "You're close. Paper is like a cardboard in a lot of ways."

Comment: In that case, Teacher J did not provide any explanation about the properties of paper, which is different from cardboard. For example, he did not explain that cardboard is stronger than paper. He did not relate the attribute of

materials and their values such as the strength and weakness of different materials. He gave a vague response to his student's answer.

To point out the material made of cardboard to his students, Teacher J stood near the mailbox, which was made of cardboard and said "I'm standing by a side of cardboard." When his students answered, "box," he said, "The mailbox itself is cardboard." He spoke himself, "I think this is clear." Then, he gave the last choice of glass. In the following conversation we can see how Teacher J described the cardboard and other materials in the class for the activity.

T: I'm standing by a side of cardboard. (Teacher points and knocks the door.) No.

Ss: box

T: mailbox? You can see it, not the plastic cover. The mailbox itself is cardboard. This is actually made of cardboard (by picking box). I think this is clear. I'm going to stick this up here. So, you can see it. So, you have three choices so far. You have mmm...metal, this is cardboard, and the wood

S: wood

T: your last choice starts with a

S: 'p'

T: No, we are not going plastic. That is too easy. You guys will all choose, I bet. (Teacher writes the word 'G') What's the letter?

Ss: 'G'

T: 'G' what?

Ss: Glass

T: Glass. Point to the glass.

T: you know what? What glass is right over me? Right by me?

Ss: TV

T: TV screen. Let me put it over there. So, we don't need to look at all over the materials.

Then, Teacher J distributed paper and crayons to the students to draw the slide and asked them to think what they were going to use. He repeated four material names such as wood, metal, cardboard and glass for their choices. He gave instruction to put their names at the top of the paper and draw a slide. And,

he said, "Your slide can be twisted. Your slide can be straight. Can be short or tall? It's your choice because you are designers." Then he asked students to write what they chose in the sentence of "My slide is made out of ..." and reminded the spelling of the names of materials. While students began their drawing slides, he was walking around the class and reminding students to draw the slide by choosing the color and shape as they like. He was turning on music while students were working their tasks. Then he asked the class that every people thinks of themselves, "What would make a good slide?"

Comment: In this case, Teacher J played his role as instructor and students played their role as ownership with their drawing. Students can draw slides freely with their own choices. They just needed to choose one material and did not need to describe the properties of the material in their drawing. As students were drawing the slides on the flat piece of paper with crayons, it was impossible for kindergarten students to describe the appearance of glass or metal or wood or cardboard in their drawings. The strength of the material could not be described in their drawings, as their pictures were two dimensions. Students could describe only the color and the shape of the materials.

At one point, when Teacher J asked one student, "What do want to make your slide out of?" and student said "wood and glass." The student added, "Bottom is wood and top is glass." Teacher J did not ask any follow-up question to students about the two different materials in his drawing. He also did not give any feedback on it. He looked at other students' work and praised that "interesting slide", "Excellent, you color that", "This is an amazing playground"

and “That’s a good shape.” Sometimes, he asked a student how his/her slide works. But there was no student’s answer. After walking around and monitoring the students, he asked for students’ attention to listen to his direction for the next activity of drawing the happy or sad face on a piece paper as they evaluated their own slides. Then he gave his students three questions to evaluate their own slides as in the following conversation.

T: Now, the first question...I want to say the first question right now. Then, you can think about it. We can go over it again when you get your paper but I want you to know what you have to do first.

T: which is...“Will my slide have a problem if it rains? Think about the material you used. Will your material have a problem? If wood or metal or glass or cardboard that has a problem...the slide has a problem if it rains. I want you to think about that. If you have a problem, this is not very good for your slide. So, you have to circle the sad face. Actually, just color them in. with marker, like this. Let say, you have an orange marker or orange crayon. Oh...this isn’t good. It will mess up my slide if it rains. Color it in. That’s the problem if color is in. I read all three questions and we will go over them again. Now, the second question is “will my slide have a problem if big kid jump on it?

A few students: yes...yes

T: Well...depends...what kind of materials is it made out of? If you think about your materials, glass or metal or cardboard, will your slide have a problem if big kid jumps on it?

S: yes

T: Think about it, not necessarily. Not all. It depends...what your material is. If they would have a problem, color it. If wouldn’t, if it does have a problem, color sad face. If no problem, color the happy face. OK?

T: The third question here is...will my slide have a problem if it is windy.

S: yes

T: There’s a lot of wind

S: no

T: Right now, I want you to pay attention. This ... your slide has a problem if it is windy? If your slide is tipped over by wind because of the material it is, that’s a problem and color the sad face. You might have a happy face. You might have a sad face for each of those questions.

Comment: In this activity of evaluation of their own slides, it is not possible for kindergarten students to evaluate the materials without touching or feeling and

knowing the strength of the materials. Without experiencing three dimensions objects, students could not answer with their imagination. The questions are not helping students demonstrate scientific knowledge.

2007 Lesson

1. Content learning goals, activities, and materials

In 2007, Teacher J's goal was to discover key knowledge of what his students knew about sound. He wanted to review not only his students' knowledge about sound in general but also to provide more scientific understanding relating to the attributes and values of sound. He asked his students to describe what they observed about sound, which has two dimensions of loudness and pitch. He wanted students to see the pattern of "loud/ soft sound" and "high/ low pitch" by using his own chart/table divided into quarters which included four different parts with loud/soft; high/low. He used many examples to put the data in the table, which helped students see the two dimensions of loudness and pitch clearly. He linked the observation with real life experience. There is evidence in the narrative that the activity in 2007 was more driven by the learning goal. Teacher J was getting diagnostic information back from the students and adjusting his teaching according to the learning goal.

Teacher J clearly developed the activity to link their knowledge and experience about the level of sound. He was cautiously making a different dimension of loudness and pitch saying that loudness is this way (moving his hand from side to side) and pitch is this way (moving hand up and down). He

used many different kinds of examples such as a woman opera singer, stepping feet, snoring, blowing with a kazoo, and the sound of a car engine. He let students make the same sound as it was described in the paper. For example, during the activity featuring a woman opera singer, one student made the sound of a woman opera singer and all of the other students imitated the sound and then one student made the same sound or pitch with a kazoo. Thus, he provided his students many opportunities by letting them experience loud, soft sound and high, low pitch. He made a connection between the discussion and activities. The discussion involved the inquiry learning approach, having them experience different sound and pitch. Teacher J achieved the learning goal through many experiments and examples until the students saw the pattern of loud/soft sound and high/low pitch.

2. Student work and embedded assessment

During the 2007 lesson, Teacher J provided students with a lot of experiments and experiences to coordinate the loudness and pitch. For example, he asked students to make their voice with loud/ soft sound and high/low pitch. He also asked students to signal thumb up and down to so that he could see the different responses from the students. Then, he provided additional experiments as necessary until his students could identify the two dimensions of loudness and pitch. He asked students to show their understanding of different levels of sound and pitch by moving their hands (side to side for the loudness/softness) and (up and down for the high and low pitch).

In 2007, Teacher J was not only determining whether his students agreed or disagreed, but also evaluating his students' work. There was much more feedback from the students through their participation. Teacher J's questions were more diagnostic and better for telling how kids understood. He did a good job in making adjustments. He knew which materials did not work as he expected. For instance, he realized that the kazoo was not helping him to achieve the goal. Moreover, he was developing different ways of doing experiments to allow students to monitor the whole class as they were doing it. He was coaching individual students in 2007 while he was mostly monitoring in 2003. He was looking at the students' written work and responding to their spoken answers in the class. In the activity of making a car engine sound, he built the activity with their experiences in different level of sound to see the pattern of loud/ soft sound. Then, he provided an explanation about how the car sound changed when gas was given to accelerate the car engine. At the end of the activity, he gave his students the assignment of developing their own experiences to follow the discussions in the next period. When he realized the students' confusion, he spent more time on giving more experiences with their hand and body signals again and again.

3. Student and teacher roles

The teacher's role in this lesson was not only to solicit information from his students about sound but also to analyze the students' reasoning about the properties of sound. He also created his own activities, which allowed students to

explore the idea of making different sounds. When he provided the experiments that allowed students to hear the different sound and pitch, he used many activities to make sound and identify those sounds. He adjusted the time for modeling the activities to build the pattern of loud-soft sound, and high-low pitch. He set up various experiments to give more practice to students. His role in 2007 was coaching his students whereas he used to do monitoring in 2003.

The students' role in 2007 was to engage more in experimenting with the different materials and also with their own voices. Students were doing more cooperative work on the experiments of loud/soft sound and high/low pitch through their active participation. While they participated in the group work, they indicated agreement and disagreement with others and also gave feedback to each other. Students also responded to Teacher J by using their hands to show the level of loudness and the level of pitch while he made different levels of sound. Also, they described their understanding with their body moving 'up and down' and thumb signal 'up and down'. During the activities in 2007, students were more engaged in the activities of identifying the sound and then using those data to fill the right sound and pitch in the four quarters chart that Teacher J created.

The story of the lesson in 2007

Teacher J began the class by calling the individual student to the front of the class for doing the cooperative activities. He made arrangements for all students to sit at the corner of the class together. He began today activity by

telling that we do an experiment to see what 2nd graders can do, can think of and understand about sound. He pointed out the four quarters chart, which was posted on the board and divided by four cells written with High, Low pitch, and Soft and Loud sound. And, he read those four words and students repeated after him. Then he used a saxophone to demonstrate different levels of sound. In the following conversation, we can see how Teacher J started the lesson by using the chart and the instrument.

T: We will experiment to see what 2nd graders can do, can think of and understand about sound. Ok? So, I think you know this, right here. LOUD

Ss: LOUD

T: this is what?

Ss: High

T: High pitch. Those are two different things. We're going to work with loudness and also the pitch. Loud. We have loud and we have here soft

Ss: soft

T: and we have high pitch

Ss: high pitch

T: and we have

Ss: low

T: low pitch

T: And we have low pitch. I'm going to show you that how we're going to use this chart. We haven't done this chart before but I think you can do it and find out. OK? This is an experiment. OK.

T: First, I would like to demonstrate to you how sounds could be one of those things. Let's see. First of all, as you know, when you play it, you have to use those. Sometimes you play loud, loudly. And, sometimes you play, what? Sometimes you loud, sometimes you...

Ss: low

T: ssss

Ss: SOFT

T: sometimes, you play...

Ss: HIGH pitch

T: Sometimes you play... (Teacher makes low pitch voice)

Ss & T: low pitch (with low pitch voice)

T: OK. I thought this one would fit better for this lesson (Teacher prepares the saxophone to make a sound)

Teacher J blew the instrument and made a sound. He asked students to show him with their hands signal according to the level of sound he played. He demonstrated first with the movement of his two hands touching in the middle and moving far to side to show the different volume of the sound. He blew it again and asked students whether it was high or low sound. When he was making a sound louder or softer alternately, students were moving their hands from the middle to side back and forth gradually.

Comment: Teacher J had a well prepared plan to provide the activity with the experiment. He provided his students the opportunity to link their knowledge and practice by using his creative chart. His choice of material supports student learning by experiencing and signaling their understanding. He gave a demonstration to his students with clear information of how to participate in the activity and how to describe their understanding visually.

At one point, Teacher J said this was “same pitch” and he switched the sound making high and low pitch with the instrument. He asked students to show the signal with their hands way up and down due to the high, low pitch. But, he realized that it was hard for him to make a high and low pitch with the instrument and hard for students to understand the pitch with what they heard. So he asked students to make a low pitch with their voices as follows.

T: Ok. This is a little hard to understand the pitch. Make a low pitch.
(Students make a low pitch sound.)

T: Make a high pitch. (Students make a high pitch sound.) (Teacher shows the signal to stop making sounds) When I do this, you have to stop. It's pretty good. Let's do it again. High pitch? (Teacher shows his hand high up)

Ss: AHHHHHHHHHH (with high pitch)

T: OK. When your hands go together, no sound. Let's do this ...when my hands go far apart, you make it louder.

Ss: AMMMMMMMMMMMMMmmmmAMMMMMMmmmm (students make sound gradually high when teacher hands moves far apart.)

T: Pretty good! So, we can try that signal. When we are done making a sound, I'll put my hands together. That means what?

Ss:...silent.

T: Now, I want you to tell me. This way is low pitch (hands near floor) and HIGH (hands go up) now let's see. I just want to see the hands. Don't make sound. Just show me with your hands what you hear. (While teacher is making a sound, students are moving their hands and even their body to show the high and low pitch)

After practicing with the identification of high low pitch with hand signal, Teacher J moved to the activity of making the sound as it was mentioned in a piece of paper and posting it at the appropriate quarter in the chart. He held a box, which has many draws with a list of activities. He gave instruction for the activities and explained what two students who he assigned were supposed to do for each activity. He demonstrated with one activity of making a whistle and putting it into the chart. The instruction and demonstration can be seen in the following conversation.

T: Now, the sound is from your list. You remember? You did the last four days; Loud sound, low sound, high sound and soft sound. This one actually, I put on the list. OK? There are going to be two people. One person's job is going to be figure out where this sound goes to the chart. I will help you. We will go thru together at the beginning. And, another person's job is going to make a sound on the kazoo. They are trying to make the same sound. I'm thinking to make a whistling. Ahmm. Let's see. I can make a little whistle. Do you think you can make a whistle with me, Linzy? And, this is your chance, Linzy. OK. The second person will come up and make a same whistle. Let's see. (Teacher makes whistle with kazoo) OK? Think about how can make a whistle. My voice. How I can make my (hum) to make a sound. (Teacher makes sound) Can you make a (hum) sound like that with me? Ok. Now, the first person who's going to make a sound has to pick a piece of tape over here and figure out where on this chart...we are going to put this sound. This chart has four different

parts. Doesn't it? And, each part has a different part of sound. So, we think about a whistle, first question will be "Is it a loud?"

Ss: loud

T: soft. The second question is "is that a low pitch or high pitch sound? Show me this way (Teacher whistles with low and high pitch and shows his hand goes up at the same time) I'm going to put this into no. 2 square rectangle. It said low sound and high pitch sound. (Teacher whistles) is that loud or soft?"

Ss: loud

T: Is that low pitch or high pitch?

Ss: high pitch

T: So, we have to move it depending on what kind of whistle is. OK. Now, we start the experiment and see which children can do it. Let me pick the name out here.

After this demonstration, Teacher J picked two students and one student picked the draw and read the name of the activity "woman opera singer." He added instructions that all students have to imitate the sound what the first student made and then the second student has to do the same sound with kazoo. And, he asked the student called Ms. Dream, who made a sound of woman opera singer, whether her sound is loud or soft sound. While she was thinking, Teacher J gave her opportunity to choose someone for help from the class. After that, the second student imitated the sound by blowing the kazoo. Then he asked the agreement from the class to show with hand signal of thumb up and down.

T: How many people thumbs up to that? Thumbs up. Woman opera singer can make the best sound and you can hear at the back. So, it's a loud sound. The question is what is the pitch? Would we say that is a low pitch or high pitch?

Ms. Dream: high pitch

T: thumbs up or down on that?

Ss: (make thumbs up)

T: we agree that woman opera singer has high pitch (with high pitch sound). And, very loud sound. Give her a hand, nicely done. I'm going to

pick another one. Listen. Part of being good listeners is making a good sound.

When the class agreed, the assigned student posted the activity name in a suitable quarter. As the same procedure of “woman opera singer” activity, Teacher J provided his students many opportunities of making sound, imitating sound with their voice and kazoo and asking agreement with hand signal with multiple activities such as the activity of making sounds by stepping feet, “Small bell sound”, “dad’s snoring”, and “a particular car engine sound.”

Whenever students were confused to show the right hand signals or when they changed up and down their signals, Teacher J gave them another chance to listen to the sound again until they agreed each other. In the same way, when the assigned student found it hard to decide the right choice in the chart, he gave opportunity to ask the class for help to decide.

Comment: Teacher J was getting diagnostic information back from the students in a systematic way. His activities were carefully designed around scientific observations and practices in finding the patterns. Students were practicing description and identification of the sound and pitch in scientific ways. Students were not only contributing their ideas freely but also indicating their understanding with signals.

After the small bell sound activity, he gave students opportunity to get up and show the signal with their body instead of hand signals. Then he continued another activity of dad’s snoring. In the last activity of car engine sound, he

picked a particular student “Luke” who had experience with cars often at home with his dad.

T: Ok. Last one. I got one I have to do. Luke, I think this is the sound, you like cars, don't you?

Luke: yah

T: Luke, you got a chance when your dad works on car? I know you did kazoo already but I want you to make this sound. When you work on a car with your dad, sound goes up but the car does not go fast. You just turn on the engine but you're not giving a gas, right? Just idling, just sound the car. Engine is just going on but you are not giving a gas car. How does the car sound?

L: Beautifuluuuuuuuuuuuu

T: That's you're giving a gas. How about when you do not give a gas, how is the car sound? (Teacher and students are making a sound together) I got one person to do that sound with kazoo. Lindsey? (Lindsey blows kazoo)

Ok, Listen, Lindsey is making a sound. Listen, she got it. That's really good. The car is just sitting there and not going anywhere. Excellent! Now, I need one more person to find out where this sound goes? Mr. Logan. Let's see if he can figure out. Tell us how...what do you think it goes? Tell to us how you decide where it goes? What do you think of first?

Logan: (putting the paper on the fourth quarter)

T: So, you're saying that soft and low pitch. Tell us how do you decide. Shhh, Listen up! Tell how do you decide it. Just say what do you think. I can see you're thinking a lot of things in your head. You have a reliable thought. So, just say.

Logan: I didn't think of it.

T: You didn't think? You stick it up? So, you decide what?

Logan: just put it there because it's a kind of

T: So, it's low pitch sound.

T: Lets' see how many people agree with that choice. Soft and low pitch. Thumbs up or down? (Students show thumbs up)

T: some saying no, you're not sure. Let me ask.

T: good job (to Logan)

T: let me ask, Luke. Why do you think that might not be a right place? What's your thought?

Luke: It's not soft because they make noises.

Logan: it makes sound because it's a kind of old.

Luke: No, they all make different sounds.

T: Good point. They all each make a different sound, don't they? When you have a car and you're not giving a gas, you do not press the accelerator, the car goes fast. The car engine is just going. If you give some gas, Luke, the engine goes fast. How does that sound?

Luke: AAAMMMM

T: Guess what, AAAAAAMMMMMMMMMMM
 Luke: Dad just do....he probably know what the problem is.
 T: Ok. You just starts out before he makes engine go fast, is that low sound or high?
 Luke: it's low but
 T: high pitch?
 L: yes
 T: you're saying not a soft sound though?
 L: No
 T: Ok. We have a little...I tell you what...Here is your assignment. Next time, when you are in a car, you turn on a car or you pick up the car from the parking lot, OK? Before...before they start driving away, I want you to listen that sound.

After spending quite a long time through interaction, Teacher J gave assignment to the class to listen to the particular sound as he mentioned above. And, he raised the question of "Does sound help to figure out what's wrong with the car?" for Luke to ask his father. He ended the class saying that he would give a lot more sounds to give more chances in the next day.

Comment: Thus, Teacher J provided his students many opportunities by letting them experience loud, soft sound and high, low pitch. He made a connection between the discussion and activities. The discussion involved the inquiry learning approach, having them experience the different sound and pitch. His choice of examples provided the scientific knowledge and pattern of the sound and pitch. He also linked the activities with the real-world experiences when he tried to achieve the learning goal of attribute and value of the sound.

Similarities and differences of Teacher J practice in 2003 and 2007

Through my observation, I realize some points that showed Teacher J did not change and others that he did change after his five-year long participation in the

study group. There are very important ways in which we can see changes in Teacher J practice. I will discuss those changes with respect to three points as follows:

1. Content learning goals, activities, and materials
2. Student work and embedded assessment
3. Student and teacher roles

1. content learning, activities, and materials

Table 4: Content learning, activities, and materials

When studying 2003 and 2007 data, multiple differences can be seen in the way that Teacher J handled content learning, activities, and materials:

	2003	2007
Identification of students prior knowledge	Identified prior knowledge by reviewing facts	Identified prior knowledge during experiments and cooperative work through participation
New knowledge	Provided more facts	Provided more experiences to coordinate loudness and pitch for the conceptual scientific understanding
Knowledge – practice relationship	Knowledge was not related to practice	Knowledge was applied to practice
Material use	Labeling materials during review of prior knowledge	The instrument were used effectively in group work while identifying prior knowledge
	Drawing the slide with one chosen material for activity	More creative materials and activities to engage all students together and identify the sound
	Activity of drawing slide unrelated to the properties of materials	More creative activities which allow students to answer questions (various instruments and own voice)

2. Student work and embedded assessment

Table 5: Student work and embedded assessment

Differences can also be seen when student work and embedded assessment are examined.

	2003	2007
Teacher's response to students' ideas	- No explanation followed student responses - Make students pleased with their work	- Responses to students contained explanations - Exploration to get deeper understanding
Teacher – student communication	One-way communication with questions and answers	Interactive conversations around students' ideas and more feedback from students
Instructions given to students	Instructions focused on what to do but not how to think to do	Instructions were given by the teacher and focused on what happened and how do we know
Number of activities	Activities of drawing slide and evaluation of own slides but two activities did not match	Various experiments which developed more practice to see the pattern of sound and pitch
Evaluation of student work	No evaluation on how well students achieved learning goal	Evaluation included to know how well students achieved learning goal
Monitoring vs. coaching	Monitoring during the activity	Coaching during activities

3. Student and Teacher Role

Table 6: Student and Teacher Roles

There were also distinct differences in the teacher's role between 2003 and 2007.

	2003	2007
Student participation opportunity	Individual work and evaluate their own work	Cooperative work opportunities were given to students to participate in experiments and indicate agreement and disagreement
Use of time	Use time for doing activity but not provide time for the discussion on their work	Use time to allow all students adequate time to experiment and discover patterns
Conceptual understanding	More procedural learning (labeling materials) rather than conceptual learning (identifying the materials and their properties)	Emphasizing on conceptual understanding of the attribute and values of sound and pitch

Although there are many differences between 2003 and 2007, similarities can also be seen when examining classroom arrangement and creative materials. In both years, Teacher J's classroom was very organized with tables and chairs for either whole group or small work. The way he created new materials can be seen in both years. Reading and writing materials such as a whiteboard, charts, graphs, and science books were set up appropriately. His ability to organize her students into various groups was very evident during both years. By 2003 he was already committed to moving beyond the textbook and helping his students learn through group activities.

CHAPTER FIVE: ANALYSIS OF CHANGES IN TEACHING PRACTICE

In this chapter, I will explore changes in Teacher K's and Teacher J's teaching practice during their membership in the PI_CRUST study group from 2003 to 2007 and consider why and how those particular changes happened. Through interview excerpts I will report how teachers explained their changes and how they believed participation in PI-CRUST made those changes possible. This chapter is framed by three key changes in the teachers' knowledge and practice:

1. Teacher's content learning goals, activities, and material:

- Both teachers changed the nature of their goals as well as the activities and materials they used to achieve those goals.
- The knowledge they taught as well as the activities and materials they used changed from naming and listing facts to attribute and value discovery and description.

2. Teacher designed student work and embedded assessments

- Teachers designed student work so that it shifted from free expression of their ideas to engagement in specific scientific practice designed to help students recognize the attributes and values of sound
- Teachers designed activities that allowed students to practice the process of finding patterns and describing attributes and values.
- These activities also allowed teachers to observe students' learning performances and respond with immediate, specific feedback

3. Teacher and student roles

- The teachers' roles shifted from encouraging students as they did activities to active coaching of specific scientific practices
- The students' roles shifted from reciting or drawing objects with which they were familiar to practicing the scientific process of attribute and value discovery and description.

Each of these three change areas will be examined through two lenses: (a) observation and interview data and (b) study group data.

Teachers' Content Learning Goals, Activities, and Materials

Teacher J and Teacher K both changed the nature of their goals as well as the activities and materials they used to achieve those goals. In 2003, the teachers did not have clear scientific goals in mind and during the activities that they did with their students. They were not actively judging whether they were successfully achieving their goals. Observation and interview data reveal that at this stage, they had not seen that young children could make predictions, plan investigations, and draw conclusions. Instead, they were relying extensively on the printed word or pictures in textbooks to increase students' science knowledge.

Study group data from 2003 sessions confirm Teacher J's and Teacher K's dependence upon printed text as the primary source for student learning. For example, during one session, the concentrated, along with other group participants upon their pacing guide as they discussed their upcoming sound unit. The teachers were also interested in gathering objects that might demonstrate sound changes. They explored the possibility of gathering objects

such as rulers and rubber bands to demonstrate sound changes. Their discussion extended further into community resources such as inviting an audiologist from the local university to demonstrate “some machines.” One participant also noted that a local symphony might “do demonstrations for kids.”

Throughout many of their 2003 study group discussions, Teacher J’s and Teacher K’s discussions with colleagues also focused on broad concepts that they wanted their students to learn.

Leader: They [students] have a very narrow definition of animals.... So that’s kind of the big idea that we’re working with here. We might want to just kind of keep an eye out for sort of what are the criteria that kids are using to decide this.

Teacher K: The biggest thing for them is yes, dog is an animal, yes, a bird is an animal. Humans are not animals, you know, that’s the...., I just don’t know if they’re able yet to do that.

When I asked Teacher K how participation in the study group helped her prepare to teach, her response confirmed that early group discussions centered around broad issues and did not often include goal setting for specific lessons.

Q. Can you talk about what kinds of learning occurred to you in the study group?

A. “I think more, a kind of national level, that kind of thing. I wasn’t familiar with those standards and benchmarks, that kind of stuff. I just knew the pacing guide, so the study group helps to bring out what’s national - you know that kind of broad thing.”

By 2007, the teachers were establishing clear goals and designing assessments that allowed them to evaluate goal achievement. This process was facilitated by their participation in the study group. During one session, for example, participants focused upon their goals for their sound lesson and ways to reach those goals. They talked about their goal of teaching vibration and identified this as a difficult goal to achieve.

Teacher J; "Clapping hands is not a clear way to see the vibration...because the sound does not continue. The vibration of the hand or vibration of the air... [It's] not a good example for vibration. It is not visual. A rubber band activity can help to see the vibration." (Teacher J suggested that they use a hammer activity.) Use it a lot...it's an 'Ahha' activity ... to get the concept of the stopping sound.

Teacher J reported that he saw goals change over the years. It wasn't just that participation encouraged members to adjust their individual goals. It was that the group as a whole intentionally broadened their thinking. "People in the group are the special case...the kind of people chosen for the group. They want to know what the next level is, how to get something else done, how to build on understanding. [They are] looking for further detail or richness of kids' experience."

Now study group discussions turned frequently to reports about how students responded to learning materials and activities. Participants shared how those activities involved student use of materials rather than just observation of demonstrations. They reported to each other about misconceptions held by their

students regarding sound and which questions best redirected student thinking. They described for each other activities that they had found to be most effective.

To explain further, Teacher J said that group discussions in preparation for a weather unit helped him raise his goals and his expectations. “The first year we did not understand clearly. Now we understand how to help students understand and how you can help them remember – different ways you can symbolize information and record it and how to get more detailed and use different materials.” He said that by listening to other teachers tell what they accomplished during their weather unit, he realized that their students gathered data that his did not and that by setting his goal higher, he could help his students learn more than they had previously.

Activity Changes

In addition to strengthening their goal setting process, both Teacher K and Teacher J changed the nature of the activities and materials they used to achieve their goals. In 2003, they designed activities that only elicited from their students free expression of facts and names. As students called out bits of information that they already knew about guppies (Teacher K) and materials items are made of (Teacher J), the teachers wrote on a board or chart hanging on the wall.

However, in 2007, both teachers designed activities that required students to engage in scientific observation of attributes and values, which guided them toward discovery and description of sound. According to Teacher K, this change occurred gradually between 2003 and 2007 as the study group continued to meet and search for better teaching methods. In the beginning their work was

around “a kind of general science teaching.” But, “at the end, we focused more on the unit.” She explained further that her first year was just a kind of exploration and a telling of what she should be doing but she didn’t know why. However, as years went by and the study group met each summer to discuss specific upcoming units, their conversations became more helpful to her. She emphasized that as their conversations changed, participants were able to plan in greater detail all the things they were going to be doing during the year to come. As Teacher K and Teacher J participated in these in depth discussions of units, they were able to develop unit goals, and as the time to begin new units approached, those unit goals facilitated their creation of daily lesson goals. Teacher K even indicated that during the years in which her study group met, the participants learned to set goals that were not necessarily identical to those of their textbook publisher. “That’s the kind of learning that I did. Just because it’s in the book, it doesn’t mean that it’s right. Somebody wrote the book. It doesn’t mean that it works.” Teacher J agreed and expressed confidence in the ability of the PI_CRUST group.

Sometimes, the activities they [publishers] provide are good but sometime we make better ones. Many times we go beyond what was in the curriculum and use a different activity with our community experience or a speaker or different type of investigation or demonstrations that will allow us to go beyond the curriculum.

He valued the fact that he could “get information in the group [and] figure out what kids misunderstand....”

From 2003 to 2007 membership in the study group gradually helped Teacher J understand how to organize his students and how to handle materials during activities. In order to transition from reliance on textbooks to learning by doing, he needed this knowledge. "That kind of discussion really helped me figure out," he reported, "how to use the group, how to share materials, how to anticipate how long an activity will take and break it down [if] it cannot be done in one period." He added that group discussions raised his expectations about using materials as learning tools and avoid using the textbook so much or presenting "all the information." He said that by listening to his colleagues he began to think about how to "use the materials so they allow students to explore and think again and draw their own conclusions."

Teacher J also reported that he believed his knowledge about children's developmental levels increased as he continued to attend PI_CRUST meetings because there was discussion about what should be accomplished at different grades. He said that he now thinks differently when choosing activities and particularly when choosing materials. He said that group feedback was especially helpful and added that it encouraged him to consider 'how I can change for the next year.'

Content knowledge changes

In addition to goal and activity changes, Teacher K and Teacher J reported that the knowledge they taught as well as the activities and materials they used also changed from 2003 to 2007. As the participants grew to know each other better and their conversations deepened, they began to view each

other as good sources for teaching ideas. Teacher K said that meetings with her fellow study group participants provided her with resources.

[Meetings] gave me a chance to bounce the ideas off the other teachers. I guess they helped me understand what worked and what did not work and how to tweak things so they work better. For example, they gave us things like... 'this was okay, but it would be better to use a different one.' I'm thinking about the weather unit. They gave us the weather station and wind gage, speed indicator, and ...then we found out that the windsock works well. They gave us something but something else is better. We found out from the group. They said it worked for them and to try it out. That's kind of thing.

It is interesting to note that Teacher K reported that the study group's development toward increased mutual trust and idea exchange happened simultaneously with their change of role. In 2003, teachers functioned primarily as participants while their leader drove ideas around teaching activities. The leader arrived to study group sessions with activities already in hand. However, by 2007, teachers were taking a much greater leadership role than the leader. They were preparing for meetings themselves and sharing responsibility for planning teaching activities to enhance the unit currently in preparation. It is understandable that she would also report that in 2007 teachers were spending more time on study group work than they had in 2003.

For the purpose of this research, it is important to examine the cause for this positive change. One answer seems to lie in the way that members

responded to each other. As time passed, they became more and more willing to accept each other's challenges. They established a culture of inquiry that allowed one participant to question or even challenge another's statement. Once constructive challenge and rebuttal became the group norm, members were free to make risky statements and venture into the unknown. Teacher K explained that she believed all of the participants, including herself, were more knowledgeable by 2007 because they had become free to question others' thinking and to challenge each other. They "became less formal" and less concerned about being "put down."

Over time, PI_CRUST participants adjusted the value they placed upon their textbook and the way they used it. Teacher K explained,

"Well, after we were able to go through a unit..., we were able to say that we're going to skip that lesson. We are not going to do this lesson because it repeats over and over again. Or, if that's not there, we need to find the lesson. Those are kinds of things we did."

I asked her if there were changes in the way they used other materials.

Oh, yeah. A lot of things we left out. [For] a lot of the sound unit, we did not use the materials. We had to get different materials because in the sound unit, they gave us all tools and wood and things to make instruments, [but] we changed those completely. Like in my classroom, [Students] had to use recyclable materials to create their instruments instead of the instruments in the textbook unit. They had to gather their own materials to create the instruments. So, a lot of thing we didn't use.

Before that, we had to use this stuff. It didn't serve a purpose, but we were using it.

When I asked Teacher K if membership in the PI-CRUST study group changed the way she approached her science units, she replied affirmatively and said that, for example, the sound unit at first "seemed overwhelming and too difficult for the second grade." However, after the study group collaboratively analyzed the unit's components, they realized that there were not an excessive number of concepts to be learned and that students just needed many opportunities to experience the concepts "over and over again." Eventually group members recognized that they could build the unit as a progression of experiences.

Changes in teachers beliefs about student work

When I asked Teacher J whether any change had occurred in his thinking about student work during the time he participated in PI_CRUST between 2003 and 2007, he responded,

I would say I have a better understanding the students' developmental level. I can understand clearly the level of where I can start and...try to be more explicit about what do they really know... what I could expect reasonably. I have learned not to make assumption...that's helpful.

He added that the group leader was "really good" about showing him how to interpret student work, understand what student work means, and how to best explain content.

Growth in understanding of how to use one piece of student work as a tool for further learning can be seen through examination of the work that Teachers K and J gave over time. In 2003, lessons began with students being asked to freely express their knowledge about lesson content – for Teacher K, guppies and for Teacher J, materials used to make things. They were not asked to investigate first. Instead they could rely solely on prior knowledge to satisfy the activity requirements. During the second part of the guppy lesson, students observed guppies and drew pictures of what they saw. During the second part of the materials lesson they drew a picture of a slide, but there was no real slide for them to observe.

In contrast, in 2007 both Teacher J and Teacher K launched their lessons with investigations in which students actively participated. Because real sound-generating tools were in the room, students could collectively think of ways to make the sounds vary and immediately listen while their ideas were tried. This was, of course, accompanied by discussions about why the sound pitch and volume were varying. As these activities continued, they became more fully driven by the students, since a result from one student's suggestion led to a subsequent suggestion by another student, and a long series of sound variances occurred.

Teacher K reported that participation in the PI_CRUST helped her develop a 2007 sound unit that was more investigative for her students than her 2003 guppy unit had been. She explained that, the biggest change brought about by her participation was that she had a better understanding of what her children

needed, how they learned, and the experiences they had to have before they could internalize new concepts. She added that by 2007 she was putting more responsibility for the learning on her students as she invited them to explore.

Changes toward collection and analysis of student work

During Teacher K's interview, her progression toward better understanding of the place held by student work was evident during her 2007 interview.

K:1 I just found out how important to collect the student work and analyze it. I'm not looking for the answers. I want to know, even though they came up with wrong answers, it's not bad and now I can figure out to change ...why they came up with and change it and fix that part of the lesson or say that I need to readjust and I need to go back and revisit it. A kind of driving instruction, more than in getting answers.

H: Can you bring those experiences to the classroom teaching practice?

K: Oh, yeah.

H: So, could you give me a little bit more about it?

K: I guess, I was able to analyze the work and their work drove by more options. It wasn't that it lets go, we only have five weeks to get through it. If they did not get it, I'm sorry. The rest gonna be messed it. I have to go down to the beginning or try in different way. So, their work drove to instruction more than a time line or district is telling me. That's kind of thing.

Teacher K also talked about her increased awareness of her students' reasoning ability. "I guess I'm more interested in their reasoning," she reported. "The process is more important than just the outcome of it. The reason what I'm interested in is...I don't care if they have the right idea or if they don't...how did they come to conclusion? What do I need to support them or help them? So it's not the answer."

Teacher K also pointed out that a major contribution in the study group was discussion about assessment since it helped her in assessing student work and her own practice. She said that membership in the group sharpened her ability to assess student work. "Not only assessment of what they know but assessment of our teaching. When we're successful, getting the ideas across...Can they do it? Some people say 'No, they could not do that.' but when you assessed them, sometimes you find out 'yes' they can. So, you know it was assessment of both students and teachers.

Sometimes Teacher K turned to performance assessment. Her sound unit was an example. As she talked about this and other units, it was apparent that effective performance assessment in this unit had increased her confidence and encouraged her to repeat the practice. "That worked out well and I like that approach. There was a product at the end, something for them to construct. A lot of other units did not link as well. But I guess, there could be ways we can do that. Maybe, adding more constructive performance."

In addition to transitioning toward more performance assessments, Teacher K also revised the lens with which she examined student work. "I'm

looking more for deeper understanding of the concept, just deeper understanding of the concept behind it. They gave you the right answers. It doesn't mean they know it. They know what I'm expecting from them to say. So, I'm looking for the understanding part."

It was interesting to note that Teacher K recognized her own progression as one study group session followed another. When I asked how she and her colleagues had adjusted their view of student work, she replied, "[It's] just more in depth. At the beginning we were just looking more like did they give the right answers. And, as we progressed, how did they come and why they think that way? Yah, I guess. It is more in depth."

At the time of Teacher J's interview he had decided to add a new piece of student work to his science program – a student notebook in which students would record knowledge gained through class activities. "That's the group's suggestion," he commented.

Transcripts of study group sessions reveal that in both 2003 and 2007 teachers wanted to talk about student work. For example, in 2003 Teacher K took scientific drawings that her students had completed to a study group meeting. The discussion that followed indicates that participants studied those drawings and identified what students did and did not understand about sound. In 2007, Teacher K not only took student work (a worksheet on sound), but she also took a video tape of the science lesson in which sound was taught to a study group meeting. A discussion among group members followed in which they

explored their different ideas about what the students were apparently thinking as they participated in the lesson.

A comparison of 2003 and 2007 study group data indicates that participating teachers had learned to consider not just what students knew, but how they were approaching learning.

Shifts in teacher and student roles

Examination of interview and study group data reveals a shift in teacher and student roles. Because Teacher K and Teacher J adhered to the group's conclusion that scientific practice would free students beyond the restrictions of textbook reading, they found it necessary to study some scientific concepts ahead of time so they would be ready for students' questions. I asked Teacher K

H: When you compare your knowledge at the beginning of the project with your knowledge at the end of the project, do you see any changes?

K: Yeah, first of all you have to learn for yourself. In a case of sound, probably, it is the most abstract. Even though I do not teach the process of producing sound, I have to learn for myself. Weather is Ok. Water is OK. Animal is OK. Sound is the most difficult one. So, I have to go back to do some learning before I can present to the kids.

She also came to view herself as a fellow learner with her study group colleagues. When I asked what she learned from fellow study group participants, she responded,

How their children were doing, the approaches - how they taught and what they thought was going well or was not going well. We just give feedback, bouncing ideas from each other and get feedback. Lots of new ideas. A certain way they tried and it worked. And, you go back and try it.

Teacher J also recognized that he had changed through his PI-CRUST association. In his interaction with his students, his role became more reflective. He said that he increased his “ability to see what was working and not working” and to look at student work “clearly and explicitly” with “over interpreting it.” He explained that much of his improvement was made possible by networking with study group colleagues and talked about sharing ideas and resources.

Students became more active learners

As Teacher K’s awareness of sound science teaching practice grew and she began to design more experimental hands on activities, her students were required to adjust their approach to science class. Teacher K no longer simply commented, “That’s a nice picture” without questioning her students. “What’s that?” She “pulled out answers from the kids.” Students were asked to do more than respond to questions. By 2007, they were asked to help develop experiments by designing questions and predicting results. “Earlier I just asked questions and kids gave answers. I said ‘okay’ and went on. But not now.” She made the decision to put “more of the learning on the students.” She viewed this as a new teaching strategy.

One similarity in roles that I saw when studying 2003 and 2007 study group sessions was that participating teachers were always interested in

reaching beyond their classroom materials to find new teaching resources. In 2003, they did examine their in-house pacing guide, but in other sessions they also reminded each other that science instruction helps might be found in multiple sources and pointed to books, other teachers on staff, and community groups. By 2007, more of their conversation had moved to standards. By this time, they were looking beyond their local community and talking about national science education standards and science teacher conferences that they might attend to learn how to incorporate those standards.

Conclusion

The teachers whom I interviewed did not necessarily believe that all of their change as teachers had occurred because of their participation in PI_CRUST. Teacher J said that he knew that he had become more reflective, but that “that’s the way I am.” He believed that his natural tendency to observe and think would have resulted in some changes even if he had not attended study group meetings.

However, both of the teachers whom I interviewed indicated that PI_CRUST membership had strengthened their teaching practice. Teacher J explained that his group colleagues became a valuable resource as they shared ideas about “the nature center or people from the community, a video or book.” He added that “sharing information was a major impact for me.” There was a “sense of community,” he said. “These are people who are trying to do the best job they can, and they also have the same political and social expectations.” He explained that this was a group where he could share his frustration and that he

found a tolerance for not achieving the first time. "If they try to achieve and they don't, it's okay." He said, "You have a tendency to feel inadequate if you do not achieve what you are hoping to. Everybody has the same frustration." But in this group he was encouraged.

CHAPTER SIX: CONCLUSION AND IMPLICATION

The stories of two teachers' classroom practice in 2003 and 2007 reported here described significant changes in their knowledge and practice, which occurred during a period when they actively participated in PI_CRUST study groups. This study investigated the pattern of their participation through their study group discourse, how they shared and responded to students' work, what they said about students' understanding; and what teaching materials they brought to study group discussions. The findings have been presented as three key changes. 1) Teacher's content learning goals, activities, and material, 2) Teacher designed student work and embedded assessments, and 3) Teacher and student roles. This research shows that changes occurred in terms of teacher and group leader roles, study group participant collaboration, and teacher content knowledge depth.

In terms of the group leader's role, I agree with Arbaugh's statement (2003) that, "a skilled leader can build the capacity of a staff and, therefore, get better results when they gather together in study group sessions. I found in my study that when the group leader has established a clear purpose for the meeting with a specific learning goal on the agenda, the group is better able to focus on a particular issue. The leader's preparation benefits the participants, because they know what they want to achieve during the meeting. When the group leader completes the task of prioritizing discussion

topics, members can focus their reports of daily classroom challenges and achievements and draw meaningful conclusions.

This study contributes to the growing body of literatures concerned with better understanding how to guide teachers toward improving their learning and practice through participation in professional development study groups. Today many teachers are able to regularly interact with their peers in similar settings intended to enhance professional growth. By participating in study groups, teachers might be able to better understand student thinking and learning, their own (teacher) thinking, subject area content, and approaches to teaching content, along with many issues related to changes in practice (Borko, 2004; Cohen, 1990; Wilson, 2002). I found in my study that both Teacher K and Teacher J enhanced their professional growth by interacting with each other on a regular basis in biweekly meetings. Through that participation, they both changed their own thinking about how to guide student thinking. Teacher J reported that through his participation in the group, he raised his expectations for student performance and that by listening to other teachers, he realized that he could help his students learn more than they had previously. He said, "I can understand clearly the level of where I can start and...try to be more explicit about what do they really know... what I could expect reasonably" by examining student work.

The extent to which study group membership is able to impact teaching and learning lies in the willingness of participating teachers to carry concerns and ideas into group sessions and to transport new understandings back to

their classrooms. I found that both of the teachers whom I studied were regular participants and were willing to share their ideas and also bring new ideas to their classroom. On the other hand, based on the initial data of the project, I realize that some teachers in the group I studied did not commit to attending study group sessions regularly. I could not determine the reasons for their inconsistent attendance. Nevertheless, I argue that if teachers commit to regular attendance as my participant teachers did, they will definitely improve their learning to some degree.

Study groups provide learning opportunities for teacher members

Researchers find that study groups provide learning opportunities for teacher members and consider how teachers learn through collective examination of students' work. (Kazemi and Franke, 2004) I also found that the examination of student work is an important factor of study groups' ability to improve teachers' learning and change teaching practice. In my study, Teacher K reported that the biggest change brought about by her participation was that she had a better understanding of what her children needed, how they learned, and the experiences they had to have before they could internalize new concepts. Through discussion with her study group colleagues, she realized that careful examination of students' work could reveal far more to her than just their answers to questions and that she could use student work as a tool to better prepare future lessons. As I listen again to taped recordings of study group meetings, I notice that the group's conversation focus is often that the examination of actual student work

provides teachers opportunities to learn better practices Including Improved lesson planning.

Little (2001) emphasizes teachers' learning through shared discourse around their own classroom practice. What teachers learn and how they learn through teacher development groups can influence their practice. (Cohen and others, 1990; Lin, 2002; Deglau, Ward, O'Sullivan, Bush, 2006) Of course, it must be recognized that shared information does not necessarily result in participants' changes unless they really try new approaches in their own classroom teaching. The teachers whom I studied agreed that shared discourse changed their practice. Teacher J said "Shared information is a major impact for me." Both Teacher J and Teacher K tried what they learned from the group in the classrooms and then brought their experiences back to the group to discuss. Literature reveals that study groups can become dynamic "communities of practice" highly valued by members when meetings develop into sharing events (Grossman, Samuel and Stephen, 2001; McLaughlin and Talbert, 2001; Wenger, 1998) Teacher J also explained that "his group colleagues became a valuable resource as they shared ideas about " the nature center or people from the community, a video or book." It seems clear to me that sharing information about teaching practice is an important factor to improve teacher learning in the study group.

The benefits of group membership reported by Teacher J and Teacher K are echoed in literature which reports that study group participants sometimes gain (1) deeper understanding of students' thinking (Kazemi and Franke,

2004), (2) collaborative discourse to improve teachers' practice (Little, 2001), (3) learning through interactive talk (Carroll, 2005), and (4) learning in a community of practice (Grossman et al., 1998). Particularly, Grossman and others (1998) focus on teachers' learning of new pedagogical practices in the dual areas of problem analysis and improved pedagogy arising from deepened subject matter knowledge.

Ball & Cohen (1999) and Little (2002) support the idea that "the use of student work has the potential to influence professional discourse about teaching and learning, to engage teachers in a cycle of experimentation and reflection and to shift teachers' focus from one of general pedagogy to one that is particularly connected to their own students" (p. 204) Ball & Cohen (1999); Lin (2002); and Little (1999) also suggest that organizing teacher learning around the study of student work is one particular way in which professional development can be situated in practice. Teacher K also said that she progressed toward better understanding of the place held by student work while attending group meetings. She found out how important it is to collect student work and analyze it rather than simply look for correct answers.

Professional learning community meetings hold this potential, because they can offer participants comfortable settings in which they might reveal elements of their teaching practice and invite collegial critique and encouragement. Teacher K and Teacher J experienced this kind of comfortable setting and they reached the point where they could invite

collegial critique and encouragement. In the interview, Teacher J noted that this was a group where he could share his frustration. "If you did not achieve, it was OK," he said. This data suggested to me that the comfort level in the group promoted open discussion and admission of teaching challenges. As I listened to the study group audiotapes, I realized that as the teachers continued to meet over time, they were participating in the discussion more actively and expressing their feelings more openly. However, it should not be assumed that membership in a study group benefits all participants all the time. Literature referenced previously in my introduction chapter indicates that conflict can arise among participating teachers if a few feel comfortable but others feel out of their comfort zone and hesitant to join in further discussions. I saw during my observations of study group sessions that some teachers did not continue to contribute to discussions. Instead, they indicated that matters being discussed and suggestions being offered may not work out in their situations.

Kazemi and Franke provide evidence that workgroup discussions centered on student work can help teachers understand students' thinking and discover how their students reacted to the problems, and specific ways in which their students attempted to solve it" (p.209) This occurred for Teacher K who talked about her increased awareness of her students' reasoning ability. By 2007 she was able to report, "The process is more important than just the outcome of it. The reason is what I'm interested in...I don't care if they

have the right idea or if they don't...how did they come to conclusion? What do I need to support them or help them? So it's not the answer."

Kazemi and Franke (2004) also talked about teachers' interaction with their students. Because study group members are encouraged to bring work samples to meetings, participating teachers begin to search for more ways to interact with their students about learning strategies students are using and to document those interactions for the purpose of sharing in the work group. Regarding the work sample, my research shows the value of bringing the student work sample to the group, since that is what initiated the interactive discussion and increased teachers' engagement in giving feedback to each other along with new ideas. Kazemi and Franke suggest that teachers' engagement with student work shifts from one of uncertainty about students' thinking to one of active engagement with student strategies, and they report observing dialogues among study group participants that help us see how member teachers ask detailed questions of each other related to student strategies and student thinking.

Little (2001) also emphasizes teachers' discourse around classroom practice as teachers share their daily classroom teaching practice and interact with each other in collegial communities through professional discourse about their innovative practice. While I observed Teacher J, I discovered that Teacher J created his own activities and tried as an innovative practice in his classroom. Then, he brought his experience to the group and shared his difficulties and success and seek the feedback from the study group as his

collegial community. Little's also describes how teachers locate their learning in relation to their group's collective project. This happened to the teachers whom I studied. Teacher K reported that as years went by and the study group met each summer to discuss specific upcoming units, their conversations became more helpful to her. She emphasized that as their conversations changed, participants were able to plan in greater detail all the things they were going to be doing during the year to come." Teacher J reinforced this finding, saying that his group colleagues became a valuable resource as they shared ideas about "the nature center or people from the community, a video or book." He added that, "sharing information was a major impact for me." There was a "sense of community," he said.

Little (2001) found that participation in study groups draws teachers' views and practice into the open where others can examine them. Ball & Cohen, (1999) agree that through their interactions with one another and with the materials environment, they can construct particular representations of practice. He saw that teachers presented their practices and artifacts, lesson demonstrations and reviews of student work in the group and responded to each other. Thus, teacher-to-teacher interaction gave opportunities to develop both individual and collective practice. I also found that, for example, Teacher K learned from fellow study group participants how their children were doing, along with her colleagues' approaches - how they taught and what they thought was going well or was not going well. "We just give feedback, bouncing ideas from each other and get feedback. Lots of new ideas. You

hear about a certain way they tried and it how well it worked. And, you go back and try it.” It is clear that teachers’ professional study groups provide a unique situation in which their largely unseen work is exposed to others. Pfaff (2000) says that as teachers he studied gained this insight, “study group sessions encouraged subtle changes in instructional planning and decision making” (p. 5). Through similar learning experiences during group sessions, teachers can make changes to their practice. Although, research finds that some teachers prefer to be isolated in their own classroom and do not try to interact with teachers in the same building, I found that interaction in the group contributes greatly to professional learning.

Broko (2004) points out that when teachers gather themselves into professional study groups for the purpose of improving their teaching practice, it is not always necessary for them to use materials developed expressly for that purpose. They can learn just by collaboratively examining material prepared by group members and constructively critiquing it. In this way the study group becomes a place where teachers can learn together by doing and sharing their work with colleagues. Both of the teachers whom I studied were able to join with their fellow teachers in this way and to learn from them.

As I reported earlier, literature establishes that teachers benefit the most when they participate in their groups in two ways: (1) they contribute by bringing concerns and ideas to their meetings, and (2) they assimilate other members’ contributions and apply them directly to their teaching practice. When I asked teacher J in the interview how he benefited from the group, he

said that he developed his own activities that go beyond the textbook to teach sound and pitch and contributed his new ideas to the group so that they could do the same. He also said that he got feedback from the group on what kind of sound would be good for students and what kids might misunderstand.

In addition, he reported that, "In the sound unit, last year I didn't have kits with instruments for the different kinds of activities. This year Teacher K gave me the homework that she made last year with kids at home and brought them in." He appreciated that the group feedback was very beneficial for him. He also added that being part of a community that cared about him was a social and emotional benefit and helped him not to feel so isolated. Similarly, Teacher K told me in the interview that she contributed a variety of her students' work to the group and that she, in turn, benefited from seeing "a good spectrum of student work" from the group. In addition, she had learned other teachers' approaches of how they taught, how they decided what was going well and was not going well, and a certain way they tried. When it worked, she took it to her class and she tried it. She added that, "Someone else in the group tries something new and if it works, I would like to include that in my teaching."

Wilson and Berne (1999) suggest that in order to obtain optimum results, learning groups should meet regularly and for time periods sufficient for meaningful work. This was certainly true of the PI_CRUST study groups. They met every other week during the school years from 2003 to 2007, and members also joined special summer meetings devoted to detailed

examination of a unit they would be teaching during the coming year. Wilson and Berne also suggest that productive idea exchanges are centered on problems that matter to the participants, that is problems that teachers see in their classrooms. The summer sessions that were an integral part of the PI_CRUST project provided opportunities for teachers to focus on a problem that mattered. They knew that the unit under examination each summer was one that they would soon be teaching. Therefore, the material in question was highly relevant to them. It is clear that the teachers whom I studied enjoyed one of DuFour's (2003) criteria for study group effectiveness, i.e., that members must have a clear sense of purpose, specific goals and structured activities that give directions to their work" (P.5).

Group Participant Role

A skilled leader can build the collective capacity of a staff and, therefore, get better results when they gather together in study group sessions. (Arbaugh, 2003) My research shows that the leadership role is important for building the skills that the participants need. For example, Teacher J described how the group leader was good about showing him how to interpret student work, understand what student work means, and how to best explain content to students.

Researchers have explored teachers' willingness to remain with a study group for an extended time and say that this depends upon participants' opportunity to comfortably interact with their fellow attendees. Teacher J,, especially, indicated that he felt very comfortable in his groups. This is

especially interesting, because he had to change groups when he changed teaching grades. Still he reported that he was able to move into a new group quite easily and that his new colleagues quickly became a source of support for him. Wilson and Berne (1999) stated that being part of a professional group could hold teacher's commitment to learning and change their practice. Teacher J's ability to maintain this commitment even though he had to change groups suggests that a teacher's commitment to the idea of group benefit is important. Teacher J believed in the PI_CRUST project as a whole and was not deterred by having to change study groups within the project.

Literature considers how interacting in groups helps classroom performance. Pfaff (2000) reported, "changes of teachers' perceptions occurred in their teaching performance as a result of their participation in the study group sessions" (p.3) During their 2007 interviews, both Teacher J and Teacher K were able to express the professional growth they had experienced during the PI_CRUST project. They had revised their analysis of student work and had clearly moved toward increased hands on learning opportunities for their students. By 2007 they perceived the need to allow students to learn by doing.

Researchers also find that teachers who engaged in ongoing professional study group activities were more likely to gain or sustain a sense of security and confidence that encouraged them to transfer the content of their study group sessions into classroom practices. (Pfaff, 2000) I also found in my research that a sense of security and confidence promote teachers'

willingness to challenge each other in the group as Teacher K' said, "We became less formal and more willing to challenge each other." Members spoke out of concern for each other and everyone knew they were not going to be put down. Teacher J also expressed in the interview that his group was "not threatening...it is important too because the group is good...helping you feel good about where you are and where you need to move along."

Loucks-Horsley et al., (2003) noted that, "Study groups require the participation of teachers who are committed to reflection on their work and taking initiative for their own learning" (P.158). Teacher J said that he realized that he has become more reflective on what he was doing and how the activity was organized. He added that by being reflective, he realized that he need to record separately for the two different data for wind table and how other teachers get data what I never get to that." Regarding the Issue of teachers' conflict/ tension, one of the challenges in community formation and maintenance arises from diverse perspectives within a social group (Grossman, 2001) But my study found that challenges occurring during study group discussions were seen as positivies rather than sources of conflict among teachers. Both participant teachers described how those challenges helped them improve their knowledge and practice.

Development of professional knowledge

McLaughlin and Talbert (2001) identify "teachers' learning communities as a strategy to build teachers' capacity for effective classroom teaching" (P. 135) and suggest that they be respected as strategies for generating and

sharing knowledge about practice. Jan, Douwe, and Nico (2000) agree that teacher learning communities are powerful strategies for developing teachers' practical knowledge because during group sessions, participants engage in learning through networking, peer coaching, collaborative action research, and the use of real cases drawn from classroom experience to examine student learning.

Loucks-Horsley et al., (2003) suggest that within such study groups, teachers are encouraged to go deeper into their thinking about the issues as they question and reflect on their practices and their students' learning. As members discuss student needs and decide upon solutions during meetings, they also encourage each other to carry new knowledge and ideas back to their classrooms and to put new ideas into practice. My research shows that Loucks-Horsley's suggestion occurred in the study group I observed. Teacher K said that membership in the group sharpened her ability to assess student work. "Not only assessment of what they know but assessment of our teaching. When we're successful, getting the ideas across...Can they do it? Some people say 'No, they could not do that.' but when you assessed them, sometimes you find out 'yes' they can. So, you know it was assessment of both students and teachers. It is clear that membership in her study group strengthened her knowledge about teaching practice."

Limitations and Application

The scope of study was limited since it focused on only two teachers among an entire study group. Therefore, I am not suggesting that all other

participants' teaching practice improved through their participation. Additional limitations occurred since I only observed videotapes of Teacher J and Teacher K. My findings from those videotapes cannot be generalized to all teachers' learning with certainty.

Although I have mainly focused on the observation of the Sound unit, I also looked at how my two participant teachers changed in their teaching of other units such as their water and animal units. I found that similar patterns of change occurred in these units regarding their learning goals and their use of materials. I also found that the way they discussed student work and assessment changed from 2003 to 2007. In terms of the leader and group participants' role, I found the same pattern when they discussed other units with their the study group colleagues. For example, in 2003 the group leader talked about activities more than the members did, whereas in 2007 teachers were taking greater ownership of topics under discussion and assuming more leadership.

Overall, the data in my research provides greater understanding about study groups and demonstrates that on-going meetings focusing on teachers' practice, examination of student work, sharing of information with work samples, and willingness to accept challenges and give feedback are features that make the study group meaningful for teacher learning. Educators might learn from my research that the comfort zone among participants is likely to be increased as they maintain and sustain participation on a regular basis. Based on my research findings, I would think that professional development

programs would be more effective if discussions focused more on participants' practice rather than just giving additional information about learning in general.

The results from this study suggest that the study group as a professional development tool should continue to be examined. Both teachers and administrators will benefit by increased understanding of exactly how group membership might improve teachers' understanding of student learning and best teaching practice.

APPENDIX A

Interview Protocol

Participation in the study group

Related to RQ 1: How did the teachers' participation in their study group change over time?

- a) When the two teachers whom I studied were analyzing students' work with the study group, how did their discourse change over time?
- b) When the two teachers whom I studied were discussing or developing teaching materials in the study group, how did their discourse change over time?

1. I would like to begin by asking a few questions about your participation in the study groups of PI_CRUST project.
How many years did you participate in the project?

How many years have you been teaching? Where have you taught?

What grade level were you teaching at that time? And now, what grade level are you teaching now?

When your study group met, what was the focus of your conversations?

What contribution to the group did you make? Could you tell me about what is your nature of the contribution to the group over five years? How has that changed?

When you think about conversations your group had at the beginning of the project and those that took place at the end of the project, do you recall any differences?

- From my perception in the project as documenter, my understanding is that one of the things is to look at the student's works.

Can you tell me about how the role of the students' work in your study group and in your classroom practices?

Could you give me an example of each? Could you give me an example of a particular student work?

With example from meeting:

- Why did you choose this work to share?

- What did you learn from other teachers during this discussion?
- Do you think that this helped other teachers to learn? How?

Did your group have conversations about student work?
If so, did those conversations change over time?

Did your group have conversations about developing teaching materials?
If so, did those conversations change over time?

2. What did you learn from that bi-weekly study group meeting? Could you please give one or more examples of something you learned? What kind of knowledge and skill did you acquire?

(Note: analysis of students' work and students' ideas, use of teaching and learning materials)

Stimulated recall based on study group video: What were you thinking during this time?

While you participated in the study group, did you change the way you collected or analyzed student work?

Did you change the way you critiqued teaching materials?

What about the way you used teaching materials?

During that time did you sometimes develop your own teaching materials? If so, did participation in the study group affect the way you did that?

Teachers' self-reflections

Related to RQ 2: How did the teachers' personal knowledge and reasoning about teaching change over time?

- a) How did the two teachers whom I studied change their approaches to collecting and analyzing students' work over time?
- b) How did the two teachers whom I studied change the way they critiqued, used, and developed teaching materials?

3. Can you talk about what kinds of learning occurred to you in the study group?
How do you learn from these discussions?
How have the discussions and your participation changed since you joined the group?

4. What kinds of things you have learned, particularly in the sound unit?
(Make list here and track back, eg., assessment, students' learning, etc.,)
Can you tell about more? Can you give me an example of student work?
Or example of work from other students?
5. Did learning in this study group support your teaching practice? If so, how
does that learning affect your practice? Could you provide examples?

When you compare your knowledge at the beginning of the project with your knowledge at the end of the project, do you see any changes?

Teachers' self-reports

Related to RQ 3: How did the teachers' classroom practice change over time?

- a) How did the classroom practice of the two teachers whom I studied
change with respect to the kinds of work they asked students to do, the
way they solicited ideas from their students, and the way they responded
to students' ideas?
- b) How did the classroom practice of the two teachers whom I studied
change with respect to the nature of teaching materials they used and the
ways they used those materials?
6. What about changes in your classroom practice? If someone had
observed you in your classroom at the beginning of the project and again
at the end, what differences might they have seen?
Would they have seen differences in any of the following –
What you asked students to do?
How you solicited ideas from students?
How students responded to you?

If someone observed your classroom at the beginning and at the end of
the project, would your classroom have looked different to them?
Would the ways that students have engaged with teaching materials have
changed?

7. What did not change while you participated in the study group?
Why didn't that change?
How do you feel about the fact that this particular part of your teaching
did not change? Is there anything you learned you have been prevented from
doing in the classroom? OR
What is different about your teaching now compare to five years ago?

Could you provide me a specific example? Or could you give me an episode about your teaching?

9. Use the video of teaching and ask:

What do you notice about those examples?

Are there things that you think about more as a result of participating in study group? What are they?

What did you look for now and what you did not before?

What are the strength and weakness of materials you using for the sound unit?

Have you changed them? Has the way of participant change the way you use materials?

10. Is there anything else you would like to say? Any suggestions you would like to give for the project to make it better?

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