A SCHOOL-BASED PROFESSIONAL DEVELOPMENT PROGRAM FOR PRIMARY SCHOOL TEACHERS

by

LU PIEN CHENG

(Under the direction of Jeremy Kilpatrick)

ABSTRACT

The goal of this study was to investigate primary school teachers' experiences in a school-based professional development program using a laboratory class cycle as they shaped the program collectively with the professional developer. The teachers' and administrator's conceptions of change in teaching and in their team as a result of the program were also studied. The study was motivated by research on professional development and on teacher learning that calls for the use of design-based research methodology.

Six teachers in the professional development program and their administrator in a primary school in the southeastern United States participated in the study. All the teachers were interviewed concerning their experiences of the program, and their mathematics lessons were observed at the end of each cycle of laboratory classes. Each participant was interviewed 3 months after the end of the program to recall and reflect on her experiences in the program. A grounded theory approach and constant comparative analysis were used.

The study revealed how the teachers' experiences varied as they shaped the program collectively with the professional developer. The teachers' participation in the program changed as they planned and conducted the different activities in the program, including weekly meetings, demonstration lessons, and the laboratory classes. Opportunities for the teachers to experiment with different teaching approaches were important in shaping the changes in their teaching, learning, and team functioning. The laboratory class cycle appears to be a viable model for teachers to incorporate professional development into their day-to-day teaching practices.

INDEX WORDS: School-based professional development, laboratory class cycle, teachers' beliefs, teacher change, team development

A SCHOOL-BASED PROFESSIONAL DEVELOPMENT PROGRAM FOR PRIMARY SCHOOL TEACHERS

by

LU PIEN CHENG

B.S.C., Nanyang Technological University, Singapore, 1996

M.Sc., National University of Singapore, Singapore, 1999

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPY

ATHENS, GEORGIA

2006

A SCHOOL-BASED PROFESSIONAL DEVELOPMENT PROGRAM FOR PRIMARY SCHOOL TEACHERS

by

LU PIEN CHENG

Major Professor: Jeremy Kilpatrick

Committee: Denise Mewborn
Sybilla Beckmann

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
August 2006

DEDICATION

I would like to dedicate this dissertation to my husband, Seow Chong, my parents, my parents-in-law, my two brothers − Sherwin and San Chye, − and Joyce.

To Seow Chong – thank you for flying over 10,000 miles to support, and encouraged me throughout this process. You are a great source of support and inspiration.

To my father and mother – thank you for providing me a warm and supportive environment where I could discover and develop my passion, dreams, and potential in life. This is dedicated to you for the dreams that you have helped me accomplish.

To my brothers Sherwin and San Chye, your support over the years has been invaluable, and I thank you for always being there for me when I needed support and advice.

To my mother-in-law – thank you for seeing me through the last three months of my doctoral studies. Your presence helped me cope with the challenges of motherhood and many sleepless nights.

To my sister-in-law Joyce – thank you for your constant prayers.

ACKNOWLEDGEMENTS

This material is based in part on work supported by Center for Proficiency in Teaching Mathematics and the National Science Foundation under Grant No. 0119790. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

My four years at the University of Georgia were sponsored by National Institute of Education, Singapore. The financial award provided me the time and money to complete this work, and I am extremely grateful for their support. They also made it possible for me to complete my dissertation at a comfortable pace while I faced new challenges as a graduate student and mother.

I would like to extend my gratitude to my major professor, Jeremy Kilpatrick, for supporting me in my dissertation efforts and for his encouragement throughout my graduate work. I am especially grateful to Jeremy for taking the effort and time to read and edit my dissertation drafts with care and patience. I also appreciated his effort in including me in the Center for Proficiency in Mathematics project, which made this dissertation possible.

I would also like to thank my other committee members, Denise Mewborn and Sybilla Beckmann. I am grateful to Denise for guiding me in a research process as I participated in her Learning to Teach Elementary School Teachers research project. To Sybilla, I am greatly inspired by her deep insight into Singapore's textbooks and curriculum, and her mathematical knowledge in elementary school mathematics. I am also very grateful to her for being there for me when I experienced difficult moments in my pregnancy while writing this dissertation. Her

support and encouragement gave me strength and insight into my new roles as a mother and a researcher.

To the six teachers and their assistant principal who took an interest in my work and provided me their time after school for the intensive interviews, I express my thanks. They have taught me many valuable things and have affected me personally.

I extend my special thanks to Ho Kyoung, my co-researcher, for being present for every accomplishment and milestone along the professional development and research work. I also thank Tanya Cofer, who saw me through the first year of the professional development program and provided such wonderful support for the program in that year.

I extend special thanks to all my family members for encouraging me to pursue this degree and keeping me in their prayers.

To Professor Lee Peng Yee, I thank you for guiding me in undergraduate studies and asking me in 1994, “What do you foresee yourself to be 10 years later?”. You have taught me to plan ahead in life.

To my first-born, Ching Han, who grew with my dissertation and gave me renewed strength, and more courage to continue my life ahead.

Lastly, I would like to thank my husband, who helps make all challenges surmountable.

TABLE OF CONTENTS

Page

APPENDIX

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

THE PROBLEM AND ITS BACKGROUND

This report concerns a study of six primary school teachers, and their school administrator's experiences in a school-based professional development program using a laboratory class in a Southern state in the United States. I begin this chapter by presenting the background for the study, followed by the problem statement and research questions. Interviewing and observing the teachers provided me with some insight into how and what they had learned and how they changed because of their professional development experiences.

Background

Teachers' and Administrator's Conceptions of Change

Educational reform movements in the United States and around the world are setting ambitious goals for student learning. In the United States, visions of reform have been articulated by many organizations (National Council of Teachers of Mathematics [NCTM], 1991, 2000). "Many factors contribute to achieving these goals. However, the changes in classroom practices demanded by the reform visions ultimately rely on teachers" (Borko, 2004, p. 3). In current reforms, teachers are asked to make ambitious and complex changes, but such changes require more than being shown how to implement effective practices (Franke, Carpenter, Levi, & Fennema, 2001). Rather, teachers must engage in experimentation to "discover and develop practices that embody

central values and principles" (Little, 1993, p. 133) and to become what Giroux (1988) calls the teacher as intellectual. "The reforms require that teachers reinvent their practices so that teaching and learning are interdependent, not separate functions" (Franke et al., p. 654). Teachers need to be problem posers, problem solvers, researchers, and intellectuals engaged in unraveling the teaching and learning process both for themselves and for their students (Lieberman & Miller, 1990). Achieving this vision requires "coming to understand what it means for a teacher to engage in ongoing learning, and then how professional development and the development of professional community can contribute to that end" (Franke et al., p. 654). Although effective professional development programs are recognized as indispensable for high-quality teaching, the professional development currently available to teachers is inadequate (Borko, 2004) and does not take into account what we know about how teachers learn (Ball & Cohen, 1999; Putnam & Borko, 1997).

> Indeed, the field of research on teacher learning is relatively young….We have evidence that professional development can lead to improvements in instructional practices and student learning. We are only beginning to learn, however, about exactly what and how teachers learn from professional development or about the impact of teacher change on student outcomes. (Borko, 2004, p. 3)

This study examined teacher change as a group of teachers engaged in observation and experimentation in six cycles of laboratory classes. What and how the teachers learned from the professional development and its impact on teacher change were also examined as the teachers and professional developer shaped the program collectively throughout the program.

The present study adds to the existing knowledge on professional development and its impact on teacher learning and change. Teacher change cannot be studied apart

from its context. Learning should be viewed as a process of enculturation into the practice of wider society (Cobb, 1994). As situative theorists Putnam and Borko (2000) posit:

> The physical and social contexts in which an activity takes place are an integral part of the activity, and…the activity is an integral part of the learning that takes place within it. How a person learns a particular set of knowledge and skills, and the situation in which a person learns, become a fundamental part of what is learned. (p. 4)

Zeichner and Gore (1990) suggested that the study of individual teachers and their schools reveals a critical gap in our understanding of change. By studying an administrator's conceptions of teachers' change, I wanted to provide another perspective of how teachers learn and change as a result of a professional development program, how teachers respond to the organizational conditions of the school, and how teachers working individually and collaboratively affect the school context. Hence, this study also answers a call by Richardson (1996) for research between individual teachers and their schools to provide important knowledge in our quest for a better understanding of teacher change. Another purpose of this study was to describe and understand various aspects of the teachers as a team and the team's growth with the professional development program. An interpretivist position allowed me to focus on the social and cultural aspects of these teachers' experiences as a team.

The Teachers' Experiences

Borko (2004) gave an overview of what had been done in effective professional development programs and of their impact on teacher learning. She identified four key components of any professional development system: namely, the professional development program, the teachers in the system, the facilitator, and the context in which

the program occurs. She saw research on professional development as having three phases. Phase 1 research activities focus on an individual professional development program, "teachers as learners, and the relationships between these two elements of the system" (p. 4). Phase 2 research focuses on a single professional development program enacted by more than one facilitator at more than one site, exploring the relationships among facilitators, the professional development program, and teachers as learners. Phase 3 involves comparing multiple professional development programs, each enacted at multiple sites, and researchers study the relationships among all four elements of the system. Ball (1995) encouraged professional developers in mathematics (and mathematics education researchers) to take an inquiry stance to identify elements of effective professional development, experimenting to discover what can work and what teachers can actually take from a program. To take on Ball's inquiry stance, we must uncover the relationships among professional development design, individual teacher characteristics, and actual outcomes.

Farmer, Gerretson, and Lassak (2003) described some of the general complexities of designing professional development and relate how their design emerged from negotiations in their design team. Borko (2004) also called for design experiments, with their repeated cycles of design, enactment, and redesign for investigations of Phase 1 research on professional development programs (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Design-Based Research Collective, 2003). Design-based research, which blends empirical educational research with the theory-driven design of learning environments, is an important methodology for understanding how, when, and why

educational innovations work in practice (Design-Based Research Collective) and is an ideal method to take on Ball's (1995) inquiry stance.

> Currently, design-based research communicates this knowledge in many forms, including narratives of planned and enacted instruction (Linn & Hsi, 2000),…and design patterns abstracted from one or more settings describing how a designed innovation interacts with settings and evolves. (Design-Based Research Collective, 2003, p. 8)

The present study was design-based and used qualitative research methods. It was "at its heart, an attempt to combine the intentional design of learning environments with the empirical exploration of our understanding of those environments and how they interact with individuals" (Hoadley, 2004, p. 205). Interactions between partners reveal crucial practices that can lead to insights about what occurs when we orchestrate complex interventions in messy settings (Cobb, 2001). This effort to design, use, and do research on professional development activities in a real setting may help researchers and designers of professional development programs understand the demands placed on the design of professional development using laboratory classes. By sharing the teachers' experiences, I was able to "inquire more broadly into the nature of learning in a complex system and to refine generative or predictive theories" (Design-Based Research Collective, p. 7).

By studying what was being designed, the rationale for the design, and how the design evolved, I documented the intervention that included relevant but unanticipated consequences of the design (Hoadley, 2004). Also, by linking the process of enactment to outcomes, I attempted to generate knowledge that would directly apply to educational practice and explored possibilities for creating novel learning and teaching environments (Design-Based Research Collective, 2003). To provide deeper insight into the local

dynamics of learning and teaching that occurred during the program, I produced detailed descriptions of the context, the guiding and emerging theory, the design features of the intervention, and the impact of those features on participation and learning.

> As researchers we inherently become a part of, and help to shape, the settings in which we study teachers' learning. In examining her own work with children, Ball (1997) found it was impossible to determine how, and the extent to which, the understandings and insights expressed by children during interactions with her were supported by her implicit (unconscious) guiding and structuring….Ball suggested that this unavoidable influence means we must recast the question of what children "really know," asking instead what they can do and how they think in particular contexts. (Putnam & Borko, 2000, p. 13)

Similarly, researchers must be particularly attentive to the support and guidance that they provide as they try to understand what teachers know and how they learn. This attentiveness is especially important when an individual takes on the multiple roles of researcher, teacher, and teacher of teachers, and one must be careful to consider one's role of influencing and shaping the phenomena one studies (Putnam & Borko, 2000). When the researcher is a participant-observer who intervenes deliberately in the settings he or she studies,

> it is incumbent on the researcher to describe and monitor ways that his or her own agenda is responsible for the results. A researcher may produce a successful outcome due to a wonderful theory or an effective treatment or through unintended aspects of her or his own participation in the situation. (Hoadley, 2004, p. 205)

In this report, I document my perspective as well as the plausibly relevant intervention strategies used by the participants I observed and by me. "By documenting what it is like to try to make learning happen from the point of view of those who foster learning, we may be edging toward a more usable, and hence more valid, form of research" (Hoadley, 2004, p. 205).

> Viewing both the design of an intervention and its specific enactments as objects of research can produce robust explanations for innovative practice and provide principles that can be localized for others to apply in new settings….Grounding in the needs, constraints, and interactions of local practice can provide a lens for understanding how theoretical claims about teaching and learning can be transformed into effective learning in educational settings. (Design-Based Research Collective, 2003, p. 8)

The ultimate goal of this study was to identify what factors were most relevant to this particular intervention and to communicate results that appropriately contextualized them. I sought to conduct research that would lead to locally grounded theories and findings, and to uncover just how localized or generalizable research findings are.

Problem Statement and Research Questions

Using qualitative design-based research methodology within an interpretive theoretical frame, I interviewed and observed six Grade 2 primary school teachers and their administrator in a primary school. The teachers participated in a school-based professional development program employing laboratory classes that involved planning, observing, and critiquing mathematics lessons as a team. Altogether, the teachers and I as the professional developer shaped and ran six cycles of laboratory classes during one academic year. The research questions that guided this study were as follows:

1. What are the teachers' experiences of a professional development program that includes laboratory classes as they shape the design of the program collectively with the professional developer? Why and how does the professional development program evolve?

2. What are the teachers' conceptions of change in their teaching as a result of this school-based professional development experience? How do the individual teachers change as a function of their experience?

3. What are the teachers' conceptions of change as a team as a result of this school-based professional development experience?

4. What is the administrator's conception of the teachers' and the team's change?

To address these questions, I provide a conceptual framework that helped me think about professional development and an overview of the relevant literature (chapter 2), detail the theory and methodology used in the study (chapter 3), describe the professional development program (chapter 4), and present the findings (chapters 5 to 8). In chapter 9, I discuss the implications of this study and suggest some future directions for research.

CHAPTER 2

LITERATURE REVIEW

This study examined teachers' experiences in a school-based professional development program using a laboratory class cycle. Using these foci, I describe the framework of the professional development cycle in this study. I then discuss research focused on teachers' beliefs, teacher change, and team development.

Professional Development Cycle

The professional development program in this study sought to aid teachers in seeing themselves as ongoing learners, being reflective in their practices, and continually evaluating and adapting their classroom practices to implement new reforms or curricula. The professional development design process for mathematics and science education reform (Loucks-Horsley, Hewson, Love, & Stiles, 1998, p. 17) in Figure 1 was used as the overall framework for this professional development program. The framework takes professional development as a dynamic decision-making process rather than as a static set of models and as evolving and changing over time.

At the center of the framework is a planning sequence incorporating goal setting, planning, doing, and reflecting. The circles represent inputs into both goal planning and planning that can help professional developers make informed decisions. The teachers and the professional developer bring a set of beliefs and knowledge to the program.

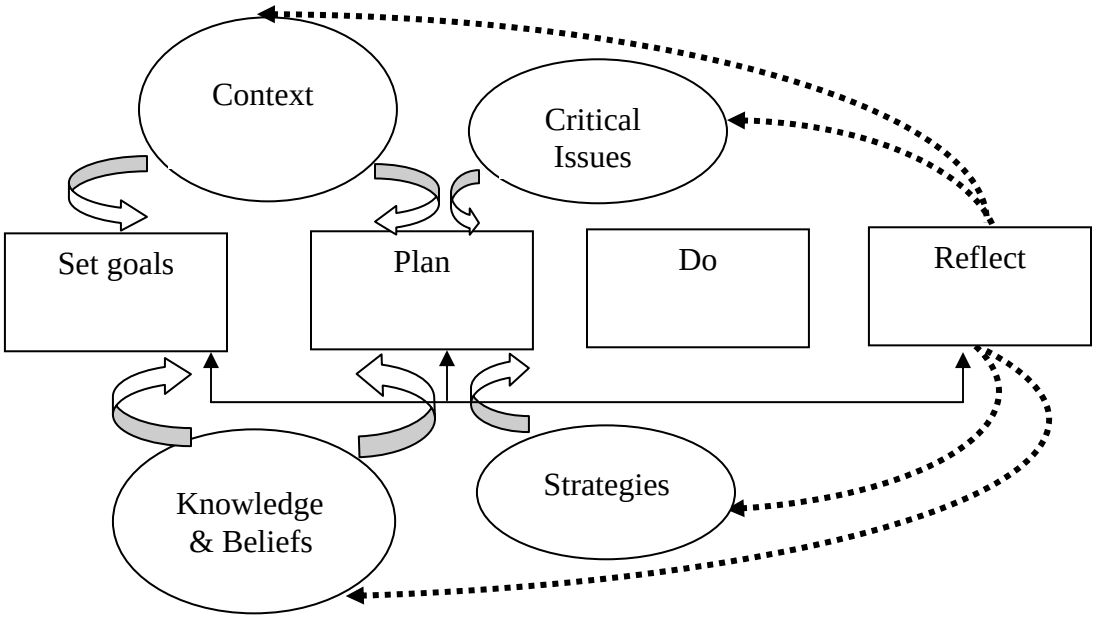


Figure 1. Professional development design process for mathematics and science education reform. From Loucks-Horsley, Hewson, Love, & Stiles, 1998, p. 17. Copyright 1998 by Corbin Press. Reprinted with permission.

The design framework delineated these beliefs and knowledge as a critical input into goal setting and planning. Another important input for the designer to consider is a repertoire of strategies or combination of strategies to form a unique design for the program. Strategies support a process of learning that unfolds over time. There is no prescription as to which strategies are right for which situations. One guide to selecting strategies is to know its primary purpose and to match it to the changing needs of participating teachers. As professional developers design a program, they are influenced by their vision of what the subject-matter teaching, learning, and professional development should look like, and also the context in which the program is to be conducted.

Professional development designers face some common issues critical to the success of programs. Some of the issues are equity and diversity, professional culture, leadership, capacity building for sustainability, scaling up, public support, effective use

of standards and frameworks, time for professional development, and evaluation and assessment (Loucks-Hosley et al., 1998). Proactive planners anticipate these issues and begin grappling with them in the initial design phase.

Before beginning, designers need a structure for planning and decision making. They need to answer questions such as, who makes the decisions, and how do the decisions get made? With a structure for decision making in place, designers set goals for the professional development program. Once goals are set, they begin to sketch out their design, bearing in mind the context, critical issues, knowledge, beliefs, and strategies. They then move to the actual implementation of their plan. In this phase, they draw on their skills as change facilitators (Fullan, 1991; Hord, Rutherford, Huling-Austin, & Hall, 1987; Loucks-Horsley et al., 1998). As the designers implement and monitor the program, they discover what works and what does not using a variety of data sources. They then revise their programs. The inputs do not remain static over time, and the programs change because designers figure out a better way or because conditions change, sometimes as a direct consequence of the program.

Framework of the Professional Development Program[1]

Teachers of mathematics struggle to make sense of the development of their students' mathematical thinking and how that relates to their instructional decisions. For that struggle, teachers need subject-matter knowledge, knowledge of students, and opportunities to observe their colleagues. Teachers can learn in the context of their

Note: An earlier version of this section appeared in Cheng and Ko (2005).

practice about the teaching and learning of mathematics and can become engaged in what Richardson (1990) terms “practical inquiry.” Smith (2000) stated:

> Situating teacher learning in practice, teachers have the opportunity to develop knowledge central to teaching by engaging in activities that are at the heart of teachers’ daily work. In this way, teachers develop knowledge through analysis of real situations. (p. 2)

That is, school-based professional development can focus more than professional development outside of school on specific students’ needs and immediate classroom application (Truscott & Truscott, 2004).

The professional development in the present study was a reform type of professional development. Reform types “differ from traditional professional development in several aspects. In particular, reform activities often take place during the regular school day” (Garet, Porter, Desimone, Birman, & Yoon, 2001, p. 920) and make it easier to respond to how teachers learn (Ball, 1996). Also, they may have more influence on changing teaching practice (Darling-Hammond & Sclan, 1996; Darling-Hammond, Wise, & Klein, 1995). Demulder and Rigsby (2003) conducted a school-based program that affected teachers’ personal and professional growth, thus transforming their classroom practices. Demulder and Rigsby argued that the program worked well for these teachers, and they attributed the personal and professional transformation of the teachers to both the teachers’ experiences in the program and to their experience of the program as a whole. Educators have found “opportunities to shift the emphasis of school-based consultation from addressing problems toward developing consultee skills, knowledge, and confidence toward a more positive and preventive model” (Truscott & Truscott, 2004, p. 51). Therefore, if researchers can identify characteristics of effective reform professional development programs, specific desirable

ways of conducting professional development can be recommended to mathematics educators.

Laboratories have been used in scientific fields such as medicine, chemistry, and physics to conduct experiments and test out new ideas. In the field of mathematics education, classes have been set up as laboratories for studying the teaching of mathematics and have been used in professional development programs for teachers and for professional developers (West & Curcio, 2004). In the present study, I employed two versions of a laboratory class cycle in a real school setting "centered in the critical activities of the profession, that is, in and about the practices of teaching and learning" (Ball & Cohen, 1999, p. 13). The laboratory class cycle used in this professional development was a type of reform activity that "situates the professional education of teachers in practice" (Smith, 2000, p. 2) and aims at providing a connected contextualized set of experiences on which teachers can reflect more critically about their beliefs and practices. According to Smith, the work of teaching should be used to create opportunities for critique, inquiry, and investigation, and the materials for the laboratory class cycle aimed to achieve that purpose. My concept of laboratory class cycle is heavily influenced by the Center for Proficiency in Teaching Mathematics and by Deborah Ball in particular. Like Deborah Ball, who used a laboratory class for professional development, I see the laboratory class as an opportunity to try out different teaching approaches and a professional development design with teachers and students. As a professional developer, I do not view myself as the expert. Rather, teachers and I have conversations about teaching, and we engage in experimentation together. This stance makes it less threatening for teachers to learn and to cope with change.

Garet et al. (2001) characterize professional development activities in terms of core and structural features. The three core features are content focus, active learning, and coherence. The three structural features are activity (traditional versus reform) type, duration, and collective participation. They reported that reform activities have slightly more positive outcomes when all the design features and quality characteristics in their model are included. I planned the professional development program around the three core features and the three structural features as discussed below.

Core Features

The professional development program was grounded in mathematics knowledge for teaching. The teachers were offered ample opportunities "to construct or reconstruct their knowledge of mathematics so that they had a foundation on which to build a practice that requires deep and flexible use of mathematics" (Smith, 2000, p. 12). The use of questioning and students' explanations to guide classroom instructions were modeled for the teachers to help them improve their understanding of how children learn, and how they think. Teaching ideas from professional journals were also discussed and tried out in the laboratory class cycles to help the teachers improve students' performance in basic skills

The characteristics of the laboratory class cycle used in the professional development program in the present study required the teachers to become actively engaged in meaningful discussion, planning, and practice. As the professional developer, I planned the laboratory class cycle together with the teachers. I engaged them in reflective discussions about the goals of the lesson, tasks employed, teaching strategies, and student learning after they had observed me conduct a lesson. Throughout this

professional development program, the teachers were actively engaged in linking the ideas introduced during the professional development experiences to their teaching context.

A third core feature of the professional development program was the extent to which the activities were part of a coherent program of teacher learning. The content and pedagogy of activities were aligned with national, state, and local frameworks, standards, and assessments. The teachers were assisted in deciding what to teach and how to teach it. Multiple sources were used to assist them; for example, they were given professional literature and preservice education materials. The reform activities used in the professional development were also developed around the teachers' records of practice.

Structural Features

The laboratory class cycle used in this study was based on the three structural features. The reform activities, which included a laboratory class cycle conducted for teachers teaching the same grade level in the same school, took place over 2 years during the regular school day and during the teachers' common planning time. These teachers had many opportunities to work together. They shared the same curriculum, and that offered a common platform for the group to discuss concepts, skills, and problems that arose during their professional development experiences. Also, by focusing on teachers in the same school and at the same grade level, the program contributed to a shared professional culture. The teachers developed a common understanding of instructional goals, methods, problems, and solutions. The goals of the activities conducted during the common planning time included in-depth discussion of content, students' conceptions

and misconceptions, pedagogical strategies, planning new activities, and obtaining feedback on the results of those activities.

Teachers' Beliefs

The notion of beliefs in this report refers to Green's (1971) & Rokeach's (1960) views that a belief system comprises permeable mental structures that are dynamic in nature, undergoing change and restructuring as individuals evaluate their beliefs against their experiences. Beliefs, whatever their source, are related to one another, forming systems in which related beliefs are connected (Rokeach, 1960). Thompson (1992) viewed conceptions as a more general mental structure, encompassing beliefs, meanings, conceptions, propositions, rules, mental images, and preferences in addition to the notion of belief system. Teachers hold beliefs and conceptions about mathematics, about the rules in effect while teaching and learning the subject, and more. Teachers' larger belief systems help them interpret and simplify classroom life, identify relevant goals, and orient themselves to particular problem situations (Calderhead, 1996). That is, beliefs play a role in decision making, although there are other elements as well (Bandura, 1986). Research studies have shown that experienced teachers' attempts to learn to teach in new ways are highly influenced by what they already know and believe about teaching, learning, and learners (Borko & Putnam, 1996). They may be influenced by guiding images from past events that created intuitive screens through which new information is filtered. Those conceptions may also act as a filter for what they learn, which consequently affects their knowledge.

> Teachers who sign up for a professional development experience expect to learn about new theories of learning or new instructional strategies. They do not expect to have their knowledge held suspect or their previous practices questioned. And admitting that you have done the wrong thing in the past or do not know the subject matter you teach is unsettling. Yet, professional development designed to help teachers acquire new professional knowledge, especially subject matter knowledge, can often involve just that. (Wilson & Berne, 1999, p. 200)

Hence, tensions may arise during a professional development program as a result of differing expectations and beliefs of participants. All professional development programs confront this challenge. Teachers hold clear ideas of what kinds of knowledge are most helpful and relevant to their ongoing learning when they arrive at a professional development program. They welcome new activities, new curricula, new instructional tools and tricks, but very seldom do they come to a professional development program assuming that their views of knowledge or subject matter or students need to change (Wilson & Berne). Thus, one challenge in professional development involves bridging the gap between what the teachers want and expect and what the professional development has as its goals. "And because one is working with adults, and their need for new techniques is genuine, most ongoing, high-quality professional development entails a constant negotiation: of content, of purpose, of control, of discourse style" (p. 199).

Teacher Change

Richardson and Placier (2001) characterized mechanisms for affecting teacher change in individual teachers into three groups: voluntary or naturalistic changes, stages of development, and teacher education for the preparation of teachers or staff development programs for the improvement of teaching. I examine the literature on

teacher change as a result of professional development programs in a single site. Historically, teacher change was directly linked with planned professional development activities (Clarke & Hollingsworth, 1994). During the Post-Depression era, professional development became a major enterprise in education (Howey & Vaughan, 1983), and professional development was based on a training paradigm that implied that teachers were deficit in skills and knowledge (Guskey, 1986). This paradigm resulted in one-shot workshops aimed at teacher mastery of prescribed skills and knowledge in most professional development. Guskey (1986), Howey and Joyce (1978), McLaughlin and Marsh (1978), and Wood and Thompson (1980) highlighted the ineffectiveness of professional development that took this deficit approach. Evidence of the failure of one-shot professional development was also provided by Fullan (1991), Johnson (1989), and Lovitt and Clarke (1988). The ineffectiveness of attempts to effect teacher change through professional development programs based on the training-mastery model provided the impetus for research related to the process of teacher change and professional development in recent years. A significant outcome of this research has been the shift in focus "from programs that change teachers to teachers as active learners shaping their professional growth through reflective participation in professional development program and in practice" (Clarke & Hollingsworth, 2002, p. 948).

Two constructs have dominated the literature on change in professional development over the past several years: beliefs (Richardson, 1996) and reflective practices (Schön, 1983). "Beliefs are examined as factors that interact with the change process and affect outcomes and are also examined as outcomes that are affected by change processes" (Richardson & Placier, 2001, p. 913). The growth in reflective practice

was advanced by the acceptance of Schön's conception of the reflective practitioner that began to drive many professional development programs (Clift, Houston, & Pugach, 1990; Grimmett & Erickson, 1988). Challenges faced by researchers have been to develop ways to determine whether teachers are reflective and ways to access intervention results in reflection. Different teachers respond quite differently to the particular approaches taken in professional development. As such, professional developers "should be aware whether their support of a particular approach to professional development is a function of the professional developers' own orientation to change" (Richardson & Placier, p. 921).

More recently, Johnson (1996) presented a case for reconceptualizing teacher professional development as "opportunities for learning" to enable it to be "embedded into the on-going work of the school" (p. 12). This reconceptualization led to the need to contextualize teaching and teacher development and the use of cases and video cases (Clarke & Hollingsworth, 2002), as a means to situate the professional development of teachers in realistic contexts.

> While authors use different terms to describe conceptions of teacher change, it appears that fundamental to "new" perspectives on teacher change and teacher professional development that have learning as their core are views of "teachers as learners" and "schools as learning communities." (p. 949)

Borko (2004) drew upon research conducted on a small number of high-quality professional development programs at a single site and summarized major themes and patterns of findings on teacher change as a direct effect of those programs. She used the individual and the group as two units of analysis to describe those findings.

Research on individual teacher change revealed that high-quality professional development programs can help teachers deepen their knowledge and transform their

teaching but that meaningful learning is a slow and uncertain process for teachers. Research using the individual as the unit of analysis also revealed that teacher knowledge (subject matter knowledge for teaching, understanding of student thinking) and instructional practices could change through intensive programs. When teachers participate in professional development programs, some teachers change more than others (Fennema et al. 1996; Franke, Carpenter, Levi & Fennema, 2001; Knapp & Peterson, 1995), and some elements of teacher' knowledge and practice are more easily changed than others. For example, it appears more difficult for teachers to use what they hear from students to make instructional decisions than to incorporate strategies for eliciting students' thinking into their teaching (Franke et al.; Franke & Kazemi, 2001).

Using the group as the unit of analysis, research provides evidence that "strong professional learning communities can foster teacher learning and instructional improvement" (Little, 2002, p. 936). The Community of Teacher Learners project (Grossman, Wineburg, & Woolworth, 2001; Thomas, Wineburg, Grossman, Myhre, & Woolworth, 1998) and the QUASAR (Quantitative Understanding: Amplifying Student Achievement and Reasoning) project (Lane & Silver, 1994; Smith, 1997; Stein, Silver, & Smith, 1998; Stein, Smith, & Silver, 1999) illustrate this finding. These two projects revealed, however, that the development of teacher communities is difficult and time-consuming (Grossman et al.; Stein et al., 1999).

One of the most important features of a successful learning community is the establishment of norms that promote supportive yet challenging conversations in the community about teaching. Although teachers generally welcome the opportunity to discuss ideas and materials related to their work, and conversations in professional

settings are easily fostered, discussions that support a critical examination of teaching are relatively rare (Ball, 1994; McLaughlin & Talbert, 2001; Putnam & Borko, 1997; Wilson & Berne, 1999). For teachers to collectively explore ways to improve their teaching and support one another as they work to transform their practice, professional developers must foster such discussions and help the teachers establish trust, develop communication norms that enable critical dialogue, and maintain a balance between respecting individual community members and critically analyzing issues in their teaching (Frykholm, 1998; Seago, 2004). Individual professional development programs that are conducted at a single site where researchers typically study the program, teachers as learners, and the relationships between the two focus on a limited number of subject areas and grade levels. There is a need for research of this nature in some subject areas and at some grade levels more than others, "most notably elementary and middle school mathematics, science, and literacy" (Borko, 2004, p. 12).

In this study, I viewed teacher learning as an individual as well as a social learning process. I also viewed teacher learning as part of teacher change. I examined teachers' conceptions of their change in learning and teaching using individual teachers as the unit of analysis. I also examined the teachers' experiences in a professional development program and their conception of change as a team, where a team of Grade 2 teachers was the unit of analysis.

Individual Teacher Learning

"Generativity refers to the individuals' abilities to continue to add their understanding" (Franke et al., 2001, p. 654). Teacher learning and knowledge become generative when the learner sees the need to integrate new knowledge with existing

knowledge in light of new knowledge (Franke et al.). Research using the individual teacher as the unit of analysis indicates that meaningful learning is a slow and uncertain process for teachers (Borko, 2004, p. 6). I view individual teacher learning as having three features: (a) generativity; (b) structured so that the knowledge is rich in connections; (c) constructed, self-created, and continually changing (Franke et al.).

Learning As a Social Process

"Innovation or intelligence arises from systematic features of a whole community or organization. Knowledge creation is not primarily a matter of creative individuals, but instead requires fundamental reorganization of the practices of a whole community" (Paavola, Lipponen, & Hakkarainen, 2004, pp. 564–565). One of the models of innovative knowledge communities is Engeström's (2001) model of expansive learning. The main focus is on expanding and transforming activity systems and developing practices to solve disturbances and contractions (Paavola et al., p. 568). In this model, knowledge creation is fundamentally a social process. That is, social interaction provides an essential cognitive resource for human cognitive accomplishment, and knowledge is always embedded in practices. The model describes how collaboration is organized for developing shared practices and activity systems in an innovative way. Interaction takes place through these activities, and the focus is on developing shared practices and activities through collaborative efforts within long-term processes. According to Engeström (2001), "in important transformation of our personal lives and organizational practices, we must learn new forms of activity which are not there yet, and in attempting to do so, standard theories of learning are not enough" (pp. 137–139).

Engeström (1997) emphasizes “the element of thirdness (i.e. mediation) in expansive learning” (pp. 221–222), and the starting point of the expansive learning cycle begins with questioning and criticism of existing practices (Engeström, 1999). Engeström’s (1999) model is based on a learning cycle consisting of seven stages. First, individual participants question and criticize certain existing practices. Second, they analyze the situation. Third, they engage in modeling a new solution to the problematic situation. Fourth, they examine the new model to explore practical action and applications. Fifth, they implement the new model to explore practical action, and applications. Sixth, they reflect on and evaluate the process. Finally, they engage in consolidating the new practice in its new form. Through this expansive cycle, participants reconceptualize their own activity system in relation to their shared objects of activity; the activity system is transformed; and new motives and objects for the activity system is created. “The cycles of expansive learning do not necessarily follow any fixed order” (Paavola et al. 2004, p. 560). The laboratory class cycle used in the professional development program in the present study include all the seven stages described above.

Engeström’s (2001) model of expansive learning is one of the models of innovative knowledge communities that has been used to guide schools as organizations, or schools as teacher communities, in developing similar practices. For example, Engeström and his colleagues (Engeström, Engeström, & Kärkkäinen, 1995) pursued a change-laboratory intervention with teacher communities in middle school by focusing on making visible to the participants constraints that hinder pedagogical transformation of a school, and on helping them overcome the constraints. “The laboratory helps them to recognize developmental challenges to the activity system of the school, collectively

creating a vision of the school's future and implementing a series of practical changes" (Paavola et al., 2004, p. 571).

Why Teachers Change or Do Not Change

> Change is necessary because high proportions of students are alienated, performing poorly or below par or dropping out. Change is needed because many teachers are frustrated, bored, and burnt out. Good change processes that foster sustained professional development over one's career and lead to students' benefits may be one of the few sources of revitalization and satisfaction left for teachers. (Fullan, 2001, p. 71)

Vaughan (1993) fostered teacher change by offering teachers rules for describing behavior. She viewed the degree to which some teachers failed to change as continuum that could be broken into five categories: Either the teacher (a) did not know what to change, (b) did not know how to change, (c) wanted to change but could not change, (d) did not want to change, or (e) did not care about change. Some teachers are motivated to try something new in their classrooms, but they require help in determining exactly what to do and when to do it. These teachers need only some help to begin experimenting in their classrooms. Other teachers are motivated to change but have no experience in doing what needs to be done. That is, they can describe what to do but need to be taught how to do it. Another group of teachers can state the rule for changing and can follow through, but they require environmental support to maintain the new way of behavior. There are some teachers who are unmotivated to change. These teachers require an external source of motivation, for example, increased salary, grants, or stipends based on students' performance. Finally, there are teachers who are unmotivated to change even with environmental support, because there are other more important issues that they have to

attend to. For these teachers, change in the classroom is not the highest priority. Other issues in their lives are more important, and they require counseling and other forms of support.

Team Development

A team is not a merely collection of individuals for improving a school (Rees, 1997). “Teams are mostly selected by the management, have pre-determined goals and therefore rather tight and formal connections within the team” (Krainer, 2003, p. 96). Teams can be formed within the school community depending on the mission to be accomplished. They may assign formal roles to their members, for example, team leader, recorder, timekeeper, and liaison to groups or individuals outside the team. The role of the team leader is a critical one (Burnette, 2002). “The whole (team) becomes greater than the sum of its parts (members)” (Gordon, 2004, p. 181). A real team develops an identity of its own. There is a shift from the traditional emphasis on individualism and competition to cooperation and team success (Gordon). Nontraditional teams focus on shared goals, collaboration, interdependence, and mutual accountability, and some researchers think that the most exciting work in school improvement today is being done by nontraditional teams.

> Most successful teams do not spend an inordinate amount of time in skill training. Rather, continued skill development is based on a combination of experience, feedback from facilitators or critical friends, reflection, and experimentation with new strategies and techniques. (Gordon, p. 184)

An effective team is characterized by a shared identity, a clear focus, and a diversity of people (including individuals who differ in roles, race, ethnicity, content area taught, gender, grade level taught and years of experience). The effective team also has

role clarity, high levels of collaboration, administrative support, effective decision-making strategies, and continuously self-assessment with an eye toward team improvement (Gordon, 2004, p. 186). Effective teams provide a variety of benefits to team members, the school, and students. Team membership gives the members a sense of identity and belonging (Trimble & Miller, 1996). Teams also provide emotional and moral support, dignity, intellectual assistance, and encouragement for teachers (Harris, 2000). Team membership fosters teacher empowerment as it increases teachers' involvement in decision making, facilitates the sharing of concerns and problem solving, improves self-esteem, and reduces isolation among teachers (Burnette, 2002). Teaming also fosters more knowledge about the school curriculum, better coordination of the curriculum, and curriculum integration (McGehee, 2001; Vasudeva & Ryan, 1997). Teaming can also foster critical elements of a professional community that include reflective dialogue, collegiality, a collective focus on student learning, collaboration, and shared norms and values (Gordon). Finally, teacher teaming can lead to stronger relationships between teachers and students (Kew, 2000; Vasudeva & Ryan) and better student discipline. It can also improve classroom practice and student learning with administrative support (Burnette; Trimble & Peterson, 1999). Collaborative teams thus can be powerful vehicles for improving teacher learning and teaching (Vann, 2000).

Teams often fail to reach their potential, however, because team members do not understand or do not support the team's mission. That is especially likely when a team is formed by an administrator without sufficient dialogue with the potential team members or school community. Team failure can also result when individuals do not understand their roles and responsibilities as team members. Incompatibility between the school

culture and team purpose can be another cause of ineffectiveness. Sometimes an inability to manage conflict results in dysfunctional teams, negative conflict, or team members avoiding productive conflict. Other reasons for ineffective teams are that they are not provided sufficient time for collaboration, or that they may not have the resources to fulfill their missions. Staff turnover may also create problems of continuity (Gordon, 2004).

Tuckman and Jenson (1977; see also Rees, 1997, and Spiegel & Torres, 1994), listed five stages of team development: forming, storming, norming, performing, and transforming. The forming stage can be confusing and anxiety-producing as members determine whether they wish to be a part of the team, how they will relate to other team members, and what their role and responsibilities will be. The storming stage is characterized by conflict, as team members assert their individuality, deal with issues, debate the team's goals and norms, and agree on a decision-making process. The norming stage is characterized by the development of trust and collaboration among team members as the team agrees on relationships, roles, responsibilities, processes, and tasks to be accomplished. The team is fully functioning in the performing stage as team members engage in reflective dialogue, consensus building, and self-assessment; identify with the team; and are committed to its mission. In the transforming stage, the team determines whether its mission is complete and celebrates its accomplishments and its members' growth. The team then either decides to adjourn or renew itself by establishing a new mission. The team begins a new cycle again if it reconstitutes and commits to the new mission. In chapter 6, I describe the teachers' change in their instructional practices,

and in chapter 7, I describe the team's development according to the five stages of forming, storming, norming, performing, and transforming.

CHAPTER 3

METHODOLOGY AND RESEARCH DESIGN

I begin this chapter with the perspectives and design I used in the study before providing a brief explanation of the research site and the participants. Next, I provide details of the methodological and procedures for the study. I conclude the chapter by giving an account of my subjectivity in the interpretative frame and discuss the validity of the study and the ethics involved in it. Interpretative analyses and a grounded theory approach were used to generate descriptions of the teachers' experiences of the professional development program and of the teachers' and their administrator's conceptions of change in their learning and teaching as a result of the program.

Theoretical Perspectives

Interpretivist Perspective

Interpretation is "central to both epistemology and ontology, to both knowing and being" (Wilber, 2000, p. 160). Interpretivist researchers are interested in uncovering naturally occurring concerns and meanings with the goal of understanding people's experiences and how they make sense of the world. "Interpretivist knowledge claims reflect the emic (within person) perspective of holistic, contextualized discourse about the meaning in human experience" (Benner, 1994, p. 112). The interpretivist perspective assumes that the complex world of experience can be understood by exploring subjective human experiences, that knowledge is contextually bound (linguistically, historically, and

culturally), and that shared meanings of human experiences must be interpreted to reveal the constitution of those meanings (Schwandt, 1994). To capture individual teacher growth in rich and meaningful dimensions, the present study was framed from the philosophical position of interpretivism. That perspective allowed me to gain a fuller appreciation of the richness and diversity of the participants' experiences, especially in the laboratory classes. "Both the personal and social are always present. People are individuals and need to be understood as such, but they cannot be understood only as individuals. They are always in relation, always in a social context" (Clandinin & Connelly, 2000, p. 2). Interpretivist research "seeks merely to understand…and reads the situation in terms of interaction and community" (Crotty, 1998, p. 113). It has the goal of understanding experience and making connections between the personal and social.

Interactionist Perspective

In this perspective, meanings are elaborated through negotiations whereby the group comes to agree on certain conventions in the interpretations of signs, situations, and behavior. Individual sharing and contribution may add up through interactions to some new ideas that nobody had thought about (Voigt, 1995). Learning occurs indirectly through participating in a culture and the discursive practices of that culture; that is, the process of construction of knowledge is based on interpretations with others within a culture and not in the individual alone. As Pepin (1999) observes,

> For Bauersfeld (1995), and according to interactionism, meanings are generated neither by…individual minds nor are they attributed to some historically founded collective mind of a society, but they are continually constituted in interactions whose patterned character accounts for the relative stability of cultures. (p. 133)

According to Crotty (1998),

> There are many accounts of society that present social settings as definitely structured and offering social actors very clear-cut roles. Negotiated-order theory disputes this view. In this stream of interactionist inquiry, to the contrary, societal arrangements and procedures are considered to be constantly reworked by those who live and work within them. Work settings in which, sometimes on a day-to-day basis, tasks are reassigned, roles exchanged, responsibilities shouldered, and partnerships formed, typify this view of things. In such settings and, indeed, quite broadly within society as a whole, there is an ongoing albeit often tacit, process of negotiation and adjustment of action. Analyzing this process in specific social situations has proved a useful avenue for interactionist inquiry. (p. 77)

I approached the present study informed by this perspective. In this study, there was constant negotiation between the teachers and me, the professional developer, on how the program should be modified to meet their needs. The teachers were constantly adjusting their roles in the program and in their team as they went through the lab classes. In the process, the teachers and I were constantly adjusting our actions in response to the evolution of the program and to each other. According to Crotty, "analyzing this process in…professional development has proved a useful avenue for interactionist inquiry" (p. 77). "Learning is not just an endeavor of the individual mind trying to adapt to an environment nor can it be reduced to a process of enculturation into a pre-established culture" (Cobb & Bausersfeld, 1995, p. 9). In this approach, interactions and development are seen as inseparable rather than auxiliary and helpful factors of development (Bruner, 1985). Knowledge for teaching mathematics is taken as both situated and socially mediated; the individual, team, school, and society are taken as interconnected units. In the present study, knowledge was taken to be mediated by the cultural, social, and historical world.

Design-Based Research

> Design-based research methods focus on designing and exploring the whole range of designed innovations: artifacts as well as less concrete aspects such as activity structures, institutions, scaffolds, and curricula. Importantly, design-based research goes beyond merely designing and testing particular interventions. Interventions embody specific theoretical claims about teaching and learning, and reflect a commitment to understanding the relationships among theory, designed artifacts, and practice. (Design-Based Research Collective, 2003, p. 6)

"Design-based research simultaneously pursues the goals of developing effective learning environments and using environments as natural laboratories to study learning and teaching" (Sandoval & Bell, 2004, p. 200). I adopted design-based research in this study because that methodology allowed me to intertwine design and research, which is especially important for establishing collaborative contexts. Design-based research also involves flexible design revision and capturing social interaction in which participants are not subjects assigned to treatments but instead are treated as co-participants in both the design and analysis (Barab & Squire, 2004). The researcher follows new revelations where they lead, tweaking both the intervention and the data collection methods as the research progresses (Hoadley, 2004). That is, design-based research methods respond to emergent features of the setting. The practitioners and researchers work together to produce meaningful change in contexts of practice. "Such collaboration means that goals and design constraints are drawn from the local context as well as the researcher's agenda, addressing one concern of many reform efforts" (Design-Based Research Collective, 2003, p. 6). In the present study, the participants and I shaped the professional development collectively.

The term *design* in design research does not mean *research* design but rather the design of interventions, including designed technologies, curricular materials, and participation structures.

> Such Design packages (Salomon, 1996) embody conjectures about learning reified in their organization of supports for learning. The study of these embodied conjectures in specific implementations can lead to increased theoretical knowledge about learning by uncovering specific aspects of the instructional context that affect learning. (Sandoval, 2004, p. 214)

When we discuss design, we imply certain ideas about the character of the activities that we engage in. Good design is purposeful, creative, open ended, and iterative. The process of creating something to address a goal is repeated many times as the designed artifact or process is tested, observed, and refined. By repeating, implementing, enacting, and improving our interventions, we begin to understand what works and what does not, and which features are essential to our goals. “In this way, we collect information about failures, which, are of equal value to successes, plus information gathered from the attempted repairs to the design, and whether they succeed or fail” (Collins, 1992, p. 18). Teachers act as co-investigators and help to “formulate the questions to be addressed and the designs to be tested, making refinements in the designs as the experiment progresses” (p. 17). In this study, the cycle of laboratory classes was constantly modified by the teachers and me so that I could study the character of activities that promoted teacher learning and teaching. As such, design-based research enabled me to simultaneously pursue the goals of developing effective learning environments and using such environments as natural laboratories to study teacher learning and teaching.

The main intent of design-based research is to produce new theories, artifacts, and practices that affected or account for learning and teaching in naturalistic settings (Barab

& Squire, 2004). It is not simply a type of formative evaluation that allows scientists to better understand "the ecological validity of theoretical claims generated in the laboratory" (Barab & Squire, p. 3). Formative evaluation methodologies are about improving the value of a particular designed artifact, whereas design-based research is "intervention research designed to inform practice" (Brown, 1992, p. 143), and it uses "design in the service of developing broad models of how human think, know, act, and learn" (Barab & Squire, p. 5) to uncover, explore, and confirm theoretical relationships.

Design-based methods face some challenges. Sustained interventions give rise to complications. A single intervention might involve several discrete decisions by designer, researcher, and teacher, making it difficult to decipher all causality and pursue all possible factors that caused the observable change. Also, "components are rarely isolatable, the whole really is more than the sum of its parts. The learning effects are not even simple interactions, but highly interdependent outcomes of a complex social and cognitive intervention" (Brown, 1992, p. 166). Hence it is almost impossible to replicate the intervention precisely and "emergent phenomena regularly lead to new lines of inquiry informed by current theories or models of the phenomena" (Design-Based Research Collective, 2003, p. 7).

Dayspring Primary School

Dayspring Primary School is a public school situated in Dayspring, a historic town 50 miles east of a large city. Dayspring is in a rural section of Dalton County, which includes two other communities. Dalton County has a population of almost 40,000, and

Dayspring has about 3,500 residents. Slightly more than 42% of the population of Dalton County has not completed high school, with just over 13% of the households living below the poverty level, and more than 36% of the households headed by a woman. The Dayspring district runs its own independent school system. There are five schools in Dayspring district, with a total of 1500 students: Dayspring Primary, Grades K–2, Dayspring Elementary, Grades 3–5; Dayspring Middle School; Grades 6–8; Dayspring High School, Grades 9–12; and Dayspring Alternative School, ungraded.

At the time of the study, the primary school grade had about 400 students and 24 teachers, and the majority of the students were from low-income families. About 53% of the students were on free or reduced lunch. About 69% of the students were white; about 29%, African American; 1%, Asian; and 1%, Hispanic. Each year, many students moved into or out of the district, and these students usually had very little support from their families. The school had some relatively affluent students, but they were mainly from the lower middle class. Owing to the lack of home support, as the assistant principal said, "What the students get is mainly here at the school." As for behavior, the students were very well behaved, and the school did not have major discipline problems. There were 6 classes of second graders with an average of 19 students in each class.

The Team-Time Tradition in the School

The school had block scheduling of classes. The teachers at each grade level had the same time during the afternoon to meet together to plan lessons and activities and to compare their students' work. The assistant principal felt strongly about the common team time and school, and she planned to continue with the block scheduling:

> By having that common planning period, the teachers are able to get more done together as a group….We are moving away from teaching in isolation. It's more

> of a team approach and everyone has to work together to make sure all of our students succeed. We can't do that if we are teaching in isolation. So the block schedule will stay because we think it is very important that the teachers communicate, that they have time together that's uninterrupted. They have no other responsibilities during that time except to meet as a group and work together on whatever areas they need to work on.

Participant Selection

The professional development program lasted 2 years, and I had already conducted professional development for the Grade 2 teachers for a year before I started collecting data for the present study. During the first year of the program, I met the teachers once a month, and we did the planning, observing and critiquing on the same day. The teachers observed me teach Macy's students during the first year. At the end of the first year, one of the six teachers I had been working with became a part-time third-grade teacher, and another teacher, Linda, was promoted to vice-principal in the school. Linda had told me that she would be promoted, and she invited me to back to the school to work with the second-grade teachers the following school year. Two teachers, Ivy and Mary, joined the Grade 2 team in the second year. Ivy had been teaching third, fourth, and fifth grade in the district for the previous 8 years, and Mary had taught first grade in the school before joining the team. Kay, Macy, Anna, and Lana were the other teachers on the second-grade team during the second year of the program.

At the first meeting with the teachers in the second year of the professional development program, I explained to them the framework and design of the program and how it would be different from that of the first year. The teachers agreed to try out the revised program, and we pilot-tested the new design once before I invited them to

participate in the research study. I issued them a consent form with a description of the details of the study and explained to them the goals of the study and their responsibility as participants. All six teachers agreed to participate. During the 2 years that I was at the school, Linda supported the professional development program. Her role as an administrator in the second year further encouraged my work at the school. I included Linda as a participant in the study because her role in the school and in the program provided a wider lens on the teachers' growth and the effectiveness of the program.

Participants

Six teachers and their assistant principal participated in the study. I discuss each teacher below in the order of the number of years she had taught second grade in the school, and then I discuss the administrator. All names are pseudonyms.

Mary

Mary was a white female. Her highest education level was a degree in early childhood education awarded in 1995. She had taught for 8 years and was in her second year at the school during the second year of the program. The previous year, she had taught first grade. She was teaching second graders for the first time, and she wanted to learn new ideas for teaching mathematics. Mary was in a master's of education program but had postponed her graduation because of her fourth pregnancy. She had read professional and research articles about how children learn. She believed in research; used the Internet frequently to search for ideas for teaching; and said she learned by paying attention to other teachers, seeing how they were doing things, and applying those

ideas to her own classroom. Mary believed in using hands-on activities and manipulatives with younger children and her first graders. She used direct instruction with her second graders because she said she believed that they learned by being told how to do mathematics and that there was only one way to approach a mathematics problem. There were 22 students in Mary's class, and her class was considered a gifted class by the school administration.

Ivy

Ivy was an African American female. She was in her ninth year of teaching during the second year of the program. She was new to the school, and she was also finishing up a one-year specialist program in leadership during that year, and she hoped to either take on an administrative role or become a curriculum specialist in mathematics in the near future. Ivy had been trained to use mastery learning in teaching mathematics. She believed that students in this school could cope only with learning basic mathematical skills, and thus she covered only the basic skills with her students. She said that these skills were all that her students needed to master and that they could always learn how to think later. Ivy called herself a traditional mathematics teacher; she was always "at the front, and the kids are listening and writing and not moving." There were 17 students in her class, and her class was considered a mixed-ability class by the school administration.

Kay

Kay was a white female. Her highest level of education was a masters' degree in early childhood education, and she received the degree in 1995. Kay was in her ninth year of teaching during the second year of the program. She had taught second graders

only. After being in the teaching profession for 7 years at another county, she started her family and stayed at home for another 7 years to take care of her children. She had been an assistant in the library in the school for a year before she decided to return to the teaching profession. Her second year in the school was also the second year of the program. Kay loved teaching mathematics and believed that she had all the mathematical knowledge needed for teaching mathematics. She believed in direct instruction and in telling her students exactly what to do and how to correct a mistake they made in a mathematics problem. She had great confidence in teaching mathematics and believed that her way of teaching it was the best way. Kay had 22 students in her class, and her class was considered a mixed-ability class by the school administration.

Lana

Lana was a white female. Her highest level of education was a bachelor degree awarded in 2002. In the second year of the program, Lana was in her third year of teaching second grade at the school. She had been in banking for 8 years before attending 2 years of college. She then had children and took a long-term paraprofessional job at the school in a pre-kindergarten classroom when her children were older. She went back for her bachelor's degree, graduated, and started teaching in the school. Lana considered herself a novice in the teaching profession, and she believed in learning from her colleagues in the school. Lana's belief in how children learn mathematics and how mathematics should be taught was influenced by how she had been taught mathematics when she was young. "When I was in school,…they just told you 'This is what you do,' and you did it. If you did it the way they wanted you to, you got good grades." When Lana started teaching, she believed in direct instruction and that children just need to

learn facts and certain principles in mathematics. There were 17 students in Lana's class, and her class was considered a gifted class by the school administration.

Anna

Anna was a white female. Her highest level of education was a degree in early childhood awarded in 1987. She had been teaching in the present school since 1989 and had taught second grade since 1996. She was the team leader for the second-grade teachers during the 2 years of the program. Anna believed strongly in direct instruction and in using drill and practice in mathematics instruction. She had employed mastery learning techniques in teaching mathematics for several years before the study, and she believed strongly in mastery learning. Anna said she loved organization, orderliness, structure, and control in her classroom. She believed that the majority of her students lacked home support in mathematics and in other subjects, and she told her students exactly what and how to do a mathematics problem or tasks because many of the parents were illiterate or at least unable to help with their children's homework. Anna provided plentiful opportunities for her students to complete their mathematics problems in school and avoided giving students homework unless they were taught exactly how to do those problems. There were 17 students in her class, and she considered her class a challenge to teach because of the large number of special education and lower-ability students in it.

Macy

Macy was an African American female. Her highest level of education was a degree in science. Macy had been teaching for 27 years, mainly in the second grade. She had been in the district for 20 years and had been with Anna on the second-grade team for about 9 years. She planned to retire in 5 years. Macy believed strongly in mastery

learning. She employed direct instruction, small-group teaching, and drill and practice in her mathematics class. Like Anna, she viewed discipline and orderliness as an important element in teaching, and she could not stand "noises." She always felt that there was a lack of mathematics instruction and mathematics professional development in the school. When she learned at a mathematics conference in another county about one of the research programs run by the mathematics education department at the University of Georgia, she notified the school principal, who then invited me to start a professional development program in mathematics at the school. There were 18 students in Macy's class, and her class was considered a mixed-ability group by the school administration.

Linda

Linda is a white female. She was selected for the study because she had a very interesting view of the program and because she was the vice-principal of the school during the second year of the program. She believed in developing students' mathematical thinking, and in using questioning, manipulatives, and activities in helping students learn mathematics. For teacher development, she believed in building learning communities across the grade-level teams in the school. She acted in a supportive role to the teachers during the program by providing them time and space to meet me and rendered whatever support she thought the teachers needed to develop their teaching practices and team dynamics during the program.

> I have an interesting view of the program because the first year I participated in it, and then the second year, being the administrator and supporting the program. The first year was very informative I felt. It was something that being a teacher was very beneficial. The ideas that were brought to us, and the suggestions and watching the lessons that were being displayed or being presented to us, allowed me to reflect into my teaching and how I can incorporate these ideas into my classroom.

The school system had adapted mastery learning before new standards were imposed on them by the state during the year of the study. Linda said, “Mastery learning is where you were taught an objective and you were retaught the objective, and you were given a paper-pencil test. And if you didn’t pass the objective, you didn’t master it. So you were retaught it.” She thought that the mastery learning system had greatly influenced a few of the teachers, who had been with the system for several years:

> We had a couple of the teachers who were very old, very traditional in their views. They really depended on their paper-and-pencil tests. They depended on the right answer. They depended on students sitting in their seats being quiet and doing their work, turning to the page in their workbook and completing the work.

Distribution of Students

As was typical in this school, two classes out of the six had relatively more advanced or gifted students, and the two teachers of these class, Mary and Lana, collaborated with another gifted education teacher in the school. The rest of the classes were more or less evenly populated by high-, medium-, and low-ability students. A special education teacher in the school worked with the special education students. Each class typically had one or two special education students, but Anna had more because the special education teacher had requested that certain special education students be placed with her. During the second year of the program, Anna’s class had a lot of movement in and out. Some of the high ability students in the class transferred out of the school, and the students who entered were of lower ability, so the class ended up with more lower-ability children.

Data Sources

I assumed two roles throughout the course of the study from October 2004 to August 2005. I was the professional developer and the researcher. Ho Kyoung Ko, a post-doctoral student in the mathematics education department at the University of Georgia, was my co-researcher from October 2004 to March 2005. The sources of data were interviews, fieldnotes, and an audit trail. Each teacher participated in 7 interviews and 6 whole-group critique sessions, one for each cycle from November to May.

After the professional development program ended in May, each teacher and the assistant principal took part in a final interview to help them to reflect on the program. The only interview with the assistant principal was conducted during July 2005. The final interviews with the teachers were conducted in August 2005. Altogether, 49 interviews were conducted for the study. All the individual interviews with the teachers were face-to-face interviews that lasted approximately 40 minutes each. They were conducted either after school or during the students' exploratory time, when the students were engaged in extra curricular activities like art, physical education or computer work. The first interview was conducted before the program began in November. Its purpose was to elicit the teachers' beliefs about teaching and learning mathematics, some approaches they used in teaching mathematics, and information about professional development programs that had influenced them as mathematics teachers. The next six interviews were conducted almost immediately after each laboratory class cycle to gain feedback on the professional development program, make adjustments in the program, and trace the teachers' learning and change individually and as a learning community. The final interview, conducted after the program ended, was an interview with each of the seven

participants to summarize their professional development experiences. Ho Kyoung Ko conducted nine interviews with the teachers, and I conducted the rest of the interviews.

Whole-group critique sessions were held and recorded after the teachers observed the demonstration lessons. Each critique session lasted about 50 minutes. Following each whole-group critique, Ho Kyoung and I would observe one mathematics lesson for each teacher for 30 minutes. I wrote fieldnotes on the same day that I observed those lessons. I also kept an audit trail of every meeting I had with the teachers. Before the next demonstration lesson, I would analyze the fieldnotes and interview the teachers in light of my observations of their lessons and their comments during planning and critiquing. Table 1 illustrates the data collection method for each research question.

Table 1

Research Questions and Data Sources

Question	Data Source	Use of Data
1. What are the teachers' experiences of a professional development program that includes laboratory classes as they shape the design of the program collectively with the professional developer? Why and how does the professional development program evolve?	Interview transcripts Audit trail Fieldnotes	The first two data sources enabled me to examine the teachers' experiences in designing and implementing the professional development program. The fieldnotes helped me keep track of the teachers' classroom practices.

2.	What are the teachers' conceptions of change in their teaching as a result of this school-based professional development experience? How do the individual teachers change as a function of their experience?	Interview transcripts	By looking at the teachers' interview transcripts, I obtained firsthand information on how the teachers felt about their own lesson and how they thought they had grown.
3.	What are the teachers' conceptions of change as a team as a result of this school-based professional development experience?	Same as for Question 2	Same as for Question 2
4.	What is the administrator's conception of the teachers' and the team's change?	Interview transcripts	By looking at the administrator's interview transcript, I was able to analyze her conception of how the Grade 2 teachers and the team had changed as a result of the program.

Procedures

During the first week of November 2004, I reviewed the design of the professional development and research with the teachers before we committed ourselves to six cycles of laboratory classes each month except April from November 2004 to May 2005. Because April is the month for administrating the state test, the teachers requested that we not have interviews or a laboratory class during that month. They also agreed to be interviewed and observed at the end of each laboratory class cycle. I observed each teacher's mathematics lessons and interviewed her almost immediately after each cycle and before the next cycle. Each teacher also chose three students from her class to participate in the second variation of the laboratory class. No criteria were set for teachers

to select those students. I had four meetings with the teachers each month except in April. One of the sessions was used to plan for the demonstration lessons, one session for the teachers to observe the planned lessons, and one session to critique the demonstration lessons. The last session was used to reinforce any concepts or teaching ideas that arose during the cycle of the laboratory class. One or 2 weeks before observing the demonstration lessons, the teachers decided on the topic for the laboratory class for that month. The team had decided to focus on one mathematical topic each month that was taken from the school syllabus. This decision took into account that many mathematical topics required prerequisite knowledge and skills from the first half of the year. A week before the teachers observed the demonstration lessons, we planned them together. I would suggest several possible ideas for the lessons, and the teachers would decide and modify those lessons they wanted to observe. Table 2 summarizes the timeline for the study.

Table 2

Timeline for the Study

Month	Plan
October 2004	• Select sample. Invite participants to participate in laboratory class and analysis. • Apply for human subjects approval.
November 2004	• Human subjects approval received. • Conduct first round of lesson observations, interviews, and whole-group critique. • Transcribe interviews and whole-group critique. • Do initial data analysis to identify topics for second interviews. • Use initial data to modify professional development program. • Conduct first round of laboratory class.
December 2004	• Conduct second round of lesson observations, interviews, and whole-group critique. • Transcribe and analyze interviews. Use data to

	modify improve program. • Conduct second round of laboratory class.
January to May 2005	• Conduct third to seventh round of lesson observations, interviews, and whole-group critique. • Conduct third to sixth rounds of laboratory class. • Do more data analysis. • End professional development program.
June 2005	• Take time away to think.
July 2005	• Interview school administrator.
August 2005	• Conduct final interview with teachers.
October to December 2005	• Continue data analysis.
January to May 2006	• Complete data analysis

Data Analysis

The transcripts of the interviews, the fieldnotes, and the audit trail were analyzed extensively. Pseudonyms were assigned to the school and the participants to ensure confidentiality. Charmaz (2000) suggests the following five techniques for using the constant comparative method: (a) comparing aspects of different people (such as their views, situations, actions, accounts, and experiences), (b) comparing data from individuals with data from themselves at different times, (c) comparing an incident with another incident, (d) comparing data with a category, and (e) comparing a category with other categories. In this study, I compared incident with incident to analyze the teachers' experiences in the professional development program and their reactions to those experiences. I also compared data from individuals with data from themselves at different times to trace the teachers' conceptions of their change in learning and teaching mathematics.

During the analysis process, I read the interview transcripts to give me an overall sense of the participants' experiences in the laboratory class cycles, and I identified key

teaching and learning experiences during the professional development program that appeared in their data. There are four stages in the constant comparative method (Glaser & Strauss, 1967). In Stage 1 of the constant comparative method, I coded the teachers' reactions to those experiences and identified key elements of each learning episode. Using those codes, I formed many categories of analysis. Some of the categories were as follows: persons involved, nature of activity, setting and timing of the episode, participants' immediate responses, participants' reflections about the experiences and beliefs, and long-term outcomes for the participants. Next, I compared the items within each categories across the teachers' experiences to trace their learning and teaching during the program and how it evolved. For example, across the experiences, I compared the persons involved, nature of activity, setting, timing of the episode, short-term outcomes, long-term outcomes, beliefs, and reflections on the episode to distinguish similarities and differences. Tensions among the teachers and how the team changed as a result of the program were a theme that emerged in the interviews after the first laboratory class cycle. I pursued this theme for the rest of the study. The teachers' feedback on the design of the program also guided the data collection, and I started to ask them specific questions on how the program could be modified to promote greater teacher learning and growth.

In Stage 2 of the constant comparative method, I continued to include more data sources to continue to categorize each mathematical experience. In Stage 3, using theoretical criteria, through reduction and saturation, I delimited the theory and committed myself to it, cut down the list of categories for collecting and coding data, focused on applicable incidents, and stopped coding saturated categories. At the theory

level, with the theory solidified, and connections and uniformities in the categories and properties emerged.

In the last stage, Stage 4, I started writing the theoretical framework using my memos to provide the content behind the categories and their properties. I had a workable theory, and I proceeded to develop hypotheses as a result of the framework to explain certain social processes and their relationships. The above process was repeated for the analysis of fieldnotes and the audit trail after the program ended.

Issues of Validity

Design-based researchers are not simply observing interactions but are actually causing the interactions they are making claims about (Barab & Squire, 2004, p. 9). In this study, I was intimately involved in the conceptualization, design, development, implementation, and investigating of the program. My role as context manipulator may have undermined the credibility of the claims in this study because "each systematic alteration of the designed context potentially contributes to the findings and claims being more artificial and less naturalistic" (Barab & Squire, p. 10). I used methodological practices consistent with other qualitative methods (Goetz & LeCompte, 1984; Lincoln & Guba, 1985) to add credibility to the claims I made. I used multiple sources of data to connect intended and unintended outcomes to processes of enactment (Design-Based Research Collective, 2003). I interviewed the teachers extensively at different points of the program to capture their varied experiences. Data were kept in context, and the program was conducted over an extended length of time at the same site to reduce

artificial responses. Clarification of the researcher bias adds validity to the study. "Validity of findings is often addressed by the partnerships and iteration typical of design-based research, which result in increasing alignment of theory, design, practice, and measurements over time" (Design-Based Research Collective, p. 7). The laboratory classes were iterated six times to increase the validity of the findings. Claims in this study were based on researcher-influenced contexts and, as such, may not be generalizable to other contexts of implementation where the researcher does not directly influence the context (Barab & Squire).

Researcher Subjectivity

A program of research into professional development often involves a tight relationship between the researchers, the professional developers, and the teachers, blurring the objective researcher-participant distinction.

> Subjectivity has long been considered something to keep out of one's research, something to, at the least, control against through a variety of methods to establish validity. It had always been a negative connotation in the research world and has not traditionally been a topic for discussion in a research proposal or project...However, Peshkin (1988b) challenged the notion of subjectivity as something negative, as others (Denzin & Lincoln, 1994; Wolcott, 1995) also have done. (Glense, 1999, p. 105)

Peshkin (1988) urged researchers to declare their own subjectivities prior to entering a research project. Once qualitative researchers recognize that subjectivity is always a part of research, they can monitor their own subjectivities for more trustworthy research and discuss how they can contribute to research (Glesne). The following discussion, drawing

from Glesne and from Peshkin, presents my subjectivities and how I managed them throughout the present study.

As Glesne (1999) suggested, I used my understanding and awareness of my subjectivity in building accepting and trusting relationships with my participants. Because I worked with the Grade 2 teachers from January to September 2004 before the research study began, I had already formed some conceptions of my participants. For instance, Anna was always taking notes and not sharing during the professional development activities, and I assumed that she was not very interested in the program. When I started interviewing the teachers about their roles in their Grade 2 team, however, I learned that she had to submit a report to her administrator whenever the teachers held a team meeting, and her additional role caused her to "write rather than talk" during those meetings.

Macy shared her classroom with a special education teacher, and on several occasions when I arranged to observe her teach, the special education teacher taught the class instead. I began to assume that Macy was unwilling to be observed. I decided to talk openly about with her about my concerns during one of the interviews. She told me that the special education teacher came to her class every day for an hour and that she, Macy, usually spent an additional 15 minutes on mathematics remediation. Macy thought that her class would be getting too much mathematics if she taught it for another 30 minutes so that I could observe her teaching. She had difficulty coping with the research study, and I did not foresee that problem. I learned to clarify the interpretations I had about the teachers by using the interview data. Those clarifications allowed us to discuss our

concerns for this study and the professional development program openly, and to work more effectively to improve the design of both.

Glesne (1999) differentiated between rapport and friendship, claiming that "friendship means mutual liking and affection and implies a sense of intimacy and mutual bonding, whereas a relationship characterized by rapport is marked by confidence and trust, but not necessarily by liking" (p. 96). Rapport and friendship were definitely missing when I started working with the teachers. The teachers and I were separated by cultural differences, and the teachers had a history of unresolved conflicts among themselves. I started gaining the teachers' trust by focusing on their teaching. I encouraged them to talk about their teaching practices, and I planned demonstration lessons with them to suit their needs and expectations. After a year at the research site, when I had gained rapport with the teachers, I started to engineer the professional development program to get the type of data required for the study. Glesne warned that "friendship entangles in that it conveys the impression that one has chosen sides, take a stand, decided on preferences. Each such impression risks shutting down data sources or biasing the data collection process" (p. 103). In this study, building both friendship and rapport with my participants was vital as we shaped the professional development program collectively and met weekly for a year. I was aware of the distinction between friendship and rapport and made a conscious effort to avoid having the participants over-identify with me and begin to act in ways to impress me. By choosing all the Grade 2 teachers for the study, I eliminated the tendency to talk primarily with those teachers I especially liked or found more sympathetic. Instead, I learned to hear from all the teachers who participated in the program and gained a perspective of their experiences.

I view my inquiry into how the professional development worked with the teachers through several lenses. First, and most connected to me, was the personal lens. The personal lens came from my family, derived from the relationship I had with my grandmother. I grew up in a nuclear family, and my two grandmothers took turns staying with my parents. Since my childhood, my parents modeled to me the importance of respecting and caring for the elderly. In my culture in Singapore, we believe that an elderly person is a treasure in the house. With this family and cultural influence, I always treat elderly people with extra respect and have a soft spot for them. In this study, I considered two of my participants to be elderly people, and I constantly reminded myself not to over-identify with them or treat them with special care.

Second, I view my subjectivity through a justice lens. I have always been an advocate for equal treatment, and I have always been sensitive to people who are underprivileged. My interest in the professional development program in this study stemmed from my observations of how some teachers are deprived of long-term professional development opportunities because their services are needed at their schools. These teachers often experience burnout or are left “dry” after a few years of teaching because they are always serving and giving to society. If more-balanced opportunities are provided for teachers to provide and receive professional development, however, fewer teachers may suffer from mental and social drought. This belief motivated me to think of ways to help the teachers catch up if they missed any of the demonstration lessons.

Researcher Ethics

Glesne (1999) addressed several roles that that may worry the qualitative researcher "while others may be attractive but perplexing in relationship to their data-gathering goal" (p. 117). She explained how qualitative researchers may easily assume the roles of exploiter, reformer, advocate, or friend and how different ethical dilemmas accompany each role. I was not an exploiter in the study. I did demonstration lessons for the teachers, and all data collection efforts were avenues for the teachers to reflect on and share their teaching practices and to learn from their colleagues. That was part of the professional development program design.

I assumed the intervener or reformer role by being the professional developer for the teachers. There were many instances during the program when I felt a strong urge to tell the teachers what they should or should not do. For example, I thought they should not simply tell their students what to do and, how to do it, or tell them to follow a set of prescribed rules to do mathematics. When I made use of students' explanations and critical thinking in my interactions with the students in my professional developer role, I had to make a consistent effort to monitor my teacher-developer lust all the time. The urge to tell the teachers how and what they should teach became especially strong after I observed the teachers' mathematics lessons. When the teachers started asking me for feedback regarding their lessons as they included me in their community of practice, I was in a dilemma. How was I to handle that request? My observations of their teaching was intended solely for the research study and not as part of the professional development program. I was unprepared to give any feedback to the teachers, because it might have had a direct effect on their teaching. This situation prompted me to reconsider the design

of my professional development project and research study. I decided to invite the teachers to share their mathematics lessons for criticism and feedback during the weekly meeting.

I learned that the reality of multiple and competing demands on teachers' time and the daily work in the low-performing school I studied could be intense, frustrating, and exhausting for the teachers. Throughout this study, I had to monitor my empathy with the teachers and my urge to simply tell them what to do rather than leading and facilitating the three stages of the laboratory class. Although the aim of the professional development project was to help the teachers reflect on their own practices more critically, the interviews with the teachers also provided them opportunities to reflect more personally and deeply on their teaching and learning. The interviews might unintentionally have helped the teachers to be more aware of themselves, and that awareness might have contributed to their beliefs about, expectations for, participation in, and reactions to the professional development program.

The professional development program was to be seen as a collaborative effort between the teachers and me. Throughout the study, the teachers could suggest various ways to improve the program. The program reflected theories and the framework described earlier that support effective professional development programs. When my researcher role required me to spend months asking participants about problems, concerns, and expectations they had in their teaching and in the professional development program, my questions elicited voices of dissatisfaction with other teachers or with some parts of the program. In the process, the teachers may have expected me to "alleviate"

their problems more than I was willing to do at times. I faced the challenge of negotiating suggestions that the teachers made during the study.

Busier et al. (1997) argue that intimacy can be a "route to understanding" (p. 165). However, "it carries with it responsibilities and considerations, including reflexivity on the nature and influence of the relationship, analysis of the role of power in the relationship, and attunement to relational ethics" (Glesne, 1999, p. 122). The participants began to treat me as a friend in the second year of the professional development program, and the interviews further shaped the relationship between the teachers and me (sometimes more than the professional development did), by allowing a one-to-one interaction between me and each teacher. There were instances in which a teacher shared her innermost thoughts and sentiments, and she requested that the information go off the record. I respected the teachers' right to privacy. Even though those data were excellent data, I did not keep written records of them.

The teachers met on days when I was not there to plan, discuss, and share their resources for other subjects than mathematics. During some of the meetings, when I was not present, the teachers shared some immediate problems they had in teaching mathematics and exchanged resources and ideas for teaching the subject. Those meetings may have influenced the teachers' professional development and growth in ways that I could not observe or record.

CHAPTER 4

THE PROFESSIONAL DEVELOPMENT PROGRAM

In this chapter, I describe the professional development cycle, and the laboratory class cycle used in the research study. Next, I provide details of the laboratory class cycle schedule and the demonstration lessons.

Professional Development Cycle

Using the framework for designing professional development in Figure 1 (p. 10), the teachers and I continually implemented, evaluated, and modified the design of the program to suit their needs. I wanted them to be able to incorporate professional development into their teaching practice so that they could cope with the new demands of educational reforms. I addressed the teachers' fundamental dispositions and beliefs about professional development programs as we set goals and planned for activities in the program collectively as a team. The professional development cycle then allowed the teachers to observe and try out ideas brought out in those activities before they reflected on their experiences and the design of the program. Using the teachers' input and reflection, I modified the design of the program. We planned and enacted a new set of activities based on the teachers' reflection and feedback on the previous cycle of the program. Although the professional development program provided raw materials for change, we recognized that the teachers brought a wide variety of experiences and needs to the program and that they ultimately would determine what the impact would be. The

professional development in this study was seen as a contextual, collaborative, and ongoing venture, involving both teachers and a professional developer affecting the content and application of the laboratory class cycle in a school setting.

I experimented with two models of laboratory class cycle in this school-based program with a group of Grade 2 primary school teachers. In the next section, I explain in greater detail the laboratory class cycle and how the two variations of the cycle functioned in this professional development program.

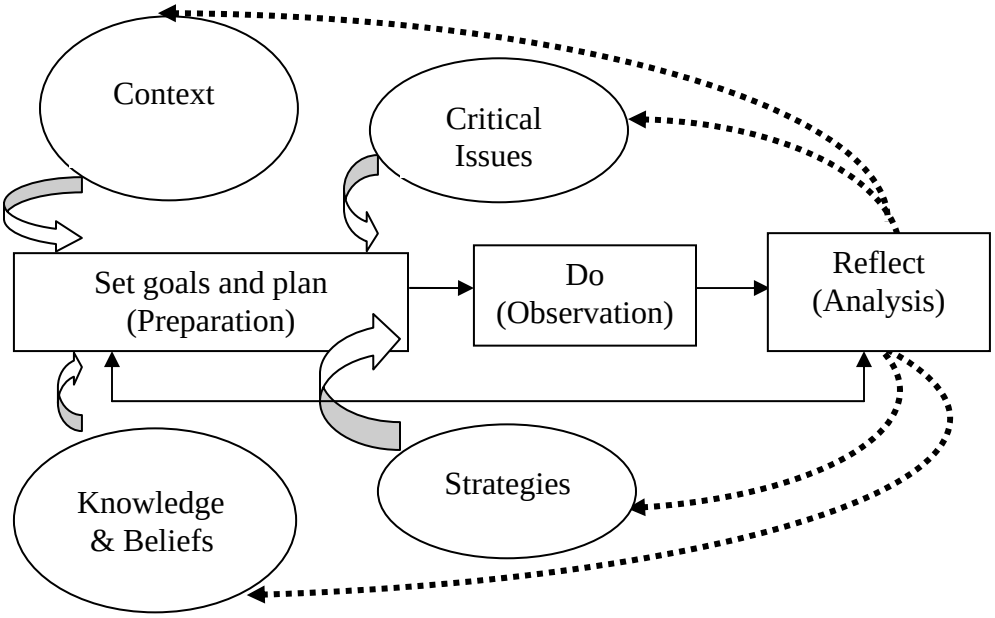


Figure 2. Laboratory class cycle. Adapted from Loucks-Horsley, Hewson, Love, & Stiles, 1998, p. 17. Copyright 1998 by Corbin Press. Reprinted with permission.

Using the framework for the professional development program presented in chapter 2, I viewed the laboratory class cycle as a teaching cycle consisting of three phases in which I would facilitate and support the teachers' learning in the preparation

(set goals and plan), observation (do), and analysis (reflect) of mathematics lessons. The preparation and analysis occurred before and after, respectively, the actual mathematics class. The observation occurred during the mathematics class. Figure 2 illustrates the revised framework used for the laboratory class cycle.

Preparation

The preparation phase is characterized by the team engaging in planning the demonstration lessons together or discussing, and hypothesizing about what they expect to see in the lessons. I addressed the teachers' fundamental dispositions and beliefs about teaching and learning of mathematics as we set goals for and planned for the activities in the program collectively as a team.

Observation

What one wants in the laboratory class is not so much technical skill as awareness and "in some typical case, command of a method of control, which will then serve as a standard for self-judgment in other cases" (Dewey, 1904, p. 28). The observation phase involves observing and reflecting on the lessons.

Analysis

In the last phase, the team critiques the lessons and discusses its applicability and adaptability to the individual teachers' classrooms.

Two Variations of a Laboratory Class Cycle

The design of the professional learning tasks using a laboratory class cycle in this study considered the "cycle of teachers' work and the nature of activities in which teachers engage as they move through the cycle" (Smith, 2000, p. 8). I conducted two variations of laboratory class cycle as shown in Figure 3 in the first three laboratory class

cycles. Both variations began with planning for the demonstration lessons. The teachers decided on the mathematical topic they wanted their students to learn according to the school syllabus; discussed how they would teach the topic; hypothesized and determined the relevant prior knowledge and experiences on which the students could draw to construct new knowledge; and adapted or created mathematics lessons that built on prior knowledge and experiences and had the potential to foster the intended learning.

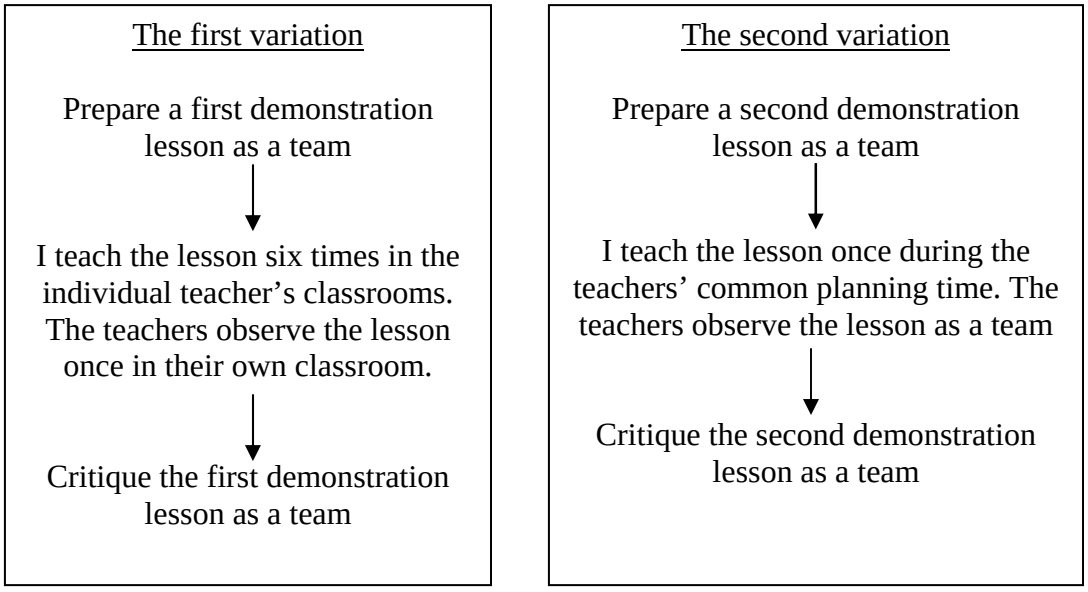


Figure 3. Two variations of a laboratory class cycle in the first three laboratory class cycles.

The first variation. In the first variation, the teachers observed me teach the demonstration lesson in their classrooms. I call this lesson the first demonstration lesson. When the teachers observed the lesson conducted with their own students, they were assisted in understanding the specific needs, mathematical misconceptions, learning styles, and learning difficulties of those students. The lesson also allowed me to understand and experience the teachers' concerns and difficulties in teaching

mathematics, hence enabling me to cater the professional development to the specific needs of the teachers.

The second variation. In the second variation, the teachers observed me teach another lesson during their common planning time. I call the lesson the second demonstration lesson. The second variation focused more on the team. The teachers shared common experiences as they observed the same demonstration lesson together. Depending on the hypothesis the team decided to test, the teachers chose different students to participate in the demonstration lesson. This set-up supported teacher and team learning as it offered the teachers different lenses to examine and understand students' mathematical learning by comparing and contrasting, how and why those children had responded in a particular manner to my teaching.

In both variations, the teachers completed the cycle by reflecting on and critiquing as a group the demonstration lesson. During this process, the teachers considered the mathematics, the level of thinking in which majority of the students were engaged during the lesson, the students' responses, and the ways in which the teaching supported or inhibited the students' engagement with the intended task. When the teachers came together as a team to critique the common lesson afterwards, they gained a deeper understanding of other students' mathematical learning, thus enhancing their own professional growth.

In the last three laboratory class cycles, I merged the first and second variation as shown in Figure 4 to form a new laboratory class cycle. That is, a single laboratory class cycle consisted of the two types of demonstration lessons. The teachers observed me teach the first demonstration lesson in their classrooms, and then they tried different ways

to teach a specific mathematics concept during the second demonstration lesson using station activities. In the station activities, each teacher worked with a partner with a group of six students. In each pair, one teacher would teach the six students, and the other would observe the students' reactions to the lesson. I blew a whistle at the end of 10 minutes to indicate that the students were to visit the next station. The second teacher now taught the second group of six students, and the first teacher observed. The teachers in each pair decided between themselves who would teach the third group of six students. In chapter 5, I explained how the two demonstration lessons served different purposes and how they complimented each other as the program evolved.

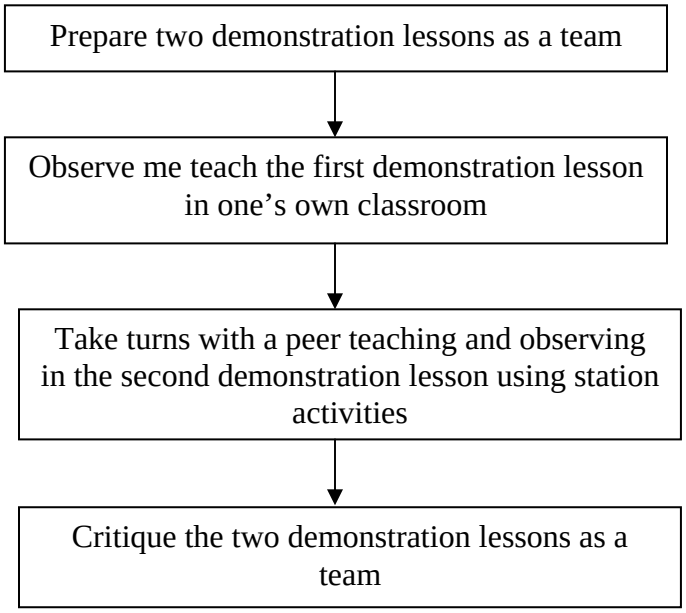


Figure 4. Design of the laboratory class cycle in the last three laboratory class cycles.

The laboratory class cycle provided the teachers the opportunities to experience firsthand a form of teaching that facilitated and supported learning. It also allowed the teachers to hypothesize about and test out their current assumptions about what mathematics is, who can do mathematics, and what it means to be successful in mathematics. According to Ball and Cohen (1999), "It would not be sufficient to simply

see what one already assumes about students, learning and content; one would also need to see others' assumptions, difference in the content and effects, or unexpected effects of one's own ideas or practices" (p. 19).

Reflection was a vital component of the laboratory class cycle, and through reflection on their own teaching after observing me teach, the teachers could gain insights into how teaching influences students' opportunities to learn mathematics. The laboratory class cycle allowed collective participation in a common experience, which in turn provided a forum for debate and improving understanding, thus increasing the teachers' capacity to grow (Ball, 1996). Knapp (1997) emphasizes that change in classroom teaching is a problem of individual learning as well as organizational learning. The laboratory class cycle set up an organizational routine and established a culture supportive of instruction that could facilitate individual change efforts so that a teacher could be "independent judge and critic of their proper use and adaptation" (Dewey, 1904, p. 19) and form good habits of teaching.

Schedule and Description of Demonstration Lessons

Some laboratory class cycles took place over 2 weeks because of school holidays. Table 3 summarizes the mathematical activities and timeline for the activities conducted in the program. Most of the topics dealt with numbers. These cycles reflected the main topics in the curriculum during the time that I was in the school.

Table 3

Sequence of Activities During the Study

Date	Description of Activity
Laboratory Class Cycle 1 (Time)	
9 Nov 2004	Plan Demonstration Lessons 1 and 2
16 Nov 2004	Teach and observe Demonstration Lessons 1 and 2
23 Nov 2004	No meeting; teachers needed time to plan lessons for return from Thanksgiving break
30 Nov 2004	Critique Demonstration Lessons 1 and 2
7 Dec 2004	Share and discuss teaching resources; decide on the topic for Cycle 2
Laboratory Class Cycle 2 (Addition of 2 Digit Numbers with Regrouping)	
14 Dec 2004	Plan Demonstration Lessons 3 and 4
15 Dec 2004	Teach and observe Demonstration Lessons 3 and 4
15 Dec 2004	Critique Demonstration Lessons 3 and 4
11 Jan 2005	Share and discuss teaching resources; decide on the topic for Cycle 3
Laboratory Class Cycle 3 (Subtraction of 2 Digit Numbers with Regrouping)	
18 Jan 2005	Plan Demonstration Lessons 5 and 6
25 Jan 2005	Teach and observe Demonstration Lessons 5 and 6
1 Feb 2005	Critique Demonstration Lessons 5 and 6
8 Feb 2005	Continue to critique Demonstration Lessons 5 and 6; share and discuss teaching resources; decide on the topic for Cycle 4; start planning for Demonstration Lessons 7 and 8
9 Feb 2005	Share and discuss teaching resources
Laboratory Class Cycle 4 (Measurement)	
15 Feb 2005	Plan Demonstration Lessons 7 and 8
24 Feb 2005	Teach and observe Demonstration Lessons 7 and 8; (Demonstration lessons postponed from 22 February to 24 February as the school had arranged for second grades to attend a talk)
1 March 2005	Critique Demonstration Lessons 7 and 8
8 March 2005	Continue to critique Demonstration Lessons 7 and 8; decide on the topic for Cycle 5; start planning for Demonstration Lessons 9 and 10
Laboratory Class Cycle 5 (Fractions)	
15 March 2005	Continue to plan for Demonstration Lessons 9 and 10; share and discuss teaching resources
22 March 2005	Teach and observe Demonstration Lessons 9 and 10; critique Demonstration Lessons 9 and 10 after school

Laboratory Class Cycle 6 (Multiplication)

12 April 2005	Continue to critique Demonstration Lessons 9 and 10; plan for Demonstration Lessons 11 and 12
26 April 2005	Teach and observe Demonstration Lessons 11 and 12
3 May 2005	Critique Demonstration Lessons 11 and 12

Table 4 summarizes what each demonstration lesson entailed. Demonstration Lessons 1, 3, 5, 7, 9, and 11 were the first demonstration lessons, and they were conducted in each individual teacher's classroom. Demonstration Lessons 2, 4, 6, 8, 10, and 12 were the second demonstration lessons, conducted during the teachers' common planning time.

Table 4

Description of Demonstration Lessons

Demonstration Lesson 1: A story *Get Up and Go* was read to the students, and then a few students were picked randomly to show, read, and write the various times in the story.
Demonstration Lesson 2: The lesson focused on reading elapsed time. The students were asked to read, show, and write the time and to explain how they arrived at the answers.
Demonstration Lesson 3: Students were introduced to the game Race for a Flat. They first explored the relationship of the blocks before I modeled the game. I then assigned roles (one child to be the banker, a second child as the first player, and a third child as the second player) to every student before they played the game in groups of three.
Demonstration Lesson 4: I modeled the procedure for decomposing a given number into two other whole numbers. We called it the Christmas Tree activity. The students next practiced decomposing some given numbers.
Demonstration Lesson 5: I demonstrated the game Race to Zero using base ten blocks that were flats, units, and longs. The procedures for subtraction with renaming and without renaming were modeled to the students. The students next played the game in groups of three.
Demonstration Lesson 6: The focus of this lesson was to develop multiple strategies for two-digit subtraction with renaming. A problem "54 subtract 28" was posed to students. The students were then encouraged to come up with as many solutions to the problem as possible. Alternative strategies for the problem were developed in this lesson.
Demonstration Lesson 7: This lesson covered introductory ideas on length, capacity, and area. A variety of objects were placed on the overhead projector, and the students ordered their lengths from the shortest to the longest. The students next engaged in

estimating the lengths of several objects in inches and centimeters. An overhead ruler was used to check the students' guesses. The starting and ending points during measurements were highlighted for students. For capacity, the students arranged the capacity of containers and estimated their capacity. The measuring cup and a beaker were next introduced. The terms, *cup, pint,* and *quart* were also introduced. The students then measured the capacity of the containers using the measuring cup and beaker. The water used was colored blue, and the teachers called this the Blue Water activity. For area, the students were shown what a 1-inch square looked like before they estimated the area of triangles, squares and rectangles shown to them. Next, the students were asked to find the area of three figures drawn on squared paper.
Demonstration Lesson 8 (station activities): Before the lesson, the students estimated how far they could throw a fabric softener and a paper plate, how heavy a handful of marbles was, the capacity of containers, and the number of spongefuls of water needed to fill those containers. The students next worked in four groups (4-5 students in a group) at three different measuring stations attended by their teachers to confirm their estimates.
Demonstration Lesson 9: The lesson focused on relating fractions (halves, thirds, and fourths) to concrete and pictorial models and models to fractions). The students were shown pictures of pizza that came in varied sizes. The pictures were folded in half and the students were asked to identify which halves were bigger and why. The unit whole was highlighted for the students. Next, the students were taught how to make their own Fraction Paper Plate which allowed them to read and play with fractions (½, ¼ , ¾, and 1 whole). Lastly, the students related fractions to materials available in their daily life (e.g. a stack of multicolor CDs and DVD cases, a stack of multi-color Post-It notes).
Demonstration Lesson 10 (station activities): In this lesson, the students related fractions (halves, thirds, fourths, and sixths) to concrete and pictorial models and models to fractions. The students worked in three groups (6 students in a group). Activity booklets were issued to the students before they took turns working at three different stations. Station 1 focused on developing students' visual, and geometric representations of fractions. The students used geoboards and geoboard dot paper to construct different ways of representing halves and a quarter and their respective wholes. In Station 2, the students were introduced to what a hexagon pattern block looked like before they constructed their hexagons using different combination of pattern blocks. The students traced their hexagons and labeled the different fractional parts and respective colors in their activity booklet. At Station 3, the students were shown flags from different countries around the world. They were then asked to read the fractions representing the regions that appeared on those flags. Next, the students designed and made their own flags on the inch-square graph paper.
Demonstration Lesson 11: This lesson is an introductory lesson on multiplication (addition and set model). Buddy The Robot was introduced to the class. Buddy and his family all had the following features: 1 circular nose, 1 rectangular on/off button, 2 rectangular ears, 3 oval eyes, 4 square lights, 5 circular wheels, 6 function buttons, 7 diamonds, 8 letters, 10 rectangular teeth. Students next constructed mathematical statements for Buddy (e.g., 1 group of 1 nose = 1 nose). Another member of Buddy's family was introduced, and the students continued to construct mathematical statements involving Buddy and his family member (e.g. 2 groups of 1 nose = 1+1 =2 = 2×1=2).

Demonstration Lesson 12 (station activities): Three activities were developed to aid students in developing the basic multiplication facts for the array, addition, and set models. The students worked in three groups (6 students in a group) and recorded the activities at three activity stations in a booklet given to them. Station 1 supplied a developmental activity for students where the sum of equivalent sets served as a model for multiplication. The students used paper plates to help them grasp the concept of multiplication as groups of a given number of items (e.g., beans, macaroni, and counters.) for multiplication of 2, 3, 4, and 5. Station 2 provided students an experience with the array model in order to help them develop the basic multiplication facts. At this station, students formed different rectangular arrays using Unifix cubes for the 2, 3, 4, or 5 times tables. Next they drew the corresponding rectangular arrays using grid paper and wrote an addition and multiplication sentence besides each rectangular array. Station 3 also provided students an experience with the array model in order to help them develop the basic multiplication facts. On the geoboards, the students placed rubber bands around pegs forming entries in the 2, 3, 4, and 5 times tables. Next, they counted the number of squares enclosed by the rubber bands and drew the corresponding rectangular arrays using geoboard paper. They also wrote an addition and multiplication sentence besides each rectangular array drawn on the geoboard paper.

When I reached Laboratory Class Cycle 4, the teachers suggested that we modify the second demonstration lesson to include station activities. Demonstration Lessons 8, 10, and 12 were the station activities. In chapter 5, I describe in greater detail how the professional development program evolved as a result of the collective feedback from the teachers.

CHAPTER 5

THE EVOLUTION OF THE PROGRAM

In this chapter, I describe the evolution of some of the activities in the professional development program. In the following paragraphs, major themes regarding the evolution of the program and the teachers' and my experiences in it are described.

Demonstration Lessons

All six teachers thought that observing the two demonstration lessons in each of the first three laboratory class cycles had helped them in their teaching. Those lessons provided them with opportunities to see the use of questioning and probing in teaching mathematics. The demonstration lessons also allowed them to be spectators and concentrate on learning how their own students interacted with someone other than themselves, and they learned specific methods to cater to their students' needs.

> Watching somebody else teach and watching my students interact with another teacher helps me step back and see them in a different light, and I can reflect on how I can teach differently or maybe even better. (Anna interview; 15 December 2004)

> I get the most out of watching Lu teach in my class with my students, because I can use it. I can see what my students are thinking, what they are doing, and that's what I'm going to work with everyday when she does her lesson with my class, I can see Lu questioning my students and how my students respond to her. (Kay interview; 14 December 2004)

Anna reflected on the benefits of observing the demonstration lessons from the students' perspectives. She said that in the school, most of the adults were white females with a few African Americans, and "the children don't see people from other countries. The

children think this is it. And for some of them, this is as far as they go right here." Anna believed the program allowed her students to see people from another country. She said, "They hear me every day, and sometimes it is good to have somebody different, to see somebody new, especially from a different country." Macy shared her mathematics classroom with her special education teacher, and she found it "refreshing to listen to somebody else doing the mathematics lessons." Ivy thought that the demonstration lessons benefited her students, as it exposed them to a lesson that she would normally not do. She said, "You are doing more of the higher-order-thinking lessons with them. That's great because we spend a lot of time doing basic practice in the classroom." For Mary and Ivy, the demonstration lessons allowed them to observe how their students interacted with another teacher. In that way, Mary said, she could "just kind of sit back and watch them and see what they are thinking, and their thought process, and what they really understand."

> For me watching Lu benefits me most because I like to copy her. And I wish we had time in this school year for all teachers to visit different classrooms, because I learn that way. I want to see what the other teachers are doing, how they do it. Because you can get a lot of information and a lot of different strategies that each teacher is using. (Kay interview; 11 January 2005)

During the third laboratory cycle, I reflected on the two lessons. I realized that both lessons in the cycles had required the teachers to observe me and that there was no opportunity for them to observe each other. The teachers were passive participants in the two lessons, as I had done most of the work. I decided that for the teachers to have greater ownership of the program, they should play a more active role, especially in the second lesson in a cycle, when the team was together. That was the best opportunity to build a learning community and boost the team's spirit. I started to explore ways in which

I could modify the observation of demonstration lessons to make the experiences more meaningful and enjoyable for both the teachers and the students. Anna definitely benefited from observing me, but Ivy and Mary did not appear to. Ivy and Mary were in their first year of teaching second graders, and I believe they needed more opportunities to experiment with different teaching ideas with the children and get feedback on their teaching. I wanted to have some common experience for the teachers, but Ivy thought the team was already engaged in a common experience in the first demonstration lessons and that observing the second demonstration lessons was repetitious. Mary suggested that the professional development could be more effective if it provided the teachers opportunities to try in their classrooms some of the ideas discussed during the program. She believed that some of the teachers were still using drill and practice all the time in their classroom despite the attempts in the program to promote reflective thinking, hands-on activities, children's literature, and mathematical explanation and reasoning. Her responses prompted me to think of ways to involve the teachers in hands-on activities with their students.

> Some of the classes seem like all they do is worksheets….I feel like the kids need to be more engaged and more hands on. Some teachers, they like to teach it, and then the kids do it on the paper. That works for some things; it doesn't work for everything. (Mary interview; 17 February 2005)

From the teachers' feedback, I decided to modify the second demonstration lesson to involve the teachers in interactive hands-on activities, and have them observe each other as they engaged in those activities. For the fourth laboratory class cycle, I paired up the teachers and had each pair attend to a station in a modified version of Metric Olympiad for the second demonstration lessons. Eighteen students, three from each class participated in the second demonstration lessons. The students were put into three

homogenous groups with six students in each group to represent a real class setting. The groups took turns visiting each of the three stations. The students stayed at each station for 10 minutes while the teachers worked in pairs to assist the students with the assigned activities at the station. At the end of 10 minutes, a whistle was blown, and the students went to the next station.

The teachers said they benefited much more when they taught at the stations than when they were observing me during the second demonstration lessons. They were already observing me teach in the first demonstration lesson, and many now viewed the previous second demonstration lessons as redundant. The second demonstration lesson in the fourth cycle provided the teachers a chance to experiment, refine, and practice whatever skills and new teaching approaches they had learned from the first demonstration lesson with students from different classes, and they could think of different ways to guide students' learning. Macy preferred the stations to observing me in the second demonstration lesson because she said she learned best when she tried out new ideas discussed during the preparation of that lesson. Lana preferred the stations to observing me in the second demonstration lesson because she said she learned better from working directly with children and could see the strengths and weaknesses of the activities more clearly by trying them out with students. Kay preferred the stations because she thought that they forced all the teachers to experiment with hands-on activities and everyone was actively engaged. She also commented that seeing all the teachers actively engaged in hands-on activities was "like a dream come true." She suggested that I should force them to try hands-on activities. Kay also thought working in pairs at the stations allowed the teachers to observe and learn from each other.

> I prefer the station activities…because you are giving us the ideas, and you are almost…forcing us to do it that way. And that gives everybody a chance to see that it is not that hard to have everybody doing hands-on stuff. Everybody is involved…. I like doing the station together with somebody. Because when I was paired up with Ivy, she was saying something that helped me think of something I wanted to say, or I saw that she did it in a neat way, or asked it in a neat way, and vice versa. And we were teaching with each other, and helping each other, and I like that. (Kay interview; 24 March 2005)

> Just by talking about the lesson can't really help me learn. I get more things when it's hands-on. I don't visualize when you're talking. I learn best when I participate in doing something; hands-on, and I am going to see it. I observe it but I have to take a little step. I need to participate in doing something. (Macy interview; 14 April 2005)

> I like the station activities. The kids had more opportunities to do different stuff, ,and it was good to see other kids from other rooms, how they do the different things, and try out things. I like to watch you teach it, but if I don't try it then I don't know what works for me. It's like practice. And then the first time you do it, it is not so good. But as you keep going each time, you add to it. And just like your teaching, at first it was like [being a] guinea pig. So I think the practice was good. (Anna interview; 23 March 2005)

I continued to engage the teachers in teaching and observing their peers for the second lessons in the fifth and sixth cycles. The teachers continued to reflect on the experience of teaching and observing at the stations. Anna's experience at her station helped her to think about different ways to guide students' learning. Working with different groups of children at the same station allowed Macy to experiment with different approaches to presenting the material. Lana liked the station activity because it helped her tie mathematics to other subjects. She thought that the stations offered students a variety of activities to see mathematical concepts in different contexts. When I observed her lessons after the fourth laboratory class cycle on fractions, she extended the fraction flag activity with her own students. Mary had taught the first grade the previous year. Seeing some of the students whom she had taught that year together with students she had never taught before was exciting to her, as she could gain a new perspective on

how children learn. She believed that the children preferred the stations to the previous second demonstration lessons because they were more actively involved. None of the students asked to return to their exploratory classes, and all at the stations were engaged in their activities after the teachers participated in more station activities in the remaining lessons. Mary said she believed that the teachers were more comfortable with the station activities. They were more familiar with their roles in those stations and how the second demonstration lessons worked. Ivy thought that the activities at the stations should be related to paper-and-pencil problems. Her suggestion was used in the fifth and sixth laboratory class cycle by providing activity worksheets for the students to record their observations and results during the lessons. Macy believed that hands-on activities aided students' learning. She enjoyed working in the stations because they offered students more opportunities to be exposed to different types of activities and she believed that helped the development of children's left brain and right brain. However, she preferred whole-class teaching to having station activities in her class because she anticipated that the noise levels would be higher than usual, and she had a "low tolerance for noise."

The second demonstration lessons allowed the teachers to focus more on children learning mathematics, on different perspectives of children learning, and on their interactions with children as they used more questioning and probing. After working with their own students all year, the teachers had mentally categorized them into low, middle, and high learning-ability groups. Having to work with a fresh group of students in the second demonstration lessons provided them with opportunities to view the students' learning from a different perspective and to figure out different approaches to help them learn.

> If we got a different variety of children in there that aren't necessary in the same classroom, their abilities tend to stick out more. Because in a classroom, you have your students that are here, higher, and then the middle, and then low. But when you are in here with students you don't see every day, you don't really know where they are. And that gives you an opportunity to help them to figure out where they are, and that gives you an opportunity to say, "There may be some children in my class that are looking at it this way too. I need to make sure that I am reaching those children also." (Lana interview; August 2005)

Although I tried to pair up teachers in the stations, there were two occasions when a teacher had to work alone in her station because her partner was not at school. On one occasion a pair, Anna and Mary, decided to work individually, as they thought that a group of three students was more manageable than a group of six. This decision defeated the purpose of having the teachers work in pairs and observe each other, but I did not force them to stay as a pair. One disadvantage of having the stations was that the teachers were not able to observe my questioning techniques. Kay suggested that I demonstrate for 10 minutes how one activity could be done before having the teachers continue the activity with three students. I did not take up Kay's suggestion, because I wanted the teachers to experiment with different ideas in teaching the same concept so that they could share and discuss their experiences.

Setup of Second Demonstration Lessons

Selection of Students and the Teachers' Seating Arrangement

In the first laboratory class cycle, each teacher chose any three students from her class to participate in the second demonstration lesson. After that lesson, Ivy suggested choosing one student each from the low-, medium-, and high-ability groups in the class to

represent a regular class better. “When you have them all together, they learn from each other. I prefer them all together. It would be more true to life. It’s a reality.” Mary was very open to the investigative nature of the program from the beginning. She suggested that we choose a variety of students for the second demonstration lessons to represent the type of children that the teachers had to work with every day. And she was willing to try something else if that suggestion did not work. She also suggested that we use the same students every time so as to keep track of the students’ learning. Ivy’s and Mary’s suggestion was posed to the team, and we decided that beginning with the second laboratory class cycle, each teacher would select the same three students from each of the low-, middle-, and high-ability groups to participate in the second demonstration lessons. The teachers thought that having students from three ability groups for each demonstration lesson was more effective than having all from the same group, as a greater variety of students would be able to experience the lessons. After the third laboratory class cycle, however, the teachers told me that since we had been choosing the same children for the second demonstration lessons, some of them had been missing the same activity during exploratory time and that those children who were scheduled for the computer laboratory during that time were extremely upset when they were asked to attend the second demonstration lesson. I asked the teachers if we could choose a different group of children for each of the remaining second demonstration lessons, and they agreed. They said they would even select children who volunteered to attend the lesson. For the rest of the second demonstration lessons, the teachers chose a different group of children each time.

During the second demonstration lessons in the first and second cycles, the teachers sat together in front of their students to observe them. Mary noticed that some students were uncomfortable with that arrangement:

> The children may have been intimidated a little bit with us seated right in front….Instead of sitting right at front, we could just sit over to the side and still be able to see the kids and their facial expressions for the most part. That might work better, so the kids would not be like "Oh, my teacher is looking at me. I don't know what to say." (Mary interview; 12 January 2005)

I spread the teachers around the classroom in the next second demonstration lessons to alleviate the tension that some children felt.

Scheduling and Videotaping

After the second lessons in the first and second cycles, which were scheduled with the students during their exploratory time, I noticed that the students were not as keen as they were in their normal classrooms. The teachers confirmed that the children did not like to miss their exploratory class for the second demonstration lessons and that they showed more enthusiasm for the first demonstration lessons. During the critique after the second demonstration lesson in Cycle 2, the teachers suggested that we hold the second demonstration lessons in the morning, when the students were more alert and would not have to forgo their exploratory time. The teachers also suggested they could be in class with their own students teaching a regular class while I conducted the second demonstration lessons in the morning, and those second demonstration lessons could be recorded for the team to view and critique during the meeting. They preferred watching a taped second demonstration lesson to observing it live because it was difficult to remember and capture all the interactions between the students and me. With the

videotape, the teachers felt that they could stop or review any sections of the tape to discuss any interesting observations.

> When you are in there observing the lessons together, you can't just start talking to each other about what's going on, because it is distracting. Whereas you can stop the video and talk about it more deeply. (Anna interview; 12 January 2005)

I did not take up the teachers' suggestions of conducting the second demonstration lesson in the morning when the teachers were in their regular class and thus not able to be present, because the main purpose of the second demonstration lessons was to engage the teachers together as a team in some common activities or experience. After I explained the rationale for the second demonstration lessons to the team, the teachers agreed to continue to conduct the second demonstration lessons during the afternoon exploratory time. As a result of the teachers' feedback, however, I did decide to record the second demonstration lessons in the third, fourth, fifth, and sixth laboratory class cycles and use the videotape as a tool to help the teachers recapture significant sections of the lessons during the critique sessions. The teachers also observed the rest of the second demonstration lessons live during the afternoon exploratory time to get a deeper impression of each lesson.

Videotaping was useful to both the teachers and me. It helped me analyze my own teaching more deeply, and the team was able to generate more discussions during the critique, as we were able to go back to the tape to recapture any incident. Some teachers had to miss a second demonstration lesson, and they could participate in the critique by watching snippets of the lessons from the video. Since each teacher could only observe her partner at her own stations in the last three second demonstration lessons, she had no opportunity to observe the teachers at the other two stations. Watching the video gave the

teachers a glimpse of the full second demonstration lesson. They were also able to compare their interactions with the students with those of the rest of the teachers. After watching themselves teach second demonstration lessons on the tape, the teachers became excited about their own teaching, and all of them shared their thoughts spontaneously. They began reflecting more about their own teaching rather than complaining about their students' lack of ability. After watching themselves teach on the video, the teachers also remarked on how bad their teaching was and said they wished they had taught the material differently.

> I guess you don't think you look like that, not so big. Because the rest of the teachers don't really look like that. I guess it's the physical thing, hearing yourself. You know I really sound that "country." I guess you don't realize how you sound till you hear yourself talk or see it like your own TV. (Anna interview; 2 March 2005)

> Watching the video helps us...because that way we can get a look and see what we all were doing, plus we can get what everybody else was doing too. Because I don't really remember what went well in Kay and Anna's station when Macy and I were in our station. I remember hearing voices, but I don't really remember a lot of what they said or what they did. (Lana interview; 8 March 2005)

Weekly Meetings

Frequency and Duration

The team and their administrator had varied opinions on the frequency of the meetings. Throughout the program, Linda and Anna thought that meeting weekly contributed to the rate of growth of individual teachers as well as to the team.

> The every-week meeting works better than having them once a month. I know it might be taxing on Lu, but it was beneficial for us because we had the exchange, the talking back and forth. We just had time to share with each other, with the

> second-grade team. And Lu shares with us, and all of that works. (Anna interview; 15 August 2005)

> If you had come once a month, or once a quarter, I think we would have seen results, but it would not have been that quick. It probably would have been...longer and may have been a couple of years before we saw the growth that we did. (Linda interview; 13 July 2005)

During the first laboratory class cycle, Ivy and Kay suggested that I meet with the team less often. Ivy suggested that we cut down on the number of times we would meet in November, April, and May. In November, the school would be overwhelmed with school activities for Thanksgiving, Mathematics Curriculum Night, and Mathematics Day. In the third week of April, the students had to take their state tests. May was the end of the school year, and the teachers would be busy with stocktaking and getting ready for the students' yearly reports. Ivy also considered her master's degree program as her professional development, and she was afraid that she might not be able to cope with our meetings and that program. After the second laboratory class cycle, Kay, Ivy, and Macy asked to meet fewer times a month, as they felt stressed by the many activities happening in school. Some of the teachers were also involved in school committees, which required them to attend other meetings.

> Sometimes the meeting's a little bit of added pressure, but not always. You have your weeks where we've met Monday, and Wednesday, and Thursday. Sometimes I get my lesson plan written for the next two weeks. You all [the school] call the meetings you want to. But that's not because of you all; it just might be with any meeting. The school is always meeting because they are big on collaborating. Our meeting with you is getting better this year. Every meeting there is an agenda typed up. We have done better about sticking to the topic. We've actually gotten finished before our planning time was up. I wonder if we don't meet every week…like the week that you interview us if you didn't meet in the Tuesday meeting, just so it's not so much in one week. (Kay interview; 11 January 2005)

My intention was to devote the whole exploratory time to professional development. At the first meeting during the second cycle of the program, the team requested that they start off with administrative work before proceeding with the professional development. I agreed to this request but soon realized that by the time the team finished with their discussion of administrative work, very little time was left for professional development. Also, I observed that although the teachers enjoyed discussing their students and how they could help them when we met as a group, they were faced with more administrative work than they could cope with. In addition, the teachers were already meeting on their own one other day each week for administrative work. For Kay, the team meetings meant more paperwork and less time to do it, and hence she suggested that we meet every other week so that she could cope with paperwork. Kay said, "Tuesday and Thursday meetings is a lot of paperwork stuff, and you got to get this turned in. I would much rather be in my classroom and get more work done." Mary also believed that "sometimes when we talk about school and administrative stuff, people get flustered, or they get overwhelmed because it's more work to do. And the feeling gets carried over to the meeting with Lu." She believed that there were a lot of meetings at her school and that sometimes the meetings added together to become overwhelming. She believed that this program was beneficial to her and it was something that "teachers need to just take time to do." Mary would like the team "to talk about more things instead of just their schedule. It's just that there is so much going on. We cannot all fit into the 40 minutes. But it's not your fault." She also hoped that the team could work around their schedules to fit into the program.

I took Ivy's suggestions in planning for the number of meetings in April and May. Despite the teachers' persistent request to meet fewer times a month, I insisted on meeting the teachers once a week except for April and May because I believed that it was the school activities, festive celebrations, intensive interviews and observations of teachers' mathematics lessons throughout the program and not the meetings that added stress to the teachers. I was also trying to establish some routine in the professional development, and I believed that meeting once a week would contribute greatly to the effectiveness of the program. The teachers were generally supportive of the program, and they could see how the program had benefited their teaching practices. Hence, the team agreed to meet once a week except in April and May for the rest of the program. Ivy's and Kay's suggestions prompted me to create a calendar for the program that would list the days on which I would meet with the teachers, observe them, and interview them. I listed the kind of activities that would take place in each weekly meeting so that the teachers as well as the school administrator would be clear as to where the program was heading. The teachers' suggestion that the team should meet less often with me on certain weeks was also incorporated into the calendar. On the first week, we would plan the laboratory class cycle; the second week, observe the demonstration lessons; the third week, critique the demonstration lessons; and the fourth week, reinforce and share ideas generated from the critique. Interviews and classroom observations with each teacher then followed after each laboratory class cycle. The teachers and the school administrator were each given a copy of the calendar of events. I also put a copy on the teachers' bulletin board outside Macy's classroom to remind them of the activities on the

scheduled days. Lana said that the calendar benefited the teachers: “I think that was great because that way we can come talk about how we want the rest of the year to work out.”

During the second laboratory class cycle, I requested that the team share their exploratory time equally between the professional development and their own team meetings. The team agreed, and we decided that the first 20 minutes, from 1:40 to 2:00, would be led by Anna for administrative discussions, and the last 20 minutes, from 2:00 to 2:20, would be led by me for the professional development program. On weeks when the teachers were scheduled to observe the second demonstration lesson, they would devote 30 minutes to the program after they met as a team for 10 minutes to discuss administrative duties. Once the team and I had worked out this arrangement, I concluded that I now played a more definite role in the team. I also noticed that Anna tried to keep the 2:00 to 2:20 timeslot for the professional development by using an agenda to stay on task when she led the teachers. The teachers felt that the agenda helped the meeting to be more focused and productive in their administrative discussions and contributed to the team’s effectiveness. By the fourth laboratory class cycle, the team had gradually allocated more time for the program. The teachers believed that they were becoming more efficient with their meetings, and they tried to conduct all their administrative discussions on Thursday rather than on days when they had their professional development with me. Beginning with the fourth laboratory class cycle, the teachers devoted the whole 40 minutes to developing the second demonstration lessons when they were engaged in station activities.

Observing and Planning the Demonstration Lessons

I observed the teachers' mathematics lessons at the end of each laboratory class cycle, and the teachers usually taught a lesson based on the topic that the cycle covered. During the second cycle, Mary felt that those lesson observations by me were great opportunities for her to try out new ideas, refining or expanding what I did in the demonstration lessons. She requested that I give her feedback on those lessons. Observing the teachers was part of the research study but not part of the program, and Mary's suggestion gave me another perspective of lesson observations and their role in professional development. Just as the teachers observed and critiqued the demonstration lessons I taught, Mary was keen for me to observe and critique her mathematics lessons.

> [After being observed], we didn't really get to talk about the lesson that much. It would be great if we could meet and talk casually about what we could have done or other ideas to make the lesson better. Or what really went well, or what we could have changed without putting someone on the spot. Like we talked about Lu's lessons, and it really helped us. (Mary interview; 12 January 2005)

Kay wanted more conversation among the team and opportunities for the teachers to observe each other's mathematics lessons. She thought that it would encourage the team to talk more about their own mathematics lessons if they could see each other's lessons. Also, since I was observing all the teachers' mathematics lessons once a month as part of the research study, Kay suggested that I summarize my observations during those lessons in a chart and share it with the team during one of the meetings. I incorporated Kay's and Mary's suggestions into the program. Instead of sharing what I saw and thought about the teachers' lessons, I invited some of the teachers to reflect on and describe the lessons I saw them teach before allowing the team to critique those lessons. I thought that this activity would provide the teachers a glimpse of their colleagues' mathematics teaching

and enhance their learning as a team. I chose the lessons to be shared based on effective teaching strategies, the ideas the teachers picked up or modified during the program, or other interesting ideas they used in teaching mathematics. Kay's feedback also challenged me to think about how I could involve the teachers more when planning for the demonstration classes. I had been suggesting ideas for what the team could do in a lesson, and the teachers were asked only to modify the lesson. This practice had been in effect since the beginning of the program because we had only 20 minutes to plan for each demonstration lesson, and we needed to start with something. Kay prompted me to get the teachers to talk about what they had done in their classrooms before I suggested what we might do in the demonstration lesson. We tried this approach beginning with the third laboratory class cycle, and the teachers thought that sharing their practices encouraged everyone in the group to feel comfortable talking, gave them many useful ideas for teaching the particular topic during the planning, and inspired more of them to try new ideas. Many of the ideas that the teachers shared were used to plan for the demonstration lessons. The planning helped the teachers check whether they were on track with the syllabus and motivated them to keep up with the topics covered in each laboratory class cycle. Planning for the demonstration classes thus helped the teachers keep abreast of the syllabus and stay focused in teaching a particular mathematics topic. The teachers became more and more proactive in planning the demonstration lessons. By the last laboratory class cycle, they were suggesting a number of ideas and almost led the meeting on their own. All of their ideas were adopted in the first and second demonstration lessons.

Beginning with the fourth laboratory class cycle, we modified the second demonstration lessons to allow the teachers to observe me introducing the students and teachers to the different stations. It also allowed the teachers to observe students and their colleagues, and to teach at the stations. This setup benefited Anna most because she would not consider going to observe other teachers teach in their classrooms. She said she would feel uncomfortable observing her colleagues, so she figured that observing me teach her students and observing her colleagues in the different stations were the best way for her to observe someone else teach.

> I guess I am a sequenced person, really left brain. I have to have it written out. Linda says that she wants us to keep observing each other, and I said, "Oh." I don't like going to other people's rooms. I just don't feel comfortable. But if you are doing laboratory, that doesn't feel bad at all because it's like mutual territory. The second demonstration lessons, you are still observing each other. You are still with somebody else, and you learn from other people. (Anna interview; 15 August 2005)

The teachers thought that the change in the second demonstration lessons from observing me teach the lesson to taking turns teaching and observing their colleagues at the stations was a perfect transition because they were ready to experiment with new teaching ideas. Kay was already conducting station activities in her language classes, and she was thrilled that she could also conduct station activities in her mathematics class.

> I think in the beginning I liked the one where we were watching you because it helped us to see how you did it. And then it was a perfect transition into, now let's do it in groups. And I really liked that. I think we needed that. (Kay interview; 10 May 2005)

Variety of Activities

Use of Children's Literature

We started the program using children's literature to plan for the first and second demonstration lessons. Some of the literature was available in the school library. Ivy, who was new to the school and teaching second grade for the first time, liked the use of children's literature in mathematics instruction. She learned about the available resources in her school library for teaching mathematics and learned how to use those resources.

> I like the one with the book with the little sleepy boy who didn't want to get up. I like that. It was cute, and related time to [the students] and made it more personal….There are books in the library, and I'm sure that some of them are related to math. We get the supply ordered at the end of every year. We get to say the things that we want. I was at the other school last year, so I just got a basic order. I didn't get to choose what I wanted. But next year I will have a say in what I want. (Ivy interview; 18 January 2005)

The teachers thought that having the resources that they needed was important in this program because it saved them time looking for resources from scratch, and it gave them ideas on how and where to look for resources on their own. Ivy said, "When I was a student in college, I had time to…find books to go with lessons. But now as a regular teacher you don't have as much time. So the resources are already there for you, you know what each book is for, and that would save some time." In one case, during the fourth laboratory class cycle, children's literature shared during the program was used to develop a mathematics lesson. It was the first time Lana had tried using the children's literature I had provided. I later invited her to share her experience in reading and developing her mathematics lesson using the book *How Big is a Foot?* The teachers then became interested in compiling a list of children's literature that they could use in teaching topics in second-grade mathematics. During the course of the program, to meet

the teachers' evolving needs, we included two additional activities that had not been planned initially: preparing the team for the state tests, and field trip.

Preparing the Team for the State Tests

It was not a common practice for the team to discuss and prepare the newer teachers in the team for the state tests. Kay's experience as a first-year teacher the previous year had revealed the kind of help that would benefit her if she had a team to support and guide her in preparing her students for the test.

> I had never prepared students for the CRCT, and last year I wanted somebody to talk to me about it so bad that I would question people on the grade level: "What do I need to be stressing?" "Oh, just make sure you hit all those topics." And I couldn't wait to get to that test so that the next year I would know what I needed to hit. Now I feel comfortable that I am hitting everything. But last year, I definitely would like someone to say for all of us, "How are you going to prepare? And are you going to get them ready?" I feel like I had to figure them out on my own last year. (Kay interview; 8 February 2005)

Some teachers on the team were either unsure of what would be tested on the state tests or had different beliefs about what would be tested. After hearing Kay's experience and what some teachers needed for the state tests, I decided to include a discussion of the mathematics topics on the state test in the weekly meeting during the third laboratory class cycle. I gave a list of topics and the specific learning objectives to be tested on the test, and the teachers shared examples on the type of questions that had appeared on the test in previous years.

Field Trip

During the fourth laboratory class cycle, I saw a very interesting display on Macy's bulletin board in her room, and I took the other teachers on a "field trip" to Macy's room to view the bulletin board. Macy was not around that day, but I had her permission to share her bulletin board display. I showed the teachers the bulletin board

where Macy had put up pictures of 2D and 3D shapes. I asked them to examine the board and share their observations. The teachers had several responses. They saw Macy's creativity in using the bulletin board to teach mathematics. Those who believed that she was a drill-and-practice teacher were surprised that she could be a creative person in teaching mathematics. I then asked for the teachers' observations of the mathematical concepts illustrated on the board. Anna said that there were 2D and 3D pictures. I probed by asking the teachers to describe how Macy had arranged the figures. Kay said that the pictures were arranged according to properties of the 2D figures. When I probed further, the teachers said jokingly, "Just tell us the answer. We want the answer." This incident reflected the teachers' beliefs about how they taught and learned mathematics: There is only one right answer, and teachers should tell the answer instead of letting students investigate for themselves. I thought that this event strengthened my relationship with the teachers as well as some teachers' relationship with Macy. Macy had had a strained relationship with some of the teachers, who believed that she was a lecture-only teacher who could never be open to new ideas. The field trip allowed the teachers a peek at her creativity in teaching mathematics concepts. In the meetings that followed, I noticed that Macy started to share. The field trip to her classroom appeared to be a way for her to feel recognized by the team as well as by me for her teaching expertise. The trip to Macy's room had also allowed the teachers to get a better picture of each other's teaching practices, promoted an appreciation of each other's strengths, and boosted the teachers' confidence in sharing ideas during the meeting. I organized another trip in the fifth laboratory class cycle to Lana's room to sustain such noticeable teacher changes.

Resources

Notebooks, Articles, Activity Worksheets, and Manipulatives

Because Anna was the team leader, she became the keeper of any resources (usually one copy of each article) that I gave to the team. The articles contained teaching ideas from professional journals. We planned the demonstration lessons using some of the ideas from these articles. During the first laboratory class cycle, Lana observed that the articles were not easily accessible to the teachers, which deterred the teachers from reading them. She said she did not get a chance to read the articles because "Anna had them, and she is not here today. I don't know if she has finished reading them. Hopefully when she gets back to school, we would be able to get those articles passed around." Anna later suggested making the articles more accessible to the teachers by giving everyone a copy.

The teachers also expressed their ideas about what kind of resources they wanted from the program during the first laboratory class cycle. Mary said she liked the articles that I gave the team on shared lessons that people had tried and that had worked in their classroom. She wanted more examples of best practices and why those lessons were successful. She also wanted those articles to "really explain things and not just provide an overview" because she "wanted to try those ideas" in her classroom. Anna and Kay suggested that we have a variety of articles. They preferred short articles or materials that had practical ideas, providing hands-on activities and worksheets that they could pull out and use in their classes. Anna also said, "I like a lot of words sometimes. But sometimes I don't even have time to read the newspaper at home, and I love reading it." Responding to the teachers' feedback during the second laboratory class cycle, I gave each teacher a

copy of the articles and her own three-ring binder in which she could store whatever resources I give to the group. Anna later said, “Giving us a notebook, that’s a great idea. So we don’t have papers everywhere. Everybody got something.” Beginning with the second laboratory class cycle, I decided to include an assortment of long and short articles so as to cater to the varied needs and likes of the teachers. I also started giving the teachers worksheets and hands-on activities that they could pull out and use in their mathematics classes. We worked through “Sum of Triangle” and “Diffy” during the second laboratory class cycle. The teachers generally liked the worksheets because they believed that the worksheets promoted mathematical thinking and could be easily implemented in their classrooms. Mary believed that some of the teachers might be skeptical about the worksheets and suggested that I provide them with more articles that demonstrated that those resources worked.

> The Sum of Triangle and Diffy were so neat. And that was something I had never seen before other than having in the book. It’s neat to see how easy it is to implement something like that. It doesn’t take a lot of preparation. It was nice to see, that it’s just convenient and easy but still beneficial for the kids. More of those activities would be great and also just more articles showing that what are we talking about every time, that it does work. Maybe some of the teachers are skeptical about “do we really need all this professional development?” They see that these things have been proven to work; maybe we need to implement that in our room. I think that’s good for everyone to see it for themselves. Instead of just someone coming in and telling them. For some people were just like that; they want to see it for themselves written somewhere. (Mary interview; 12 January 2005)

> The sheets that you gave us the other day, those are new ideas. I’ve never seen it before. I do like it. In fact I’m going to make copies, so that when the kids finish their work, and they are waiting for others to finish, they can just sit and do this at their desk. (Ivy interview; 18 January 2005)

Those teachers who had time to read the articles liked them because they provided useful teaching ideas. The teachers also liked the worksheets given to them that were not

drill after drill. They already had many such drill-and-practice resources. Those teachers who did not have time to read or use any of those resources said that they were overwhelmed by other school work. At the end of the program, to encourage the teachers to continue learning and growing in their teaching practices, I gave them some additional teaching ideas and resources that they could try in their classrooms.

Throughout the program, manipulatives were used. The teachers thought that the activities and manipulatives used during the demonstration lessons promoted students' thinking and aligned with their goals in teaching mathematics. Having different hands-on activities at the stations further exposed the teachers to different manipulatives that they could use in their mathematics lessons. Some of the materials were new to them, whereas others were more common, such as measuring cups or scrap materials. The teachers could practice using the manipulatives. Resources were shared among team members as they made known the resources they had in their classrooms.

> I like the articles, and I also like the hands-on, the different activities ideas. So this is what you need, this is what you do, and I like that. Because it is just laid out, and a lot of things that you made, find, or have access to, I may not find or have access to, so it is nice to see them. (Lana Interview, 8 Mar 2005)

> And I think it was Anna who said, "I've all this stuff in that box." I didn't know that. So when we were going over it, and everybody is saying, "I have got this, and if you all want to do that, I can bring these from home, the measuring cup and containers." (Kay interview; 2 March 2005)

Closing Comments

The program evolved. It changed as more teachers were sharing ideas and new ideas were being generated and expanded as a result of the discussions. Although the

teachers' role in the professional development program increased beginning with the fourth laboratory class cycle, when they were required to teach and observe in the second demonstration lessons, they felt comfortable with their changed role. The teachers felt ownership of the program as they shaped its growth and evolution collectively with me. My role as the professional developer appeared to contribute to the effectiveness of the program, and the laboratory class cycle appeared to be important in generating more ideas and discussion.

> I feel like we all played a part. We were all working together. We all came up with new ideas, and we tried different things. And I think everybody has. So I think we all have a part of how the program has turned out. Like the use of video. It turned out to be very good. And you never know if it is going to turn out to be something good or bad. I think we kind of evolved, and things have worked out well for us. And I just think that things have turned out nicely. Most of the professional development programs that I have been in have not been in the school. And if they have, they have been one-day, two-day [sessions] at the most. And it hasn't been on-going so this [program] has kind of grown. We started out at one point, and then we have kind of grown into something else. And I do think it's good. We are able to take our time more, and I think that's why it has grown. Because I just think we just needed that extra time to do the things that we do appropriately. (Lana interview; 8 March 2005)

The teachers also thought that the program became more effective as they became more familiar with it. Macy said, "I think the program got more effective towards the middle and the end. In the beginning [you] kind of feel your way through things." The program required them to observe, to experiment with different ways to teach a mathematics concept, and to share and critique any ideas they had about the lessons, students, or ideas for teaching mathematics. The resources and activities used in the program were another important factor contributing to its effectiveness. The teachers found the resources and activities applicable in teaching mathematics and easily accessible. Although the interview and lesson observation were not intended to be part of

the program, they helped me gather more extensive feedback about the teachers' experiences, their sentiments about the program, and their reflections on their teaching. The interview and lesson observation data also helped me make important suggestions and decisions to modify the program to suit the teachers' needs and expectations. From the start, the teachers viewed the interviews and the lesson observations as part of the program. Although they thought that the interviews were the most time consuming and least beneficial component of the program, the interviews greatly affected the teachers' reflection on their own teaching and participation in the program. They were asked to reflect on their mathematics lessons, the program, and their team. After each laboratory class cycle, those questions encouraged the teachers to pay more attention to their teaching practices. For example, one of the questions was to share a mathematics lesson that went well and one lesson that did not go well. After they realized that they would be asked these questions in each interview, four of the teachers paid special attention to their teaching practices and shared in great detail their reflections regarding those lessons.

The duration of the program, the frequency of the meetings and observations, and the time available for the teachers to participate and apply the knowledge gained from the program played an important role in the effectiveness of the program. Lack of time was the greatest deterrent for the teachers in trying out new ideas they identified during the meetings as they struggled with the heavy demands of the curriculum, administrative work, and other school activities. By running the program a second year, I enabled the teachers and me to establish greater familiarity with the program and each other, and was able to provide greater support for the teachers' professional growth. The weekly meetings and the laboratory class cycle set up a routine for the teachers that built

professional development into their everyday practices. Although the program and the research study demanded great energy and time from the teachers, they realized that they had to invest sufficient time for the program to be effective.

CHAPTER 6

TEACHERS' PERCEPTIONS OF THEIR CHANGE IN INSTRUCTIONAL PRACTICES

In this chapter, I highlight common changes in the teachers' instructional practices before describing how each teacher thought she had changed as a function of her experiences. The discussion of individual changes is organized according to the number of years the teachers had been teaching at the school: 1, 2 or 3, or more than 3.

Perceived Changes in Teaching

All the teachers said they believed the program helped them rethink and reflect on their teaching practices and had affected them most in their interaction with their students and learning in what their students were thinking. They all showed changes in their teaching techniques. They focused more on students' thinking, tried harder to teach mathematics for understanding, believed more strongly in learning mathematics as a process, and provided more activities and hands-on experiences to cater to their students' varied abilities to learn mathematics. In the following paragraphs, I describe in more detail some common changes the six teachers made in teaching mathematics.

Questioning, Probing, and Students' Explanations

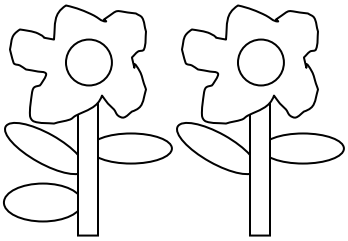
The teachers said they believed they had changed in teaching second-grade mathematics from being more procedural to allowing more questions, probing, and students' explanations. Although the teachers had used some questioning in teaching

mathematics before the first laboratory class cycle, they thought that watching me demonstrate questioning techniques had encouraged them to employ more questioning in their mathematics classes. It also helped them develop their questioning skills further to have students explain their solutions even when they were incorrect. The teachers used more probing in their mathematics classes instead of always telling their students what was wrong with their solutions. The program also engaged students in mathematical explanations and in examining which part of a solution was correct or incorrect. Lana said, “Having the kids think about why their answers are right…so that they can tell me which one was right which one was wrong” helped to promote mathematical thinking instead of simply mastering mathematical skills.

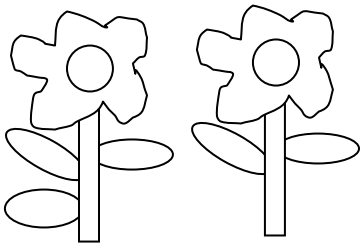
I illustrate how Ivy had changed her teaching. In the second lesson observation on addition of two-digit whole numbers without renaming, Ivy wrote 85 plus 64 on the whiteboard with two different solutions and then asked her students how they knew whether 149 or 139 was the correct answer. Ivy instructed her class to “add it again and see what was wrong.” Next, she performed the subtraction using a procedure and repeated the procedure using other numbers. Ivy asked only factual questions and did not explain why those procedures made sense.

In contrast, during the sixth lesson observation on multiplication, Ivy placed two groups of two flowers on the whiteboard and wrote 2 on top of each group of flowers. Ivy questioned the students on the multiplication symbol and helped the students view multiplication as involving sets of objects, and as a special case of addition in which all the addends are of equal size. She also attempted to help Mark figure out why addition was used instead of multiplication in the teaching episode below.

Mary's garden
2



Tom's garden
2



Ivy : We want to find out how many flowers are there altogether. What can we do?
Class : Add
Ivy : How many flowers are there in the two gardens?
Cindy : 2 and 2.

Ivy writes 2 + 2 = 4 on the board.

Ivy : We can multiply. How can we write a multiplication statement to figure out how many flowers are there in the two gardens? How many groups of flowers do we have?"
Jaren : 2.
Ivy : How many in each group?
Dave : 2.
Annie : 2 times 2 equal 4.

Ivy writes 2 + 2 = 4 and 2 × 2 = 4 on the board.

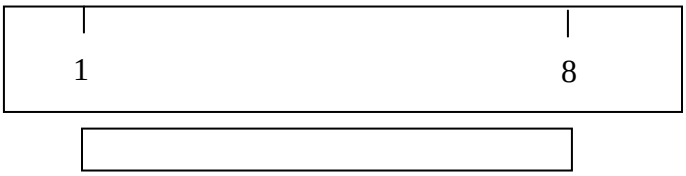
Ivy : How do we figure out how many stems are there in the gardens?
Class : Add.
Ivy : What would I add?
Class : 2 plus 2.
Ivy : Is there another way to figure it out?
Class : 2 times 2.
Ivy : Why 2 times 2 and not 2 times 4?
Peter : Because you have only 2 in each group and 2 groups.
Ivy : How many leaves are there in Tom's garden?
Class : 5.
Ivy : How many leaves are there in the 2 gardens?
Daniel : 5 plus 5.
Mark : 5 times 5.
Ivy : 5 times 5 means we have 5 groups of 5.

Ivy writes 5 + 5 + 5 + 5 + 5 on the board.

Ivy : Is this the number of leaves you see?
Mark : No.

The teachers had changed, but there was still room for changes. For example, although the teachers began to use more questioning and multiple solutions in solving a mathematics problem, they could have provided more opportunities for their students to figure out why their solutions were incorrect. During the fourth lesson observation, Mary could have asked her students to figure out why Jane's answer was correct and why Ivan's answer was incorrect in the following teaching episode. Mary showed very little change in her questioning techniques in the remaining two lesson observations.

Mary : Notice, we are going to use the inches today. I am going to ask how long this strip this? This is where Ivan puts it, and he says he has 8 inches.



Mary : Can someone come up and tell me if they will do it in a different way?
Jane : I think it is 7.
Mary : Tell us what did you do.
Jane : We have to put it at zero.
Mary : Jane, you say it is 7. But Ivan says it is 8. Only one of you has the right answer. It is easier to use the very end of the ruler at the zero. So, when Jane ended, she has 7 inches because she started at zero. But Ivan started on 1 and ended on 8. Let me show you what Ivan has to do. He has to subtract. How can Ivan get a correct answer?
Joy : He can subtract. 8 minus 1.
Mary : Where did you get 1 from?
Joy : From where you start from.
Mary : So the pencil is 7 inches. If I start at 4, where does it end?
Class : 11.
Mary : So this pencil. How many inches long?
Class : 7.
Mary : What is the easiest way to measure? Where do you put your pencil?
Class : At zero.
Mary : How can I figure out how long if the ruler starts at 5 and ends at 12?
Peter : 7.
Mary : How do you find out?
George: He subtracted 5 from 12.

Mary : Or he could say he started at 5 and ask how many inches from 5. And then goes 5, 6, 7,…12. Some of you say you want to start at zero, some at 3. Does it matter? No. Because as long as you are comfortable with whatever way and remember when to subtract.

Although the teachers now used more questioning in teaching mathematics, they often seemed unable to use their students' responses effectively to develop their lessons. During the sixth lesson observation, Anna ignored the finger multiplication for 9-times facts mentioned by Daisy when Anna was teaching multiplication in the following teaching episode.

Anna : I have 5 groups, 9 in each group, how many do I have?
Class : 45.
Anna : I can sit here and count 1, 2, 3,…, 45
Sue : You can just count by 5, 9 times.
Anna : Show me how you do that?
Sue : 5, 10, 15, 20, 25, 30, 35, 40, 45.
Anna : 5 times 9 is 45 and you check that 4 plus 5 is 9.
Daisy : My mom taught me the nine times table using fingers.

Anna continued the lesson by illustrating 5 groups of 9 pictorially.

Teaching Mathematics for Understanding and Focusing on Students' Thinking Skills

After the teachers taught at the stations in the second demonstration lessons, and observed how students reacted to the different mathematical concepts through the activities, they said that students should understand what a mathematics concept really means and not just know how to arrive at the correct answer. After observing me in the first demonstration lessons, the teachers also came to think that students should know why mathematics is done in a certain way so as to develop their higher-order-thinking skills. They said that knowing why mathematics works would help students use later the mathematics they had learned. The teachers began to use students' explanations to check whether the students understood the mathematics taught in class. They also said that the

students would be able to apply mathematics in their daily life if they understood the mathematics they had learned in class.

> I look at things a little bit differently now. It's not just that they know how to do what I asked them to do. Instead, it's why they are doing it, can explain how to do it, and can explain why they are doing what they are doing. I think that's probably been the biggest part for me, knowing or making sure that they understand. (Lana interview; 3 February 2005)

The teachers said the program redirected their attention to their students' thinking processes and helped them establish developing students' thinking skills as the most important component of a mathematics lesson. Once the teachers believed that mathematics should be taught as "a thinking exercise, or an exercise in thinking" (Lana), they altered their mathematics instruction according to their changed belief about how children learn mathematics. They changed the type of questions they asked in their classroom by using a lot of "Why do you think that?" type of questions to evaluate their students' learning and to fill in the gaps in their learning "if they have misunderstood the concept or they missed a step" (Lana). They said that having more questions in their mathematics class helped them understand their students' mathematical thinking and find ways to develop that thinking. They also said that asking their students "Why?" enabled the students to eventually figure out their misconceptions on their own. The program, by focusing on children's thought, provided the teachers support to reflect more deeply about their teaching and how children learn mathematics.

Different Teaching Approaches and Multiple Solutions

The teachers had believed that teaching students one way to solve a mathematics problem was the best approach to having them master mathematics concepts. After observing me approach the subtraction of two-digit numbers with renaming using the

hundreds chart, base-ten blocks, the game of Race to Zero, and the usual paper-and-pencil method in Demonstration Lesson 6, the teachers saw the possibility and the benefits of using different approaches in teaching a mathematics concept. Lana said, "I'm just learning that there are different ways to get there…and there are more ways to get there." Anna said, "I am able to think about the different things I am teaching in another way, using another approach instead of the same things that we have been doing for the last 15 years…try something new." The program also encouraged the teachers to engage students in mathematical thinking by exploring different solutions to mathematical problems.

Learning Mathematics As a Process and the Use of Manipulatives

Instead of teaching students simply to perform on their mathematics tests, the teachers said that the students would have a better understanding of a mathematics concept if they focused more on the process than on the product. The teachers also said that once the students understood the mathematics concepts, were able to apply them in various contexts, and mastered the basic procedural skills, they would be able to perform on their mathematics tests.

The teachers said that drill-and-practice activities were necessary to equip students with the skills to master their computation skills and to move on to higher-level skills but that such activities were not sufficient in learning and understanding mathematics. Some of the teachers were already using manipulatives in teaching mathematics. The program encouraged more of them to use manipulatives more effectively by demonstrating how manipulatives could be used to teach mathematics concepts with understanding. For example, in the first two lesson observations, Anna

started her mathematics lesson with students practicing their mathematics facts using flash cards. She would arrange her students into two rows and had them take turns in pairs to answer questions from the flashcards when it was their turn. The first student in the pair who answered the basic facts correctly stayed in the line. The student that answered incorrectly or was slower in giving the right answer returned to his or her seat. Eventually the last three students who remained in the line became winners of the game. Some of the problems in the flashcards were 7 + 7, 12 - 7, 15 - 6, 3 -___= 1.

In the sixth lesson observation, after being encouraged to use manipulatives, Anna used the flash cards and base-ten blocks to teach for conceptual understanding. She had her students represent the product of the two numbers 5 and 9 shown on a flashcard using base-ten blocks.

Although the teachers used more manipulatives in teaching mathematics, they did not fully connect the pictures, manipulatives, spoken language, and written symbols. For example, when I observed two students in Anna's class representing the product of 5 and 9, they took out a bundle of base-ten blocks and arranged them in any manner they wanted. Anna did not check how the students were using the base-ten blocks. She instructed the students to stop their tasks, and she illustrated the meaning of the product on the whiteboard as 5 groups of 9.

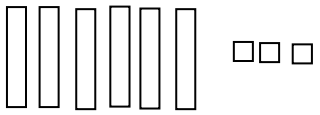
Anna : How many groups will I have 5 times 9?
Steve : 5.
Anna : You have 5 groups and how many dots do you have in each group?
John : 9 dots.
Anna : How do I show 5 groups of 9?
Tom : Draw 5 circles and put 9 dots in each circle.
Anna : Why do you want to put [them] in a circle?
Taylor : Because it is easier.

Anna then counted 1, 2, 3, …, 9, 5 times, and pointed to each dot that she drew on the board as she counted them.

Anna : I have 5 groups, 9 in each group, how many do I have?
Jenny : 45.

Anna explained the concept of multiplication using pictures, and she instructed the students to illustrate the concept of multiplication using base-ten blocks. Although she engaged the students in the use of base-ten blocks to illustrate the meaning of multiplication, she did not make an attempt to connect the pictures, manipulatives, spoken language, and written symbols.

The teachers tried to teach for conceptual understanding using manipulatives; however, there were still areas where they did not use the manipulatives effectively to help the students understand the mathematics. For example, in the third lesson observation, Kay had the opportunity to explain to the students why one might choose to start the subtraction problem with the ones column instead of the tens column using the base-ten blocks. Instead, Kay had simply told her students it was wrong to start the subtraction problem anywhere else other than the ones column. See the teaching episode below.

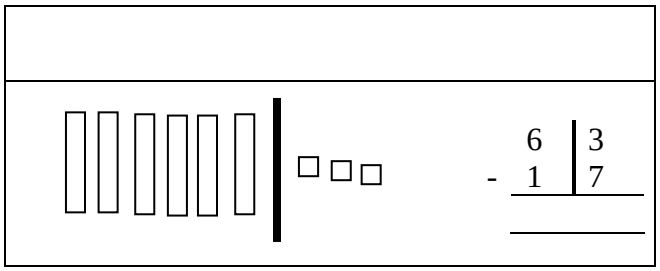
Overhead transparency	
Kay wrote 63 – 17 on the overhead transparency.	6 3 - 1 7
Next, Kay illustrated the subtraction using base ten blocks.	 6 3 - 1 7

Kay: We are going to call the blocks the units or the ones. We have done the first step, “Read the problem”. Our first number is

63. What is our second step?

Tammy: Split the problem into tens and ones.

Kay split the base-ten blocks into tens and ones by drawing a line.



Kay : What is the third step?
Charles: Start on the right.
Kay : Because?
Charles: Anywhere else is wrong.
Kay : What is the next step?
Nick : You ask yourself, are the bigger numbers at the top?
Kay : Is it?
Class : No. [The number at the top is smaller than the number at the bottom]
Kay : Because the number at the top is 3, and 3 is less than 7. So you go next door, knock on your neighbor's door and say, "6 tens, we need to borrow 1 from you." We take it, and how many tens have we left?

Students' Perspectives

According to constructivist theories of learning, children are actively engaged in constructing their own knowledge from their personal experiences. Mathematical knowledge is constructed by learners as they seek out meaning and make mental connections in an active manner. It is thus important for educators to understand mathematics from the children's perspectives to help us improve our classroom instruction by anticipating the difficulties children may face in learning mathematics. My use of colored water in activities involving measurement in the fourth laboratory class cycle had a deep impact on the teachers. They had never thought that coloring the water would enhance the students' ability to read off the amount of water in a container. Macy said, "The color helps them see things. It [makes] it more visual to it." This incident provoked the teachers to think about teaching and learning mathematics from the students' perspective. The teachers, however, had mixed feelings about conducting such

activities in their classrooms. Macy was concerned about the students' messing up the classroom with careless handling of the water, whereas the rest of the teachers were in favor of using activities involving colored water.

> What the blue water experience represents to me was that you think outside of the box. You are not doing the same old thing that you have done year after year after year…something different and it's creative and you are showing us that it is hard to see the white water so…make it blue. And the kids love it. (Ivy interview; 15 August 2005)

After observing the teachers at the end of Laboratory Class Cycles 2 and 3, I identified some crutches that the teachers used to index distributions of subtraction and addition, and I discussed how those crutches could pose learning difficulties from children's perspectives. I then suggested to the teachers how children can be guided in understanding the addition and subtraction algorithms after recognizing these proposed difficulties. A detailed discussion of the use of crutches in addition and subtraction with renaming is in the appendix. The teachers said that the discussion of the crutch helped them realize that they had not thought about the possible difficulties that mathematical symbols could pose to the students. Lana said, "It was interesting to see that three of us do it one way, and three did [it] the other way. It was interesting to know that nobody really knew where they got it from, or where originally came from."

At the end of the program, the teachers said that the use of manipulatives and station activities were two ways to help students understand mathematics. They also said that there should be a mixture of conceptual understanding and procedural knowledge in teaching mathematics. Kay, Anna, Mary, and Macy said that conceptual understanding precedes procedural knowledge. Kay said, "Young children may, through drill and practice, say that 2 and 3 makes 5. But if they don't start with manipulatives, for

example, 2 cubes and 3 cubes, and make them together, they may never grasp that 2 and 3 together is 5."

> Whatever you try to teach, like math facts, show what it means when you have addition and have them able to explain what that means. Show what subtraction means and have them be able to explain what it means. And have them relate to each other. Then, work on different games and stuff. Get them to practice after they have the concept down. (Anna interview; 15 August 2005)

Mary said, "Mathematics should be taught where the kids are actively involved, and they are doing a lot of the talking, explaining, reasoning, and the teacher keeps the [conversations] going, getting the students to come up with more things during the lesson." She said, "At least 4 out of the 5 days, my class was doing hands-on in mathematics. The students were either working with a partner or with a small group reasoning out things." Mary also said that her class did some paper-and-pencil work when it was appropriate. She said, "We don't do that much of paper-and-pencil."

Macy said that she was using more manipulatives and activities in teaching mathematics at the introductory stage of a mathematics topic. She said, "After that, you have to know that the kid can do the mathematics. So you still got to have the practice. You still have got to have the paper-pencil. Paper-pencil becomes very important."

In contrast, Lana and Ivy did not think that the order in which procedural and conceptual knowledge were taught mattered. Lana said that she would like the students to understand the mathematics by connecting it to their everyday activities. Ivy said that many first-grade teachers overemphasized the use of manipulatives and neglected the use of procedural knowledge in teaching mathematics. Ivy said that this neglect resulted in many of the second-grade students not being able to "read simple directions and figure

out how to do mathematics problems. And it was hard for them to sit down and even do a worksheet with 15 mathematics problems on it."

Why Did the Teachers Change Their Teaching?

In this section, I elaborate some common reasons the teachers gave for changing their teaching of mathematics.

Better Student Performance

A main reason the teachers identified was that their students performed better in mathematics by asking questions and reasoning through their solutions. For example, Kay tried using some of the ideas she had learned from Demonstration Lesson 1 and saw great improvement in her students' ability to read elapsed time. Macy said that she had picked up ideas for teaching time from Demonstration Lesson 2 that helped many more of her children differentiate between the minute and the hour hands in their work. That experience left a deep impression on her.

> The Demonstration 2 lesson that sticks out is the lesson on time. And since that lesson, I have used the idea, and it has worked. I have used two clocks to show one time and an ending time. When I was assessing students who had mastered elapsed time, I had 17 or 18 out of my 22 students do an elapsed time. That seems to click. It helped. Last year, when I taught elapsed time, I never thought to put two clocks up. (Kay interview; 14 December 2005)

> You used two circles: one for the hour hand and the outer circle for the minute hand. And this give the students something concrete to work on. That was good for me because it's very confusing to get all those hands. I am learning another way to have my children understand those hands. (Macy interview; 13 December 2004)

The teachers said that improved mathematics test scores at the end of the program built their belief in the program and further reinforced their motivation to change their

instructional practices. They were also motivated by their students, who now had a reason for working out mathematics in a certain way and were always ready to explain their reasons and logic to the rest of the class.

> I changed because … the children…were very good about the demonstration classes….They already knew that you were going to ask them "why," so they knew that they have to have an answer. I think it got them to really think, to expand their thought processes….Not just a way to work out the right answers, but "Why did I get the right answer? Why did I get the wrong answer?" I think it expanded their thought processes and really broke through on some of those higher-order- thinking skills that they can use throughout their lives. (Lana interview; 18 August 2005)

Increased Proficiency in Teaching Mathematics

Another common reason the teachers gave for changing in their mathematics instruction was that they understood their students better after employing more questioning, probing, and students' explanations, and they were able to help their students "fix their problems" with a particular mathematics concept more effectively. This change could be seen in the lesson observations. For example, when Mary asked her students to figure out how long an object was when placed against a ruler, she was able to help her students relate measurement to the number line. She said her students were able to understand why they could subtract the starting point from the ending point after placing the given object on a number line.

The teachers said that the sharing of different ideas and discussing how different students learned helped them come up with better ideas and a variety of teaching approaches to cater to the varied needs of students. This change was evident from the lesson observations, as the teachers used more activities in teaching mathematics as the program progressed. Some of the activities were ideas shared during the meetings. The teachers said that some of the activities were based on ideas they learned elsewhere.

Changed Beliefs About How Children Learn Mathematics

Another reason for the teachers to change was a change in their beliefs about how children learn mathematics. During the program, the teachers said that they changed from believing that young children learn by being told how to do mathematics to believing that young children learn mathematics when they are actively engaged in their learning and that they learn and remember better when they are manipulating objects. The teachers also said that having the opportunity to practice what they observed in the station activities after observing me teach the first demonstration lessons in the last three laboratory class cycles provided them greater insight into how children learn. Anna said, "What was unique about this program was that we had you teach for us. And we actually got to practice, and try out the different ideas." Mary said that the teachers no longer conducted mathematics lessons with just having "the students to open up their books, and the teacher explain what we are going to do that day, and the kids sit there and work out [of] the book." The teachers said that mathematics should be taught so that the students are actively involved and are doing a lot of the talking, explaining, and reasoning. The use of students' explanations and reasoning was evident in the lesson observations after the first laboratory class cycle, and the teachers refined and improved their questioning techniques for the rest of the lesson observations.

Some areas of teacher change were different with different teachers and took place at a different point of the program. In the remainder of this chapter, I present how the teachers changed as a function of their experience from the perspective of the first-year, the second- or third-year, and the more-experienced teachers. Mary and Ivy were

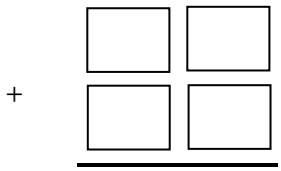
the first-year teachers. Kay and Lana were the second- and third-year teachers, respectively. Anna and Macy were the more-experienced teachers.

First-Year Teachers

Use of Mathematical Games

Mary and Ivy had different beliefs about their students' mathematical learning abilities throughout the program. Mary had a gifted class, and her students were moving beyond the basic mathematical skills to more challenging mathematical tasks. Her class was also easily bored with routine tasks, and she had to include more games and challenging tasks to make her lessons more enjoyable. Ivy was struggling with teaching the basic mathematical skills to her students. She used to believe that they needed to master only basic mathematical skills and that they could always learn how to think later.

After observing the first demonstration lesson in the second laboratory class cycle, where I engaged students in the Race to a Hundred activity, Mary saw how she could make her mathematics lessons more enjoyable for her students by using mathematically rich activities and games. Mary said, "They've done so many worksheets; they are tired of worksheets. They needed a game. They get more out of it because they are thinking more, not just writing down on their worksheets." For example, in the second lesson observation, Mary rolled the dice four times and got 3, 5, 5, and 1 (in order). Mary told the students that whoever obtained the largest sum when they put the numbers in the boxes were winners of the game.



Jenny : We have to do the ones first.
Mary : Because you may need to regroup your answers, always do your ones first.
Mary asked the students to raise their hands if their sums were higher than 110.

Mary : How do I know that you can't have more than 104?
Peter : You want the bigger number in the tens column.
Mary : The biggest number here is 5, and they are both in the tens column, so 104 is your biggest answer.

Mary also began to incorporate more questioning in the games and activities, which she thought would challenge the students to think more about the mathematical concepts and different strategies used to solve a problem. From trying out games from professional journals and games she learned from other teachers, she built up a repertoire that she could use, and she learned which games were more suitable for her students.

Mary was the only teacher on the team to consider alternative modes of assessment such that assessment became a tool to inform instructional decisions and guide students' learning. She said that the traditional paper-and-pencil tests did not allow her to understand what her students were thinking, and they did not provide the appropriate guidance her students needed. That belief became especially strong after she used more questioning, students' explanations, and mathematical games. She was inspired to think of ways to assess students that required them to explain their solutions and give reasons, which enabled her to provide more feedback to her students. She was also inspired to devise mathematics assessments in which students were asked to identify and explain what was wrong with a solution.

Ivy had previously taught mathematics to older students and had had limited time to include games and activities in her mathematics lessons. Teaching second graders gave her more time and flexibility to include games and more activities in her mathematics class, as she was in charge of all the subjects except exploratory time. After the second laboratory class cycle, she tried using more games. The second demonstration lesson in the fifth laboratory class cycle allowed her to use geoboards to help a group of students read simple fractions. She also guided them in drawing the fractions that they formed on the geoboard onto geoboard grid paper. After this experience, Ivy made greater attempts to connect the concrete stage of learning to the abstract stage. She realized that many students were unable to make the connection without a teacher's help.

> I found that a lot of times, people would do the hands-on, and then later they go back and they said, "Okay, we did this the other day, and I want you to do this now with the paper and pencil." And the kids can't make the connection from the hands-on to more abstract form. The experience makes me think … about how can I take this from the concrete to the abstract even if they are not ready. I think it is good to expose them to more abstract thinking, and some of them sometimes surprise me. (Ivy interview; 12 April 2005)

Higher-Order-Thinking Skills

Mary had been looking for ways to challenge her gifted students, whereas Ivy had previously covered only basic mathematical skills with her students, as she believed they could only cope with learning such skills. Also, Ivy had been in the school system when it adopted mastery learning, and she said, "There are many kids being retested when we do mastery learning. So trying to make sure they were getting those objectives mastered, you really didn't have the time to go and teach the higher order thinking." As a result, she had not provided opportunities for her students to engage in higher-order-thinking tasks. After seeing her students cope with the higher-order-thinking-skills during the

demonstration lessons, she said, “I think about expanding more enrichment activities, abstract thinking now. I don’t want to just do the basic skills. I ask what can we do beyond that.” She said she began to incorporate higher-order-thinking strategies in her teaching by using more student explanations and games. It was evident from the lesson observations after the second laboratory class cycle that Ivy was using more questioning and explanations in her mathematics lessons. Although she had used activities in the first two lesson observations, I observed that the activities she used were mathematically richer in the rest of the lesson observations.

Ivy and Mary thought that they benefited from the weekly meeting, as Ivy put it, “because that’s when we actually get to sit down and share our ideas.” Mary and Ivy benefited from hearing and sharing ideas that other teachers had tried in their classrooms because they were teaching second graders for the first time, and that sharing gave them some knowledge about second graders and some teaching ideas that they could try out in their classrooms. Ivy said, “For me, being new in second grade, it has been a great help because I came in not having anything for second grade.” Ivy said she changed in her teaching because she believed that was the only way to keep abreast of the challenges as a new second-grade teacher. She had been trained to use mastery learning in teaching mathematics. She believed that the school was “done with mastery learning,” and she was ready to pick up new approaches to teaching mathematics in order to cope with new demands from the state in teaching second graders. Ivy also said she believed that the new state standards required students to be in cooperative groups, and she thought that the program helped the team meet this objective. She was motivated to change because there was an alignment between what the program promoted and the standards by the

state. She said, “The new standards that are coming down from the state, everything is more of a collaborative….The program helps you…relate to the more traditional methods of teaching.” Ivy thought that “all the information, different ideas and different ways of doing things from the program” that we shared during the meetings contributed to her long-term career goal. She also believed that the program “helps the team see a variety of things they can do and keeps them from getting stale.”

Second-or Third-Year Teachers

Pedagogical Knowledge for Teaching

Until the first demonstration lesson in the fourth laboratory class cycle, Kay had always thought that her way of teaching mathematics was the best for her students. She had always insisted that her students start measuring by placing the object to be measured at the zero mark because she believed that was the only way students could learn how to measure a given object. After observing how I guided some students in measuring some objects without starting at zero, Kay was the only teacher who said she was able to identify one misconception she had about measurement that which would change the way she taught the topic. She recognized she could develop her pedagogical knowledge for teaching and listening to students and helping them develop their solutions even though those solutions were not what she had in mind. Kay said that observing me had had a great impact on her teaching. She made every effort to model my use of questioning, probing, and having students explain their solutions. She thought that she had become a

better mathematics teacher because she had made the effort to explore students' thoughts and use their solutions to guide them to figure out why a solution might be incorrect.

Kay had also used to believe that she had all the pedagogical knowledge she needed to teach mathematics; hence, she would simply tell her students how to do a mathematics problem. She reflected that children sometimes understand better from their peers' explanations other than from their teacher after seeing that she could learn mathematics so much more by listening to and trying to understand her students from the demonstration lessons. Kay was the only teacher who said that she could learn pedagogical knowledge for teaching mathematics from her students.

> Lately I have kids tell me "Yeah, that works. I did it." And I tell them "Go up there and tell the class," because I cannot say [it] better than they did. It helps me to question more, see what they are thinking, and know that I don't have the one right way. (Kay interview; 10 May 2005)

I observed that Kay made use of strategies that were more mathematically meaningful after the first laboratory class cycle. For example, before the first laboratory class, Kay demonstrated some strategies for students to remember the steps for rounding off to the nearest tens. She told her students that 5, 6, 7, and 8 were numbers with powers and that 0, 1, 2, 3, and 4 were numbers with no power. She then gave several examples to illustrate how those numbers with or without powers were used in rounding off to the nearest tens. For example, in the number 34, Kay said, "The number 4 in 34 had no power so it went to heaven, and it was replaced with zero. 34 therefore became 30." Another example was 39. Kay said, "The number 9 in 39 had lots of power. So you add one to the number in the tens place. That is, 3 became 4." The number in the ones place went to heaven, and it was replaced by zero. Hence 39 became 40 when rounded off to the nearest tens. After the first laboratory class cycle, I observed that Kay used a chant to

address the addition of two-digit numbers with renaming, using the problem 8 plus 6. There was more mathematical reasoning in the chant that Kay used in the lesson after the first laboratory class cycle.

Kay: We should have 8 at the top and 6 at the bottom. Look at this ones house. We're too crowded. How many can live here?
Class: 9.
Kay: Can we make a ten out of these?
Class: Yes.

Kay starts taking away the 10 ones one by one and she places them in her hand. She counts 1, 2, 3, …,10 as she removed the 10 ones.

Kay: Okay. [Chanting] Look at your hand. You're moving out. You're grown up. You turn into a ten. So now you put a ten down. You can't throw away the ten. You have to move them over.

Different Modes of Instruction

Kay said she would previously tell her students, "This is how you do it, and I want you to do it this way. These are the steps you are going to follow, and there is no other way." After her experience at the stations, she said she began to believe that there are many ways that children learn instead of "being told the right way to do things." She was the only teacher who said had started using several modes of instruction like art and crafts, songs, and drill-and-practice activities in her mathematics class to cater her instruction to the different learning styles of her students.

Use of Activities and Resources

Both Kay and Lana had been using activities and resources in mathematics instruction. Kay said that she had already been using station activities in her language instruction and that the program had helped her see that she could transfer many techniques for teaching language to mathematics. She was the only teacher on the team who said she had woven many of the teaching approaches she used in language

instruction into her mathematics lesson, and tried using stations in both mathematics and language. She thought that the station activities inspired her to think more about mathematics from students' perspectives, and she tried to incorporate more manipulative activities and questions into her mathematics instruction.

Lana was already trying to include higher-order-thinking tasks with her gifted students in her mathematics class. She thought that the program made her think about ways to expand her students' thinking and offered her some ways to reflect on her own teaching. She believed the use of hands-on activities in her mathematics instruction would expand her students' thinking and engage them in "a lot of trial and error, and [she] did not expect them to get the solution right … the first time."

One reason Kay gave for her change in teaching was her awareness that she could continue to learn and grow as a teacher if she kept trying new approaches to teaching mathematics. She was further motivated to change as a result of favorable feedback from an administrator regarding her use of stations. She said that on a few occasions when she was using station activities in mathematics instruction, "the principal came in a few times. He walked to the teams, and they could tell him exactly what they are doing. He thought that was great."

Lana's belief in how children learn mathematics and how mathematics should be taught was influenced by how she had been taught mathematics when she was young: "When I was in school, they just told you, "This is what you do," and you did it. If you did it the way they wanted you to, you got a good grade." Lana talked about how she felt when she started teaching, "At the beginning I thought kids learn math, and it's just facts and certain principles. Now I believe it's more than facts, pencil and paper, and it is

actually a serious thought process." Lana believed she changed in her belief in how children learn mathematics from the experience of experimenting with different approaches, activities, and materials in teaching a mathematics concept. "I changed my belief in the way children learn because of the experiences that we had with the laboratories and you teaching our classes and observing us and everything." She said she learned from those experiences that children learn better if they were allowed to explore, figure out, and explain why mathematics is done in certain ways.

More-Experienced Teachers

> Before, I was focused on getting the answer, not worried about them explaining it, not even thinking about them explaining their answer. I should have thought through that more. For example, when doing subtraction, I used to just do the problems on the overhead and then walked around and see what the students did on their paper, and then take it from there instead of having them explain what they are doing. (Anna interview; 15 August 2005)

> I am using more manipulatives now, asking more questions, getting more thought process involved in what we are doing, listening to suggestions….Before, I was not teaching all the different strategies. Now I try to give them strategies so that they can think their way through and not something they are learning in the abstract stages, and they don't even have a foundation on the concrete stages. (Macy interview; 24 August 2005)

Developing More Patience and Higher Expectations

Anna was the only teacher who believed that her students were slower than students in other Grade 2 classes. She said, "This year has been really hard with that because it is a low group, not too many bright stars." This belief caused her much frustration in her teaching. Using more questioning with this group of students required more time than usual to get through a mathematical concept, and her frustrations were

more evident after she incorporated more questioning and student explanations in her mathematics lessons. She said, “I tend to call on some of them that know the answer after a while because it gets so frustrating with what feels like just wasting time on the students that are just lost.” She reflected on her own teaching practices and realized that she needed to develop more patience with students who needed more time and guidance in forming mathematics concepts. She reflected, “I have a tendency to get impatient where I ask a question and they don’t have a right answer.” By allowing more wait time for her students, she said she had learned how to probe and guide her students better. She also said, “I need to remember that students don’t always have the answer right at the beginning. I need to know that its okay for them to have the wait time…to think about their answer and process it.” Anna used to demonstrate and tell her students exactly how a mathematics problem was done, followed by drill and practice. After observing how I interacted with her students during the demonstration lessons, Anna reflected that she needed to raise her expectations for her students in learning mathematics. She said, “I like you to teach the class because…you have different expectations for the students than what we have.” She was also surprised that her students were able to respond to the questioning and scaffolding during the demonstration lessons, and she decided that she would make her students “think, instead of losing patience and just giving them the answer and telling them they are wrong” in teaching mathematics. Anna also thought that observing me gave her some tips on how to gain her students’ attention and cope with her students. She thought that having the team observe the same lessons and then critiquing the lessons afterwards was beneficial, as she gained different perspectives from the same lesson and learned to cater her instruction to the varied needs of her students. The

program also strengthened her belief that she needed to focus on helping students understand mathematics so that they would be motivated to do it. Anna reflected, "Understanding the mathematics was a big piece that was missing when I went to school—why you did something. I got just way behind, because I didn't understand the math at all." She said, "It is important to help them understand and also help them want to do math, because I wasn't successful at that." She believed exposing children to games and activities helped them learn mathematics better. She said, "I need to work on playing games and doing activities for them, showing them like I was telling them. This is what you do, and this is why you do it."

Coping with Change

Anna said that she had been frustrated at the beginning of the previous year because she and Macy had "gone through the mastery thing where everybody did the same thing," and she "wanted it to be the way it was before," where everybody "did very much the same thing." The program made her feel that she was "not teaching it right," because she was using mastery learning. Anna said, "It was stressful at first because of the implication that what you're doing wasn't right." Macy, on the other hand, was a great believer in mastery learning, and she said she did not feel what Anna had felt. During the course of the program, Anna said she learned to "appreciate other people's ways of doing things." She now believed that "we don't have to all do the same thing exactly the same way. It didn't bother me like it used to." Anna believed the change in this belief was due to her developing more effective teaching strategies and the team developing more appreciation and respect for each other. Another reason for Anna to change was her realization and acceptance during the fifth laboratory class cycle that

changes were inevitable. She said, “I used to have certain ways of doing it and always doing it that way. But every year everything is changing.” By focusing on experimentation, the program allowed Anna to keep trying different teaching approaches in her mathematics class: “I am trying different things…like cooperative group learning.” Those opportunities to experiment and the support given her by the program and the team as she experimented with different teaching approaches helped her feel more comfortable with the changes. As a result, Anna became more receptive to trying different ideas in her teaching and saw experimentation as a way to cope with and keep abreast of change. Unlike Anna, Macy was bothered by the team members teaching at a different pace. She thought that everyone in the team would teach the same objectives and use the same materials if they had continued to adopt mastery learning. The teachers said they observed a great change in Macy’s teaching towards the end of the program. They said Macy engaged the students in more activities, and this change in Macy’s instructional practice was evident in the lesson observations during the third and fourth laboratory class cycles.

Questioning One’s Teaching Practice

Anna was the only teacher who revealed that she had been afraid to try out new ideas in her lessons because she believed new methods would not work for her lessons. She said she also thought that trying new methods of teaching mathematics might cause her to lose structure and control. Anna said she mustered more courage to try new teaching approaches in her mathematics lessons after the second laboratory class cycle. She said the critique and demonstration lessons encouraged her to be more exploratory in her teaching. She saw how a demonstration lesson could be used somewhere else when it

did not work as planned, and she became more convinced that she could improve her teaching by trying new ideas and reflecting on lessons that worked and lessons that did not work. She also said she got more courage to work on refining the structure in her classroom and the students' role as she tested out new ideas.

> Like the number bond idea didn't work as well as…we thought it would. But still, seeing that it's something different that I might use somewhere or sometimes or with some kids…I think that has helped me to kind of step out of the box and think of things a little bit differently. Because I'm a person that likes structure and to do the same thing, and I'm not really comfortable with change…and I'm not a real adventurous person. If I think something works, I tend to do it without trying something else, because I would fail. And seeing the banker thing helps me to think about doing that. I have done the base-ten block thing, but I've never done it with the banker idea….I have not given them roles or assignments. I think that's something I need to think about doing. Especially this class needs to have a role because they're a lot of chiefs and bosses. They need to be more defined and more structured. (Anna interview; 12 January 2005)

Learning-Focused Groups

Anna used to use an overhead projector to demonstrate how mathematics problems were done, had called on a few students to try the problems at the board, and then had the whole class practice some of those problems as she walked around the room to check their solutions. Like Kay, Anna came to believe that the students sometimes learned better from their peers than from their teachers. After observing me using questioning and students' explanations in the demonstration lessons, Anna said she asked more students to explain their solutions and even had students check and explain their solutions to each other instead of just focusing on getting the right answers. The school was also promoting learning-focused groups in teaching where all the teachers were encouraged to use more cooperative learning and pair work. Anna was the only teacher in the team that related what she learned from the program to the initiative from the school. She said, "We are encouraged to do learning-focused groups to get students to help each

other in a group atmosphere where they can learn from each other rather than always learning from the teacher." This new initiative from the school coincided with and complimented what the program was promoting, which further encouraged Anna to use cooperative learning and pair work in her mathematics lessons.

Confrontation with Macy

When I tried to arrange with Macy to observe her teaching during the first two laboratory class cycles, either the coach was teaching the class mathematics or she forgot about the arrangement to observe her lesson. I confronted Macy on this issue during an interview. The confrontation drew Macy and me closer, as it made me aware of Macy's difficulties in participating in this research and program.

> Lu: We want to see you teach, but your coach was always the one teaching the mathematics lesson. This is a problem.
> Macy: It's a problem. I don't know how to fix it.

Macy revealed that she shared her class with Coach Randall, a special education teacher who came into her mathematics class every day to do mathematics for an hour. She said that she was still responsible for the class's mathematics test scores and accountable for all the objectives to be taught. She said that her class usually had more than one hour of mathematics with her and the coach every day. She was hesitant for me to observe her because she would be doing remediation and repair work, and that would not be a true reflection of her teaching. This confrontation also made Macy aware of my expectation about her participation in the research. After the confrontation, Macy and the coach co-taught the mathematics lessons that I observed. During the rest of the observations in the program, Macy gradually took over the mathematics lessons, and she arranged for Coach Randall to observe her.

Connecting Theory with Practice

Conducting demonstration lessons for the teachers in actual classrooms triggered Macy's thoughts about her experience in her preservice teacher education. She said that her preservice training did not provide a true reflection of what teaching really was, and she had struggled with teaching when she first started. In this sense, she believed that researchers live in ivory towers, and she always felt that researchers should stay in touch with real classroom situations rather than simply coming up with theories that might not be applicable in real classroom situations. Macy said the demonstration lessons and critiques were important for her because she believed that by opening up her classrooms to me, she helped me construct a truer picture of what worked in a classroom, which added credibility to my work. Macy believed that children need concrete experiences to help them understand mathematical concepts, and she liked the fact that I was providing hands-on experiences for the children in this program and working directly with the children.

Station Activities

Macy said, "I usually do a lot of direct teaching, and we do a lot of practice." She was also using cooperative learning in her mathematics class before the program began. She usually identified students who were not understanding what had been taught. She assigned students to groups that had a mix of low, middle, and high ability to find out which students worked together best. After the first laboratory class cycle, Macy decided that engaging students in conversations in her mathematics classroom helped to promote students' mathematical thinking, and she tried to have more students' explanations in her mathematics lessons. Like Kay and Anna, Macy provided her students more

opportunities to explain mathematics to each other, as she believed that children understand each other better. When I introduced station activities to the teachers, Macy said she enjoyed the stations because she believed the children were developing their thought processes and learning "some sense of mathematics" as they participated in the activities at the stations. However, she thought that her age prevented her from participating in the stations as much as she would have if she were younger. She said, "I am not nearly as involved with the children as somebody a little younger than I am in some of the activities. I can't do those kind of things, but I don't consider myself as being a negative person." Macy also could not tolerate a lot of noise in her classroom. She said she believed that teaching was about instilling discipline in her students. She was the only teacher who said that the station activities might not be feasible in an actual mathematics classroom because they needed more than one teacher to attend to the stations and to maintain discipline at the stations. Hence she believed that she would teach better with direct teaching and controlled cooperative learning groups in her mathematics lessons. Overall, Macy believed that her style of teaching was enhanced as a result of the program. The teachers said that Macy had used only teacher-directed instruction and drill and practice before the program and that she used more manipulatives as a result of the program. Macy said she could incorporate some of the teaching ideas, activities, and resources introduced during the program as a whole-class activity where she could control the noise level better.

> I like the activities more…than running off paper. I like the picture that you drew on the fraction plate and…the hands-on things… the new ideas, the creativity. I like the positive energy you bring to the program. It makes a difference. (Macy interview; 14 April 2005)

During the fourth laboratory class cycle, Anna and Macy were concerned about the use of station activities in their mathematics instruction as the state tests were due in 3 months. They had doubts about their students translating the hands-on experiences at the stations to paper-and-pencil test items. Lana thought that the students faced this difficulty because in some classes, games or hands-on activities were not common, and the students might have thought that those experiences were not part of their mathematics lessons. The team decided to address Anna and Macy's concern by including a mixture of hands-on and follow-up activities and worksheets with drill-and-practice activities whenever we planned to use stations.

Anna and Macy held deep-seated beliefs about mastery learning and appeared to struggle with what the program was fostering. Anna and Macy were still believers in mastery learning at the end of the program. They still retaught the objectives, and administered a paper-and-pencil test at the end of each unit. The difference now was that they used a variety of teaching approaches and manipulatives to reteach each objective instead of just telling their students how and what to do with each objective. Linda said that Anna appeared to make gradual changes throughout the program, whereas Macy had made a tremendous change in her teaching toward the end of the program. The main reason for Anna's change, she said, was the support she received from the team and the program. She had felt bored with the things that she was doing every year, and her students were not performing as well as she wanted because she had not reflected on or changed her teaching approach. Macy said she thought that something was missing in her mathematics instruction. She changed after she decided that the program could help her identify the missing component in her teaching by focusing on students' thought

processes. Both teachers said they changed their teaching because the program equipped them with different approaches to teach mathematics, allowed them to experiment with those approaches, and supported their change through the critique. They recognized and acknowledged that every group of children coming to them was different and that they could not use the same teaching approaches and materials all the time. They believed that children learn differently at different paces and that they needed teaching strategies to reach out to a variety of children. Macy said, “I just have been teaching for 27 years. I know there had to be some new ways to do a thing, so maybe there’s some other ways–maybe not new. Maybe there’s some other ways to get the same results that you want to get.”

CHAPTER 7

CHANGES IN THE TEAM

In this chapter, I present how the team changed as a result of the program. I describe how the program affected the change in the team according to five stages of team development: forming, storming, norming, performing, and transforming. The model, however, did not completely fit the six teachers' behavior. The team was seen to storm before they formed, normed, performed, and transformed.

Storming

The storming stage was characterized by conflict. The conflict was already apparent during the first year of the professional development program, and at the beginning of the second year of the program before the research study started. Ivy said that teachers forming cliques caused conflict and tension. She said that the team "needs to work on collaboration. Some of us need to come together a little bit more. I think we just have a lot of personalities." Anna said that in the first year of the program, "the team was divided into the old and the new, and they didn't mesh." Mary and Kay said they had difficulty getting along with Macy because they could not stand her harsh comments. Mary was not new, as she had taught first grade in the school before joining the second-grade team. She was new as a second-grade teacher, however, and she was eager to learn and share ideas from the team at the beginning of the program. Mary said that before the research study, she had started off sharing and showing "other teachers or educators

things that work." To her disappointment, however, she had received harsh remarks and criticism from Macy whenever she shared. She said, "Some people get offended by that, or they feel like they're getting their toes stepped on." Mary said, "There were a few times where teachers would put down me or another teacher [Kay]." As a result, sometimes, Mary did not want to speak up in the team meeting because "there are a few teachers that make comments, and it is not worth it to speak up sometimes." Kay said she also felt new to the team at the beginning of the program. The new team dynamics were overwhelming to her, and she was not comfortable with the team.

Anna and Macy had been together on the team for more than a decade. They were good friends, went through the mastery program together, and had been on better teams. They said it was difficult for them to accept new teachers on their team at the beginning of the program. Anna said that her personality made it even more difficult for her to bond with new teachers on the team. She said, "I'm not a real outgoing kind of person. I have to decide somebody is a friend or foe before I say much about anything. Furthermore, I don't like change. It's hard to teach an old dog new tricks and move on." At the beginning of the program, both teachers said they had felt a gap between themselves and the team in terms of their teaching practices. They had used mostly what they had called the show-and-tell method, with drill-and-practice before the program, and they had been unable to accept other ways of teaching because they believed that the "newer methods of teaching" were a threat to their confidence and power as teachers. The newer teachers tended to bring with them more current teaching styles, and Anna said that made her feel obsolete in her teaching. The team did not openly deal with the conflicts that surfaced. Mary, Anna and Kay dealt with the conflicts by withdrawing themselves from the team. I

did not help the team resolve the conflicts in the first year of the program because I was struggling with the concept of a laboratory class cycle, and I was also trying to figure out the teachers' expectations of a school-based professional development program. I was also unfamiliar with the team, and with the American school culture. Neither did I address the conflicts in the team explicitly in the second year of the program. Instead, I focused on the laboratory class cycle and tried to meet the teachers' expectations and needs by refining the cycles. I believe the teachers were willing to participate in the research study when they realized I was there to help and not judge them.

Forming

The forming stage was seen during the first three laboratory class cycles, after the teachers were told by their administrator that they had to be part of the team and part of the program. In this stage, members determined how they would relate to other team members, and it was a period of anxiety for them. There were also moments when Mary, Kay, Anna, and Macy were storming and forming at the same time. For example, the conflict between Macy, Mary and Kay was still unresolved at the beginning of the research study. Mary and Kay continued to receive harsh remarks from Macy. Mary and Macy said they believed in teamwork and that they wanted to be part of the team. Mary continued not to share her ideas during team meetings to keep being from being hurt. She was still hopeful that the members could bond and be kinder with their remarks, and she suggested many ideas during the interviews from the beginning of her participation in the program. Many of her suggestions were used to help bond the team through the program.

Mary said she thought that the team could grow closer if the teachers' workload were not so overwhelming. Then the team members would have more time to get to know each other personally. She also believed that the way to change the team was to have more casual discussions, more open conversations where no one felt put on the spot or pressured. Mary thought that this opportunity was lacking in the meeting during the first laboratory class cycle because not enough time was given to me. She also suggested that assigning people to talk might involve more people in the discussion. I took up Mary's suggestions, and whenever I noticed that any teacher was not contributing, I would invite her to share her ideas. Mary was also affected by some team members' attitude towards the program. She said, "It's just been hard when you have teachers that don't want to participate. They were there just because they had to be there. The negative attitude—it's disheartening. And that discourages me sometimes." She said that those teachers were "too set in their ways. They had been teaching for so long or they feel like they've got so much to do now, they don't want one more new thing to do." Mary also said the teachers who appeared to be unsupportive of the program discouraged her. Mary coped with those hard feelings by listening, taking what she needed from the program, and then applying it to her classroom. She said,

> Sometimes when I do get quiet, I may be holding back a little, but I'm still participating, listening to everything. I don't try to let other teachers or bad advice get me down. I just keep on doing what I need to do. (Mary interview; 13 December 2004)

The storming-forming transition was a period of confusion and anxiety for Kay. Kay still had conflicts with Macy at the beginning of the research study. She coped by concentrating on the support given to her by some of the team members with whom she was able to get along because she felt that those team members listened to each other.

She was also unsure of herself as a teacher in the school, and she preferred to focus on her teaching, shut her door, and teach rather than be on the team.

The storming-forming transition was a period of mixed feelings for Macy. Macy said she believed in sharing ideas and resources as a team, and she had doubts about new teachers coping with their jobs. Macy said she found it difficult to share resources or ideas with two teachers [Kay and Mary] on the team, as she was not well acquainted with them. Macy also said that some teachers needed to be more accepting of other members on the team and that some teachers [Kay and Mary] were more open to suggestions from certain teachers. She thought that they were not blending into the team. They were not open to suggestions or ideas compared with the team that she had been on many years before. She also doubted that the other team members were as open as she was. She did not think that they were able to accept the way she taught.

> I think some of us have bonded in this team, and some of us have been working together a little bit longer. Anna and I have been working together probably the better part of more than 10 years, so that makes a big difference. We used to do mastery learning. To me that was really good because … I have the material at hand. It was helpful for me when I first came to work down here that they did that. Because I didn't have to worry about what I was teaching. Because they already told me, "These are the objectives, and these are the materials we are using right here. You can use all of them or some of them. But if you come up with anything else, share what you have. We want it all." We have other people that have come onto the team now, and it is not quite still happening. To me, that broke down some of the continuity throughout the team on what we are doing and everything. I know some of us might have our little structures of our classroom that make us different. And therefore because our classroom structures are different, we do things totally different. I am not sure everybody came into this program with the same openness that I think I came into it with. (Macy interview; 8 February 2005)

Macy also said that as long as there was respect on the team, and teachers were still sharing and seeking help from each other, the team could still be pulled together.

However, she said that it was difficult to work as a team and help each other when teachers at her grade level were teaching different topics each week.

The storming-forming transition was a period of stress and anxiety for Anna. Anna said that she felt a little stressed at the beginning of the program because the team was not united. Also, Anna and Macy had been in the district when the elementary school had spilt into primary and elementary schools, and she thought that the team in the former school was much closer than the current team because the former team had the same members for many years. Linda said Anna coped with the tension by shutting her door to teach and playing a passive role as the team leader during the first year of the program. Anna started to assume her role as a team leader at the beginning of the research study by having an agenda for every team meeting. She said that the agenda would help the team focus on the issues to be addressed. Before each meeting, Anna would go to each team member and ask her if she had any announcements for the team. She would then type out all the announcements and make copies for every member for the meeting. During the third laboratory class cycle, Anna said she started to allocate time for each announcement so that I would have sufficient time for the professional development program. Ivy said that the agenda helped the team to stay focused. She said, “One thing we do is good is that we have an agenda, so we know what we are going to talk about. We know to stay off, stray off the topic not too far, so that is a good thing.”

Lana and Ivy were in the forming stage at the beginning of the research study. Lana was vocal about being a novice teacher, and she looked to the team for support. She had 2 years to learn how to work with the older teachers on the team (unlike Kay who had only 1 year) before Mary and Ivy joined it. Lana and Ivy believed in teamwork, and

they recognized the conflict and tensions among the team members. They were accepting of their individual differences. Lana said, “It’s important that we respect and value each other, our teaching styles, resources, information, and strength that each of us has.” Lana also said, “We come from different aspects of life, age group, family situations, different ways of teaching, started at a different point. So when we get together, we get ideas that we can use.” Lana and Ivy were positive about the team members coming together one day. Ivy said that the program was heading in the right direction and that teachers who were not fully enthusiastic about the program would eventually participate in it wholeheartedly. Lana and Ivy also believed strongly in building workplace relationships at a more personal level. Lana said, “I think [the program] kind of drew us closer together, too, because we are not just professionally related. We are personally related, too.” She said that it was important to sometimes sidetrack during meetings and talk about family issues to build bonding and understanding among team members. “You have to be concerned with each other, with your personal life, not just your professional life. That’s just part of being in a network, being in a group, a community.”

The teachers said that the administrator’s insistence on them setting norms for the team during the two years of the program was important in forming the team. Kay said that talking about the norms during the meeting allowed the teachers to set expectations for the team, and to set the team’s mission. She also said that everyone felt uneasy with the norms at first because “if we put [the norms] on paper we felt like we have to do it.” She said the teachers started to get used to the norms toward the beginning of the research study.

Norming

In the norming stage, the team developed trust and collaboration among team members. This stage occurred during the fourth laboratory class cycle and continued throughout the rest of the research study. Collaboration and trust could be seen during the station activities when the teachers worked in pairs to teach and observe each other. It was also seen during the planning and critique of the demonstration lessons. Mary said that she was able to generate and contribute more during the meetings as she gathered more ideas from the program. She also thought that the team was now comfortable tossing their ideas around the table and that contributed to the quality of the meetings. Kay said the team tried to listen more and cared more for each other beginning with the fourth laboratory class cycle.

In this stage, the teachers agreed on their roles and responsibilities. For example, Mary and Ivy assumed special roles on the team. Because the school used different textbook series for Grades 1 and 2, Mary said that her experience teaching the first grade the previous year helped the team to fill in some gaps in the different curriculums. The following incident illustrates why her role was important. During Demonstration Lesson 6, at the beginning of the critique, Macy disagreed with the use of the hundreds chart as a tool for subtracting whole numbers with regrouping. Mary commented that the first graders were taught to subtract whole numbers without regrouping using the hundreds chart and that bringing up the hundreds chart again would reinforce students' number sense. Macy appeared to be convinced by Mary's comment. Macy later added that, "in Grade 2 they went into abstract too soon and too fast, and there should be a connection between what they learned in Grade 1 and even kindergarten, like using hundred charts."

This event boosted Mary's confidence. She felt her ideas were respected by the team. Ivy said she thought that teaching in the higher grades in the same school system had helped her contribute to the team when it came to planning lessons jointly to prepare students adequately for the next grade level. Lana recognized the value that each teacher brought to the team. She appreciated the fact that Ivy coming from a higher grade served as a bridge to mathematics in higher grades for the team. Ivy said that the collaborative effort between the teachers and me motivated her to participate in the program fully. Her specialist degree program required her to constantly look at teaching ideas. She was doing an internship with her mentor as they conducted different workshops for teachers, and she enjoyed bringing information about the workshops back to the team. Ivy believed the program enabled her to find another role on the team as she realized she could also be a bridge between education policy makers and the teachers, which gave her more confidence to share her ideas with the team. Like Mary, having specific roles on the team and having something to contribute to it made Ivy feel part of the team.

Lana thought that everybody on the team was a leader in some way or another and that she could always seek help from any of them. Lana said that the team was more cohesive than before because everyone on the team worked harder to function as a group and kept their focus on the students rather than individual differences as teachers. She also said that the team had accepted her and me as part of the team and that the team provided her the support she needed as a novice teacher.

Anna came to agree on the relationship on the new members in the team in this stage. Anna said that she had finally accepted the fact that "teachers come and go" on the team. She said she had learned to accept the differences among her team members, which

was a big change for her. Anna said she no longer felt inferior on the team and even acknowledged the strengths of the team members. She also said that the team members complimented one another with their individual strengths. She said, “Some of them are better at other things than I am. We all are leaders in different ways. They have different qualities that they bring to the table, not just me.” Anna also said, “I don’t feel like that I have difficulty bonding with the new teachers anymore, so it’s like growing pains.” Anna said that this program over the 2 years was a “growing experience” because it had helped her to “step out of the box, try something new, and try to get along with other people, because I just don’t make friends easy.” Anna said the change in how she perceived her role on the team had brought about a change in the team. She said, “Trying to work together makes it so much more pleasant to come to work. And be a team rather than just them.” She thought that the team had changed after the first laboratory class cycle “not because of the program but because we grew as a group. Wherever you are working, you grow together, a marriage, or you grow apart.” She said, “We seem to be working together better and are on the same page.” Macy said she learn to appreciate her team and value the expertise and knowledge that the teachers gathered from their teaching experience through the laboratory class cycles.

Lana said that the team was able to norm because the program modeled how team members could interact with each other professionally. Lana said that her team had grown because they had accepted each other’s differences, valued each other, and were all eager to learn to become better teachers. Mary said that the team normed because they agree on the tasks to be accomplished. She said the program was becoming became part of the teachers’ routine, and all of the teachers seemed to benefit from the program. Mary

also said that the teachers whom she believed were not receptive to the program were now seeing the program in a better light. Ivy said that the team just needed time to be a "real team." She said, "We are a new team this year. Sometimes it takes time for everybody to come together and start working as a real team, especially if we have a lot of strong personalities." Kay said that the norms and the program helped the team to become more cohesive and comfortable with each other. Kay said that having the teachers share more of their teaching strategies fostered team growth and made the collaboration effort more worthwhile.

Performing

In the performing stage, the team was fully functioning, and team members identified with the team. This stage occurred during the fifth and sixth laboratory class cycle and was evident during the team meetings. Mary said that as compared with the beginning of the year, the team was more open to suggestions during the fifth laboratory class cycle. She also said that the teachers were responding positively to the program, sharing, and reflecting the different ideas they had tried in their classrooms or their observations during the demonstration lessons. This observation greatly encouraged her as a new teacher on the team.

> I think the team is changing. It seems like everybody sometime or another, each teacher has spoken up about what they have noticed in their classrooms from using different things that we have talked about or different things that we observed. Which let us know that they are using it, and they are not just sitting there drawing pictures. So they are getting something out of it. (Mary interview, 11 April 2005)

During the sixth laboratory class, Mary said that the teachers who were not receptive to the program previously were now more open to change and more willing to try new ideas in their classrooms. Mary said she shared more in the meeting now that she felt part of the team and had received more support and encouragement from the team members. Ivy said, “We are beginning to come together more as a team than as six separate individual teachers.” Lana said she felt encouraged and even more comfortable sharing after the team responded to her ideas and gave her feedback. She also felt more comfortable sharing because everyone was sharing ideas, critiquing teaching practices, and nobody took those critiques personally. Anna said she also felt more comfortable voicing her opinions in the team meetings. She said that the team was more cohesive than the previous year. Kay described the change in the team as from being unreceptive to new ideas to anticipating the sharing of new ideas in every meeting.

Anna said she became more proactive in her team leader role. She reduced the total number of meetings with the other teachers on days when they did not have a professional development activity so that they were not overburdened with meetings, the program, and the research study. She said that she had had to play a passive role as a team leader and member of the team previously when the team had been divided into two cliques. She had wanted to avoid taking sides. Anna thought that the team was growing closer, and she saw the team members as “more of friendship community; like, share with your neighbors what you come up with … different ways to teach something.” During the sixth laboratory class cycle, Macy said that the teachers were “listening to other people, and they let other people know that they don’t think everything they are doing is the only way [for it] to be done.”

In this stage, the team members continuously engaged in reflective dialogue, consensus building, and self-assessment. These activities were evident in Anna's and Macy's behavior during the sixth laboratory class. The teachers said they observed Macy suggesting more ideas for the planning of the demonstration lessons and making kinder remarks during the critique sessions. Anna said that she herself was open to differences and changes and welcomed new ideas. She acknowledged her own weaknesses and reflected on how those weaknesses had restricted the way she viewed others. She was ready to accept the new team and felt that having the team members share their ideas was helpful in promoting understanding among the teachers.

> I used to take changes personally before, but now, I really don't. I welcome their ideas, and we talk about stuff. And I think that's a good idea, or I might try [it]. Or I don't think that's for me, but that's okay because different people have different ways to do it, different strategies, and different noise levels. I have a low tolerance for the voice, and I can't stand a lot of the off-task stuff. So I think maybe that's a weakness. Sometimes [the other teachers] are not off tasks, but they are just too loud. I guess we get to know each other more and may be more comfortable. We [were] just close before. Then when you lose members, like family, you lose members, and somebody new comes. It's just different. Like Ivy, she's helpful with the Internet and doing all those kinds of things. They have all been really helpful, supportive. It has been better this year than before because I think there is not one person who is trying to outshine or outdo each other. I don't think we do that anymore. I think having us share ideas and just having us work together, that contributes to it too. (Anna interview; 23 March 2005)

Lana said that her team was now performing because they now had a common goal of incorporating the new state standards into their curriculum. Lana thought that planning the demonstration lessons as a team helped the team members understand each other's teaching styles and personalities better. It gave them opportunities to share, justify, and clarify why and how a lesson should be taught in a particular way. It created opportunities for the teachers to clarify misunderstandings and to appreciate the strengths of every teacher. Lana thought the opportunity to work with her colleagues in the stations

fostered growth in the team. The teachers learned to put their personal differences aside and focused on the learning of the children. She said, “We back each other up working in the stations, and we learn from each other, work in a cooperative group for the common good of each child. So I think that works out really well.” Lana believed that the program especially boosted the confidence of the more-experienced teachers because their ideas and strengths were recognized and respected, and they were accepted as part of the team. She also said that the program helped her become a more resourceful teacher, which enabled her to share more confidently during the team meetings.

> This person might not have felt like their ideas were valid because they have been teaching for a while, and a lot of their ideas might be older and outdated. Really, they were very good ideas, and I think that kind of gave them more self-worth and made them feel like, “Oh well, I have been doing all this all along, and my ideas are still valid; I am doing the right thing.” I think that was the best thing for them. (Lana interview; 10 May 2005)

Kay said that the weekly meetings conducted over an extended period of time allowed the new and the more-experienced members of the team to communicate with one another, thus promoting growth and understanding among the team members.

During the fifth laboratory class cycle, Anna said that the team was able to function effectively because team members learned to respect individual differences. Anna said she felt that respect for one another was a key factor in promoting the team’s growth. Also, she said that the tension between the younger and the more-experienced teachers was reduced because the more-experienced teachers on the team were more respected by the rest of the team members now than the previous year.

> I think we are working together more ….We have grown. It [is] better than it was this year at the beginning of the year. It is better than last year. We had a lot of different personalities and stuff, and I think more respect for others’ differences…. Being in the older group, Macy and I had a certain way of doing things, and that’s the way we have done it for years. But then on the other hand, I

> think some of the other members had a more respect for us too….At the beginning I didn't feel like they respected; it's always like, if it was something old, if it's not useful. (Anna interview; 10 May 2005)

Macy said that the program helped the teachers to listen to one another and allowed more communication among team members. She also said that the program created an environment where every teacher's voice was heard. She said, "There's an exchange in communication where everybody felt that they have a voice, and they could say what was on their minds, say their thoughts." Macy said this environment encouraged every teacher to share her ideas and promoted effective teamwork.

Transforming

The transforming stage began at the end of the sixth laboratory class cycle, and continued after the program ended. All the Grade 2 teachers said they saw the effectiveness of the program and how professional development could be integrated into their day-to-day lives as teachers. Mary, Ivy, and Kay said that they were especially encouraged during the sixth laboratory class cycle to see Macy trying different techniques in her classroom and becoming more open to ideas other than just drill and practice. Kay said Macy had turned from a drill-and-practice mathematics teacher to one who incorporated the use of manipulatives and new teaching approaches in her classroom. Kay said that Macy's positive change affected her participation in the program and improved her relationship with Macy. Kay also said that Macy had accepted her as part of the team. Ivy said that Macy changed because of the new state standards and because the program had goals that aligned with the standards.

> There is a teacher that has really come from, someone who has been teaching a long time, who used to teach straight from the book "and this is how you do it and these are the steps and this is the only way" kind of thing. Because I know going through school, I know that was how I was taught. I mean that was just the way it was, you did it this way or you didn't do it. And I know that she tried different techniques in the classroom and let the kids kind of explore more and find different ways to do things. And she has been more open to that. And I think she is enjoying that more too. So that has been neat to see. (Mary interview; 10 May 2005)

> This person was unwilling to change….To her, there was only one right way. "I don't need any help. I'll sit and listen, and I'll nod my head. But I am not going to change." and everybody noticed it—other teachers and the administrators. Now, she'll come and share something. "Look what I did in my class." And it's not where they are all sat up straight and quiet and did it on paper. They had manipulatives. That was exciting because to me that person would never change. But that person did change. And I don't think that person liked me, and now I think she does. Everything just seems a lot better. There was lots of prayer that went into that relationship, and it definitely has been answered. (Kay interview; 10 May 2005)

Macy said she was impressed with Lana, who she thought was extremely open to new ideas and a very enthusiastic teacher. She said, "Lana is like a sponge … soaking … everything up, and she brings a lot of energy. She is open to all the new ideas, trying different things. It's positive."

All of the teachers continued to teach second grade the following academic year, and 3 months after the program ended, the team made plans to run their own professional development. They said that they believed that the program worked, and they started to run their own laboratory class cycle by scheduling teachers to lead a meeting for their professional development every week. Also, once a month, each teacher paired up with another member of the team to observe and experiment with different ways to teach a mathematics concept. Anna had assumed a greater leadership role in the team, and she ensured the smooth running of the program. The teachers felt motivated to continue the program on their own because they believed it contributed to the improvement in the

Grade 2 mathematics test scores and in supporting the team's and the individual teachers' professional growth. Also, they saw the program as benefiting them not only in mathematics but in all areas of their teaching. Linda said that the team collaborated so well that they were regarded as role models for the other teams in the primary school and the elementary school in terms of collaboration and in teaching mathematics. Linda also said that this recognition by other teachers in the school district further enhanced the Grade 2 teachers' motivation to continue to support each other in their teaching practices and continue their own professional development the following academic year.

CHAPTER 8

THE ADMINISTRATOR'S CONCEPTION OF TEACHERS' AND TEAM GROWTH

> There was growth in personal feeling towards each other. There is growth in how they approached each other on a team level, as a group, and also as professional colleagues for the rest of the school. (Linda interview; 13 July 2005)

In this chapter, I provide another perspective from an administrator's stance of how the teachers and team had grown. Linda was not focusing on the mathematics. She focused on the conflicts in the team, the dynamics of the team, and how those conflicts were resolved. Although Linda did not participate in the program in the second year, she was well aware of how it affected the teachers' personal growth, their mathematics instruction, and the team. Linda saw a variety of growth in the second-grade teachers. She witnessed that growth in them as individuals and as a team. In this chapter, I describe Linda's conceptions of how the teachers changed individually, in their teaching, and in the team dynamics, and I describe what she believed caused the teachers and team to change. I conclude the chapter with a short section to describe how Linda thought the change in the more-experienced teachers affected the rest of the team and the school.

Teachers' Growth in Mathematics Instruction

Linda said she noticed that the teachers changed the most in their beliefs in the way they approached mathematics instruction in the second year of the program, especially toward the end of the year. She expected the teachers to continue the program on their own the following year. She thought that the teachers who participated in the

program for both years approached their teaching much more differently than those who were in the program for only one year. “The ones with 2 years changed more. I saw more growth out of … four of them. The way they are approaching their teaching is a lot different than … at the beginning of the two years.” Linda also thought that the teacher change had been gradual throughout the year but that the “growth of the teachers was phenomenal by the end of the year.” She categorized the teachers’ changes in teaching according to their mathematical knowledge and questioning, their planning of mathematics lessons, and their use of mastery learning in mathematics instruction.

Mathematical Knowledge and Questioning

Linda thought that some teachers on the team were not very strong in their mathematical knowledge for teaching at the beginning of the program. She said, “As with any teacher group, you have strengths and weaknesses. On our second-grade team, we have some strong teachers. We have teachers that perhaps are not as strong.” She believed that those teachers had grown in their mathematical knowledge for teaching. Also, as the teachers became more cohesive as a team, she said, “I don’t see [teachers] outshining [one another], which was more prevalent before. Now I see a group of teachers that worked together that are all strong and very knowledgeable on the concepts that they are teaching.” She thought that “there was growth in the questioning techniques in majority of those teachers” when she observed them at different times of the year. Those teachers who were already using questioning in their mathematics lessons were engaging students in higher-order thinking and going into mathematical concepts more deeply. She said, “The teachers who had those questioning techniques, they are stronger now. The teachers who were using questioning in higher-order-thinking skills are still

doing that and even going a little deeper." The teachers who were not using questioning as much before the program were now questioning their students. Linda said she thought that the program was successful because it modeled teaching practices that the teachers could pick up easily. She thought that the teachers had experienced personal growth when they tried different approaches as suggested in the program and that they found their effort worthwhile.

Lesson Planning and Mastery-Learning Approach

Linda said she thought that 'the teachers had grown … in planning a lesson." She said, "Instead of just looking at 'we are adding two-digit numbers today,'" they thought more deeply about how to conduct a mathematics lesson and, the type of activities to include in the lesson beyond what the workbook offered for the concept to be taught.

> We had a couple of the teachers who were…very traditional in their views. They really depended on their paper-pencil tests. They depended on the right answer. They depended on students sitting in their seats, being quiet and doing their work, turning to the page in their workbook and completing the work. Whereas now, when I walk into those classrooms, there is conversation going on, there are questions that are being asked, and the students are allowed to elaborate on the answers. Students are actively solving problems instead of just sitting with their worksheet on their desk. So that, those particular teachers have done a lot of growing. (Linda interview; 13 July 2005)

The school had been using a mastery-learning approach for several years. Linda thought that at this school, mastery learning was "where you were taught an objective … given a paper-pencil test, and if you didn't pass it, … you were re-taught it." She said she thought that the teachers who had used the mastery learning approach for several years were the ones who changed the most as a result of the professional development program. She thought that those teachers had depended heavily on drill-and-practice activities. Now, more questioning and students' explanations could be heard in their mathematics

lessons, and the students were more active in their learning. Linda thought that the greatest changes in these teachers had been in their attitude and in their willingness to approach their teaching differently after being "traditional in their classrooms" for so long.

Why Teachers Changed in Their Teaching

> The way this program was implemented and the way that it was brought about built that trust in the teachers and allowed them to be who they are and to feel that safety. The program was set up so that the teachers could be risk takers and be able to try what the research is saying without ridicule, without being laughed at, without being judged but being given honest feedback. And not only being given feedback, but being asked, "What do you think? How do you feel it went? What would you change?" To me, that helped these teachers become more reflective in who they are, and that is a very valuable part of education. (Linda, 13 July 2005)

Linda attributed the teachers' growth to three main features of the program: namely, the structure for teacher growth, the support from the team, and a safe environment for the teachers' voices to be heard.

Structure for Teacher Growth

Linda thought that the teachers changed because the program "set up the learning, gave the teachers the tools they needed, and allowed them to try the tools. And the teachers saw the success, and that was what changed their mindsets." The demonstration lessons modeled questioning and probing students' responses for the teachers, and "that provided the teachers with confidence to try the lessons themselves over the course of these 2 years."

Support from the Team

Linda said that the teachers and students alike were guided throughout the laboratory classes to experiment with different approaches and ideas. She said that the use of questioning used during the professional development with the teachers and during the demonstration lessons with the students enabled them to think through what went wrong and what worked, and that approach had speeded up their growth. Linda also said that the laboratory class cycle with its station activities allowed the teachers opportunities to experiment with different ways to teach a particular mathematical topic, reflect on their experiences, and receive constructive feedback from their team and me without being ridiculed.

Safe Environment

Linda also thought that the teachers had changed because "the program was set up where it allowed the teachers to take risks without feeling like they were going to be failures," and the teachers' input was valued. Another reason for teachers to change and grow according to Linda was because "a safe atmosphere was established and because of the realization that they were worth something where they had value in that community of professionals right there." Teachers were able to "share their points of view, and they weren't going to be criticized but perhaps questioned about what their beliefs were and for them to elaborate on them." Linda said that this environment made it easier for teachers to "change their beliefs if they found that what they believed was not necessarily the way it should have been."

Personal Growth and Professional Growth

Linda thought there had been both personal and professional growth in the teachers. She said that before the second year of the program, “there was very little collaboration, more hostile feeling, as in towards each other in the sense that there was inferiority on that team.” She believed some of the teachers thought that “other teachers were better than them or thinking that they were better than others.” By the end of the program, according to Linda, the teachers believed that “they are equals and that they are on the same playing grounds as the rest of the teachers on the team.” Some teachers underwent “professional growth of sharing ideas and being accepting of other colleagues” as they learned to share more with their colleagues. She described those teachers as “already actively in higher-order-thinking skills and using a lot of manipulatives with their math instruction.”

Growth in the Learning Community

Change in Teachers’ Participation

Linda, as a non-participant but a supporter of the program, said she saw the learning community evolve from a team that had a lot of strife and animosity to a team that could collaborate with, respect, and uplift one another. She found evidence of team growth in their weekly meetings. She observed that “in the first year a couple of the teachers did not feel like they wanted to share, and there were a couple of teachers who shared all the time.” Toward the end of the second year, she noticed that “those teachers who were quieter during the first year were now sharing a lot more and were more involved with conversations during the team time.” Those teachers “had grown stronger

with a more positive attitude," and she said she believed that those teachers changed because "they felt safe" to share. The first-year teachers seemed to be accepted into the group by the end of the program, and "they seem to accept the program openly and tried the ideas suggested." Linda thought that "the program helped them to refocus on their teaching, especially in the area of mathematics."

Linda was constantly in the hallways walking up and down and observing the teachers' interactions with each other during their planning time. She was able to trace the teachers' growth and team growth "through the weekly meetings, just watching their interactions in the hall and the daily walk-throughs." She was usually asked to attend the team meeting once a month. During the end of the second year of the program when she sat in on the meetings, she observed that the teachers had more respect for each other as professionals and that there was no more tension and griping among team members. Instead, the team members' "whole attitudes and the way that they approached each other and the way that they cared about each other had changed."

There were also more teacher interactions in the hallway. Linda said she thought that the program had encouraged the teachers to bond as a group and grow to value and respect each other. She noticed that especially toward the end of the program, all the teachers were sharing at different points in time instead of just one teacher dominating the meetings.

> The atmosphere that was set up or given was a very positive atmosphere. It was one that I feel they felt secure and safe in, and the comments that I got from them were very positive. If I went down there and tried breaking them up, they would revolt on me. I don't think they want to be separated. They've built a team, and we wouldn't want to separate them right now. (Linda interview; 13 July 2005)

Change in Faculty Meetings

The school usually held a meeting once a month during which the whole school faculty got together and arranged for different teachers to share any ideas they had about teaching, assessment, or the curriculum. Linda observed that before the professional development program, the second-grade teachers "would not necessary pipe up or add to conversations, whereas now they have started talking about assessment." The teachers "are already piping up and sharing what they have learned through this professional development on good mathematics assessment techniques and questioning….They talked about the importance of higher-order-thinking skills and questioning students to elaborate on their answers." Also, "some of the teachers who had sat quietly before are giving ideas to the rest of the faculty on how they have grown and what they have seen in their classrooms to have improved the students."

Linda said she was very impressed with Macy's change in her mathematics instruction and Anna's change in assuming a stronger leadership role. She thought their change directly influenced the rest of the teachers on the team and the rest of the school faculty. She thought that both teachers were more confident at the end of the program. She said, "They were very positive, their attitudes. I feel they feel more secure in who they are in their teaching." She thought that change had led to their change in instruction and in their attitude toward teaching mathematics, toward the team and toward the rest of the school. In the following two sections, I describe Macy's and Anna's change from Linda's perspective.

Macy

According to Linda, Macy had been the teacher most resistant to any form of change at the beginning of the first year of the program. Linda said, "She was the most negative to begin with and probably the most resistant.…I remember her sitting stone faced in a meeting and not really sharing. And if she did share, it was usually negative." Linda thought that Macy "would never change" at the beginning of the program, and when Macy did change, Linda said, "It was done without very much pain, or there wasn't a lot of growing pain. It was just done so gradually that it just happened, and it was nice to see that." The most observable change in Macy was in her mathematics instruction and becoming a cheerleader on the team.

Change in Mathematics Instruction

According to Linda, Macy used to sit behind her desk and do only direct teaching. The program had changed her drastically because, Linda said, she changed her attitude toward how she approached mathematics instruction. She now used more hands-on activities and got her students involved in their learning instead of lecturing all the time. Linda thought that Macy's change in her approach to mathematics instruction was noticeable by the rest of the school and also by the curriculum director, who observed the teachers' lessons occasionally. Linda said, "Macy loves to talk about the children, and she likes to share that with her colleagues from other grade levels not just the six on the second-grade team." Linda said she believed one reason that Macy changed her mathematics instruction was the interactive nature of the program. She said, "It's the active participation which she actually could see going on which seemed to affect her the most."

New Roles in School

According to Linda, one teacher on the team used to be "brought to tears by Macy" with her negative attitude. At the end of the program, Linda said this teacher felt "less stressed by the relationship with Macy, and there is not animosity, and there is not any bitterness that there used to be." Macy even became what Linda called the cheerleader for the team in teaching mathematics, advocating the use of questioning and a deeper understanding of mathematics concepts. She was concerned about the other students in the school and whether they were getting the right instruction in mathematics. Macy became so enthusiastic about promoting the use of "correct mathematics instruction" that she agreed to be on the school's mathematics task force to help teachers at other grade levels with their mathematics instruction.

> Now, Macy is the cheerleader for the rest of the faculty because she was one of the teachers who's been here the longest, and she is such a veteran teacher but now has a strong voice in teaching everyone else. (Linda interview; 13 July 2005)

Linda thought that the program had helped Macy to perceive others differently and become more tolerant of changes and individual differences.

> The program helped Macy not only in her profession but…as an individual to maybe see thing outside the box instead of inside the box, and that things aren't always black and white…There are other ways to approach things. There is not always one way. And she has just expanded her horizon and developed into a better individual. (Linda interview; 13 July 2005)

Anna

Linda said that Anna used to be a very quiet person. Though Anna had been teaching for several years, was the leader of the team, and "is an organized person and has done what she was asked for, she has not gone out and really shown those leadership

skills of taking the initiative for the group." Linda thought that after the program had started, Anna was "taking initiative and finding out things for the group and…standing up more for the group, feeling more secure with herself." Linda said that "Anna was improving each year because now the seed has been planted in her life that she is a capable individual and that she is a good teacher." Linda said she was surprised at Anna's change in demonstrating leadership qualities because she had always thought that "Anna was one of the teachers who always taught in isolation and would rather be by herself with her door closed and not with the group." During the program, Linda was glad that Anna "was persistent in making sure her team obtains some professional learning credits [PLUs] for their participation in the program and research." Linda believed that the teachers were "doing a lot of work, and Anna was the driving force to ensure it got initiated and gave all the information that needed to be gathered for the committee at the central office." Linda thought that the request for PLUs was a wise decision because it gave the teachers more initiative to continue the program on their own in the following academic year. Linda said she was even more surprised when Anna was "one of the big proponents of wanting to continue the program." Anna had approached Linda on three separate occasions to say that the team really wanted to continue the professional development and to continue working together as a team. Anna was worried that the program was just going to stop, and she had worked with Linda "to develop what her goals were as the leader of the team and what the team's goals were for the next academic year, where do they want to go." Anna had some ideas about what the team could do with their own professional development the following academic year, and she invited Linda to attend a team meeting during the summer break.

Linda said she believed “the program was a worthwhile adventure.” Linda said she contributed to the team’s growth through the professional development program in many ways. She said that she gave the teachers verbal support whenever they needed it, and she worked closely with Anna to make sure the teachers were given their PLUs in participating in the professional development program. Linda believed that awarding the teachers the PLUs greatly boosted the teachers’ motivation to participate in the program. Linda also said that she made sure the principal was aware of what was going on in the program, and the importance of the program so that they could work closely together to support the teachers and me. She also said she tried to provide anything that the teachers needed in the program as long as “the teachers were going to use it for a specific lesson or reason.” Linda also said she made sure the teachers had adequate time for the program, and that “they were not tied down with a lot of other things to make sure that they could focus on the program… because the principal and [her] wanted to see the teachers sharing.”

Linda said her expectations for the teachers and team were another factor that brought about the teachers’ and team’s growth. She said that she expected the teachers “to be doing what they learned from the program. And it wasn’t on the days that Lu was with the team.” Linda said she questioned the teachers on what they learned from the program, and the teachers also invited her to observe their mathematics lessons whenever they “learned something from the program and had something to show her.” She said, “The teachers were able to show me on days that Lu wasn’t in the school that they were still implementing and doing some of those things that they had learned.”

Linda said she supported my work in the school by indicating on the school's calendar when I would be in the school. The principal also made an announcement to the school on the mornings when I was in the school to make sure that the conference room was reserved for the professional development program, and the research study. Linda also said she made sure that I was given the time with the teachers and I had what I needed for the program.

Concluding Remarks

Like the rest of the teachers, Linda felt that tension existed in the team. She thought that the tension was a result of walls erected between the more-experienced and newer teachers on the team. The more-experienced teachers in the school believed in mastery learning and employed that teaching approach for several years; any deviation from mastery learning took them away from their comfort zone and shook their confidence. When newer teachers joined the team with varied beliefs about how mathematics should be taught, conflict arose between the two groups. The program set up a structure and a safe environment for the teachers to grow in their teaching as well as an opportunity to understand each other from a fresh perspective. The laboratory classes provided the teachers with opportunities to observe and experiment with different teaching techniques. The support rendered by the team and me and the laboratory class throughout the program gave the teachers more confidence to change in their teaching. The shared experience, the sharing, and the critique sessions afforded by the program eventually led the teachers to support each other as a team. They learned to put their

individual differences aside to focus on their professional growth and work towards shared common goals. Linda's continual support for the program and the improvement in the mathematics test scores at the end of the program further motivated the teachers to change and collaborate as a team.

CHAPTER 9

SUMMARY AND CONCLUSION

Effective professional development programs are indispensable for high-quality teaching. Few researchers studying professional development, however, have taken into account what we know about how teachers learn individually and as a team. The purpose of this study was to investigate primary school teachers' conceptions of change in their instructional practices and in their team development as they shaped a professional development program collectively with a professional developer. In the study, I focused on the beliefs and practices of a group of teachers who formed a team at a primary school during the second year of a professional development program. An administrator's conception of the teachers' change in teaching practices and team development was also studied to provide a wider lens for understanding teacher change and team development. The significance of the study lies in its contribution to a better understanding of why and how teachers change individually and as a team.

The participants in this study were six primary teachers and their vice-principal at a public primary school in a small town. The teachers were selected because they were participating in a professional development program I was conducting that focused on elementary mathematics teaching. The vice-principal had participated as a teacher in the first year of the program. The six teachers were each interviewed and their mathematics lessons observed at the end of each of six laboratory class cycles in which they planned, observed, and critiqued demonstration lessons. The teachers and the administrator were

each interviewed once after the program ended. The data from the interviews and observations were analyzed using constant comparative techniques from grounded theory methodology (Glaser, 2002; Glaser & Strauss, 1967). The study addressed the following research questions:

1. What are the teachers' experiences of a professional development program that includes laboratory classes as they shape the program collectively? Why and how does the professional development program evolve?

2. What are the teachers' conceptions of change in their teaching as a result of this school-based professional development experience? How do the individual teachers change as a function of their experience?

3. What are the teachers' conceptions of change in their team as a result of this school-based professional development experience?

4. What is the administrator's conception of the teachers' and the team's change?

Program Experiences and Evolution

This study shows that the laboratory class cycle is a model of learning experiences powerful enough to transform teachers' classroom practice. The laboratory class cycle "makes learning of teachers intertwined with their ongoing practice, making it likely that what they learn will indeed influence and support their teaching practice in meaningful ways" (Putnam & Borko, 2000, p. 6). We started off with a framework for the laboratory class cycle using the three stages of preparation, observation, and critique discussed in chapter 2. Ball (1995) stated that for teachers to actually implement changes in instruction, they must be involved in creating and redesigning it. In this study, the framework was modified by the participants and the professional developer to bring about greater change in the teachers' learning and teaching practices and in a self-sustaining team. Using the interpretivist perspective, I had to find out what the teachers

were thinking before I figure out what to push on. My input as the professional developer usually involved suggestions or questions designed to clarify issues, which not only created a sense of ownership of the instructional change on the part of the teachers but also prepared them to incorporate professional development into their day-to-day teaching practice. The study showed that not only did the professional development program changed, but the way in which it changed made the program more effective at the end than it was at the beginning. The program changed not only because of the professional developer's suggestions to modify it. The teachers also pushed the professional developer in certain directions, and the program turned out to be a joint venture between the professional developer and the teachers.

Research and professional development were separate entities at the beginning of the program. As the research study progressed, feedback from the teachers, both as a team and individually, was vital in modifying the program to suit the teachers' needs. Two variations of the laboratory class were tested in the study. In all the six laboratory class cycles, I taught a demonstration lesson (the first demonstration lesson) in each participating teacher's classroom, which gave her an opportunity to observe me teach her students. The lessons showed the teachers new ways to teach mathematics and gave them a new perspective on understanding how their own students learned mathematics. A second demonstration lesson in each of the first three cycles offered the teachers an opportunity to observe me teach a small group of students from their classes. This arrangement brought about initial teacher and team change. The teachers needed opportunities to observe and critique my teaching so that they could come up with ways to improve their mathematics instruction. The second demonstration lessons, however,

came to be seen as repetitive. After the third laboratory class cycle, the teachers wanted an opportunity to practice and to test different approaches to teaching mathematics they had seen. They also wanted feedback from me and from their team as they tested those ideas. Hence, the second demonstration lesson in the last three laboratory class cycles was modified to engage the teachers in experimentation and critical examination of practices by having them observe each other as they took turns teaching a small group of students at a learning station. The modification afforded the teachers opportunities to observe their peers teach, which fostered greater team growth and individual teachers' growth. The first demonstration lesson continued to benefit the teachers' practices as they observed me model different strategies and approaches in teaching mathematics. Figure 5, 6, and 7 summarize how the role of observation evolved during the program. Figure 5 shows that in the first two cycles, I taught the demonstration lessons, and the teachers observed me teach. They critiqued those lessons during the critique sessions.

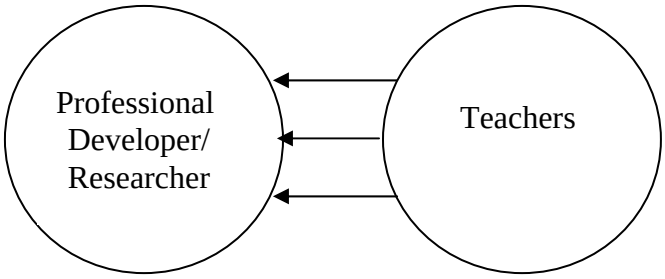


Figure 5. The role of lesson observations and feedback during the first two laboratory class cycles.

Figure 6 shows the third laboratory class cycle, when as a researcher, I realized I could merge the research and the program. The teachers observed me teach the demonstration lesson, and I observed their lessons after the laboratory class cycle. The observations from both activities were used for sharing and critique during the program.

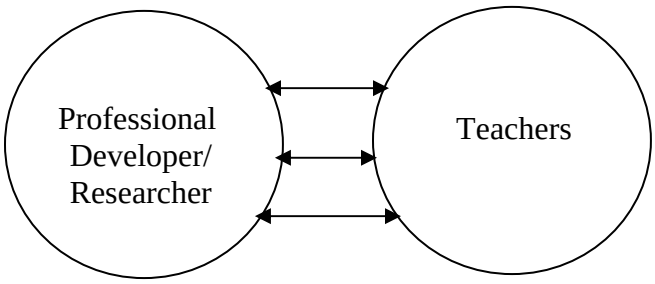


Figure 6. The role of lesson observations and feedback during the third laboratory class cycle.

Figure 7 shows the fourth, fifth, and sixth laboratory class cycles. The teachers observed me teach in the first demonstration lesson, and they observed their team members teach in the second demonstration lesson using station activities. The teachers worked in pairs, and they took turns with their partners teaching a group of students in the station activities. There were six students in each group. One teacher would teach the first group of students, and the other teacher would observe the students' reactions to the lesson. The other teacher would then teach the second group of students, and the first teacher would observe. I continued to observe the teachers at the end of each laboratory class cycle. All these observations were shared during the critique sessions.

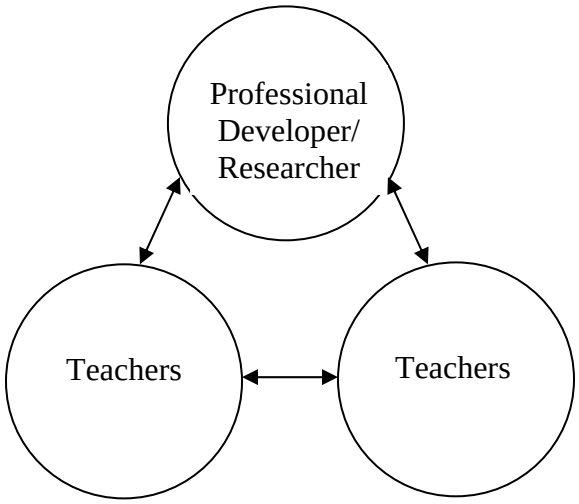


Figure 7. The role of lesson observations and feedback during the fourth, fifth, and sixth laboratory class cycles.

The modified second demonstration lessons worked hand in hand with the first demonstration lessons to bring about greater teacher and team change than in the first three cycles. Figure 4 (p. 62), illustrates the integration of the two variations of a laboratory class cycle by integrating the first and second demonstration lessons to form a new laboratory class cycle. The critique sessions were also modified to include critiques not only of my teaching but also of the teachers' teaching of the station activities. I used the results of my observations to facilitate the teachers' sharing and critiquing of the teaching of the station activities during weekly meetings. In that sense, research and professional development were merged in the middle of the program to gather feedback about the program from teachers and their conceptions of their changed teaching and team growth.

Teachers' Change and Conceptions of Change

In Table 5, I summarize the teachers' common conceptions of, reasons for, and factors affecting their change in instructional practices. The first column lists practices to which the teachers were introduced by the demonstration lessons. The teachers said that they had incorporated those practices in their teaching. The second column lists three common reasons the teachers gave for the change in their instructional practices.

Table 5

Common Changes in the Teachers' Instructional Practices

Teachers' conception of change in instructional practices	Why change?
• More questioning, probing, and students' explanations • Teaching mathematics for understanding	• Better student performance • Increased proficiency in teaching mathematics

besides teaching only the mathematical skills to enable students to perform in state tests • Focusing on students' thinking skills, and learning mathematics as a process • Incorporating students' perspectives into the planning of lessons • Encouraging the use of multiple solutions when solving a mathematics problem • Employing different teaching approaches to help students understand mathematical concepts • Using manipulatives to develop conceptual understanding	• Changed beliefs about how children learn mathematics

I summarize the teachers' change in their instructional practices as a function of their experiences in Table 6. I categorized the teachers into three groups. There were two teachers in each group, and the groups changed in different ways. The first-year teachers said they were challenged to think more about the use of mathematical games in teaching mathematics or in assessment. The second-year, third-year, and more-experienced teachers said they experienced an increase in their pedagogical knowledge for teaching mathematics. The more-experienced teachers were the only group that said they experienced some difficulties coping with change. They also made the most distinctive changes, and they participated in the program for two years.

Table 6

Teachers' Changes in their Instructional Practices as a Function of Their Experiences

First-year teachers • Greater use of mathematical games • More attention to higher-order thinking skills Second-and third-year teachers • Increased pedagogical knowledge for teaching

- More use of different modes of instruction
- Greater use of activities and resources

More-experienced teachers

- Developing more patience and higher expectations
- Coping with change successfully
- More questioning of one's teaching practice
- Use of learning-focused groups
- Increased pedagogical knowledge for teaching
- Better connecting of theory with practice
- Use of station activities

This study illustrates that "meaningful learning is a slow and uncertain process for teachers, just as it is for students" (Putnam & Borko, 2000, p. 6). Some changes were common among the teachers. The data documented that the teachers were reflecting on their practice, constructing new knowledge about teaching, and making instructional shifts as a result of the program. The teachers sought the best strategies and instructional practices to engage students in learning, making necessary adjustments to respond to students' diverse learning needs. The teachers believed they became more effective, and they felt empowered to make deliberate and thoughtful changes in their lessons. The teachers also appeared to have developed a change orientation that led them to reflect continually on their teaching and to experiment thoughtfully with new practices. At different points in the study, the teachers emphasized the importance of seeing the use of questioning techniques in practice through modeling, experimenting with, and practicing new teaching ideas, reflecting on the success and failures of their efforts, debriefing, sharing ideas with other teachers, being observed, and receiving feedback on their use of new teaching approaches. These are activities that have been found to be helpful in similar collaborative initiatives by Boudah, Logan, and Greenwood (2001), Briscoe and

Peters (1997), and Butler, Lauscher, Javis-Selinger, and Beckingham (2004). Some "teachers respond differently to the particular approaches taken in the professional development program" (Richardson & Placier, 2001, p. 921).

The results of this study support Farmer, Gerretson, and Lassak's (2003) claims that an effective mathematics professional development includes authentic and readily adaptable student-centered mathematics learning activities; rich opportunities for discussion and reflection; an open, learner-centered implementation component; and an inquiry stance taken by the facilitators. Furthermore, opportunities for discussion centered on mathematical ideas and issues of pedagogy allow teachers to construct mathematical and professional meanings for themselves from the professional development activities.

The study also supports the findings of Stein and Brown (1997), and Butler et al. (2004) that teachers need evidence that instructional approaches will actually work with their students. The study, like that of Guskey (1986), found that significant changes in beliefs and attitudes are likely to take place only after changes in student learning outcomes are evident, that is, once teachers have field tested change proposals in their classrooms and experienced change in student learning firsthand.

In the present study, some teachers needed only a little help to begin experimenting in their classrooms, some needed to be taught how to change their teaching practices, and others required much environmental support to maintain the new way of behavior (Vaughan, 1993). The study showed that modeling is a key component of scaffolded instruction (Winn, 1994) and that it can be an important contribution to teacher and team change. The gradual withdrawal of supportive learning structures, or

faded support, transfers responsibility to the teachers (Winn). This move toward increasing self-regulated learning with continued but decreasing support was a result of the teachers' increasing ownership of the program, and not a deliberate action by the professional developer in this program. The constant support from the professional developer and the team facilitate changes in teachers' practices.

Conceptions of Team Change

I summarize the teachers' conceptions of team development in Table 7. The first column lists the teachers' conception of how the team had developed as they went through the forming, storming, norming, performing, and transforming stages of team development (Tuckman & Jenson, 1977). This study showed that the team stormed before they formed. The second column lists four reasons that the teachers said brought about the team development. The third column lists three factors the teachers identified as causing the team to change.

Table 7

Teachers' Conceptions of Team Development

Teachers' conceptions	Why change?	What caused the change?
• Animosity reduced • Appreciate and respect one another more • Support for teaching • More cohesive as a team • More effective team time • Professional development in day-to-day teaching practices	• New standards and common goals • Believe in team work (support by team) • Role identified in the team • Acceptance and respect by team	• Opportunity to collaborate, time together, and shared experiences • School initiatives (Team norms and use of agendas in meetings) • Opportunity to err and experiment with different teaching approaches

This study showed how a program that develops a social context that enhances engagement, proactive skill development, and supportive structures can help teachers become more motivated and effective (Cowen, 1991; Ryan & Deci, 2000). The data also showed that teacher change can trigger team growth and vice versa; that is, teacher growth and team growth in this study were interdependent. The team changed through the ideas and ways of thinking its members brought to the discourse (Putnam & Borko, 2000). This learning was not unidirectional, as individual teachers were affected by the way the team viewed and learned mathematics instruction.

As a professional developer, I should not expect all teachers to be enthusiastic about making changes at the beginning of a professional development program. If there is a climate of disrespect, distrust, and disengagement, it must be addressed and resolved before teachers can learn to function as a team that values diversity and learning. Team development is an uphill task. It requires effort and commitment over an extended time from both the teachers and the professional developer to build collegial relationships among team members, especially if they initially exhibit some animosity. When the teachers were provided with the support and development they needed for their learning by their team and by the professional developer over an extended period, they began to place a significant value on continuous learning. This provision led the team to move beyond discussions of school schedules and administrative duties to focus on their learning and teaching.

New state curriculum standards can be a driving force encouraging teachers to collaborate as a team when they believe that the standards call for more teamwork. Also, when teachers' focus is redirected toward students' mathematical learning and

achievement, with shared goals and a vision to guide decisions about teaching and student learning, it is possible to bring about an environment of continuous inquiry and improvement, with all the members of the team invested in the learning and changes necessary to address the needs of all students.

The laboratory class cycle is part of a professional development program that provides a formalized structure for collegial coaching and the means to confront issues of isolation. The shared experiences and the type of interactions afforded by the laboratory class cycle reduces isolation among teachers and strengthens professional and personal relationships across teachers as they assume the role of critical friends for one another. Through such interactions, teachers are able to build a culture of mutual respect and trustworthiness. They began to acknowledge others' strengths and to value the distributed expertise provided by various members of the team. Through shared experiences and teachers' ownership of the program, their notions of expertise can be "changed from seeing the university researchers as the experts to seeing everyone in the group as experts" (Richardson & Placier, 2001, p. 920). The findings of the present study are consistent with those of Stein, Smith, and Silver (1999), who found that a common set of professional development activities at various levels provides "the glue that holds a community together" (p. 267). The findings are also in accord with Truscott and Truscott's (2004) finding that "acknowledging teacher strengths as internal resources fostered positive social climate overall and reinforced new learning for the teachers" (p. 62). The professional trust and respect that pervaded the team allowed the teachers to take risks in implementing new strategies.

The laboratory class cycle also created a culture in which the teachers were more willing to critically evaluate the success of their improvement efforts and to share those efforts with the rest of the teachers in the school. Teachers can learn to exercise the traits of critical colleagueship (Lord, 1994) through the cycle by sharing ideas, asking probing questions, observing each other teach with a small group of students, reviewing their teaching and their students' learning, and raising ideas for discussion and debate. Teachers who initially view disagreement personally can learn to view disagreement as opportunities to consider different perspectives and clarify beliefs (Ball & Cohen, 1999). This observation is consistent with Ashton and Webb's (1986) finding that collaboration among teachers as a result of a program produces a greater willingness to take risks, learn from mistakes, and share successful strategies. As in the programs of Frykholm (1998) and Seago (2004), as this professional development program helped establish trust, modeled communication norms that enabled critical dialogue, and maintained a balance between respecting individual team members and critically analyzing issues in their teaching, discussions became more supportive of a critical examination of teaching. This study also illustrates how teachers benefit from participating in a collaborative learning environment where they share ideas with colleagues and to deal with challenges (Englert & Tarrant, 1995; Perry, Walton, & Calder, 1999). Encouragingly, and consistent with previous research (Briscoe & Peters, 1997; Butler et al., 2004), my data also suggest that collaboration helps teachers identify potential solutions to challenges.

The Administrator's Conception of Change

I summarize the administrator's conception of teacher change in Table 8. The first column lists the administrator's conception of the teachers' change in their instructional

practices. The second column lists the reasons the administrator gave for the teachers' change. The administrator said that all the teachers had increased their mathematical knowledge.

Table 8

Administrator's Conception of Teacher Change in Instructional Practices

Administrator's conception	Why change?
• Increased mathematical knowledge and questioning • Better lesson planning • Less use of mastery learning approach	• Structure for teacher growth • Support from the team • Safe environment

I summarize the administrator's conception of team change in Table 9. The first column lists three changes the administrator said the team had made. The second column lists the reason the administrator gave for the changes. The administrator said that there was an increased in the teachers' mathematical knowledge. Unfortunately, there was no evidence to indicate what she meant by mathematical knowledge.

Table 9

Administrator's Conception of Team Development

Administrator's conception	Why change?
• Greater personal and professional growth • More participation during weekly meetings • More sharing during faculty meetings	• Safe environment

The teachers' and team's change were observable beyond their classrooms and meetings. The administrator's view of the teachers' and team's change supports previous findings that some teachers change more than others through participation in professional development programs (Fennema et al., 1996; Franke, Carpenter, Levi, & Fennema,

2001; Knapp & Peterson, 1995). The administrator said that the teachers who participated in the program for a second year appeared to change more than those who participated in the program only one year.

Significance of the Study

Teachers' and Professional Developer's Experience in the Program

The teachers' experience in the program shed light on some factors that can contribute significantly to the success of a school-based professional development program using a laboratory class cycle. Without understanding how teachers are thinking about the program, we cannot understand how different components of the program affect research and practice, and what beliefs participants bring to the study. This study, by describing the teachers' collective involvement in the design of the program with the professional developer, provides an example of how differing beliefs and tensions in a program can be resolved. Also, by describing the experiences of the teachers in this program, we are able to track the rationale for testing and modifying the model of the laboratory class cycle. In accordance with Feiman-Nemser (2001), who observed, "In place of superficial, episodic sessions, teachers need sustained and substantive learning opportunities" (p. 1042), the findings of this study contribute to our understanding of the laboratory class cycle model as a tool to bring about a self-sustaining learning community. The study shows how a program can be built into the ongoing work of teaching and relate to teachers' questions and concerns. The creative use of time and

flexible scheduling provided opportunities for the teachers to work together during the school day, tap local expertise, and generate collective wisdom by working together.

The study also adds to our knowledge of the role of an external professional developer and when she or he is needed. External professional developers are able to take a "balcony view, a macro-centric view of situations, in which they try, with compassion and detachment, to understand the nature of the existing situations" (Garmston & Wellman, 1999, p. 56). In so doing, professional developers are able to offer appropriate support and encouragement to teachers and identify resources that could help them achieve their goals. This study suggests that the stance that the external developer takes to a professional development program is important in making or breaking the program. When using the laboratory class cycle, the external professional developer should model an inquiry stance in discussions with teachers to exemplify the importance of inquiry in learning and teaching mathematics. This modeling will help stimulate the teachers' thinking about themselves as inquirers.

Teachers' and Administrator's Conceptions of Teacher Change

Describing teachers' and an administrator's conceptions of teachers' change is important for two reasons. First, by understanding how teachers change, we can identify important factors that bring about such change. This understanding adds to research efforts on effective professional development programs. The findings of this study suggest that teachers need to engage in particular practices if they are to include professional development in their everyday teaching practices. The laboratory class cycle is a model that engages teachers in generative growth both individually and as a team. It also allows professional development to be self-sustaining. For the laboratory class cycle

to work, however, teachers must establish a routine to meet frequently, engage in experimentation and critical dialogue, and adopt an inquiry stance toward learning and teaching. The study also suggests that administrative encouragement of teachers to experiment with innovative teaching strategies, the encouragement of collegial discussion, and the structural provision of opportunities to share and reflect on each other's practices are "facets of the change environment that act to afford teacher growth" (Clarke & Hollingsworth, 2002, p. 954).

Second, the findings of this study suggest that working directly with teachers and students helps a professional developer get at the center of teacher learning and change by modeling and examining what teachers do in their mathematics classrooms. By being directly involved with teachers, and by studying and learning alongside teachers, professional developers can communicate to teachers the importance of their efforts to improve their teaching practices.

Teachers' and Administrator's Conceptions of Team Development

Describing the teachers' and the administrator's conceptions of the team development is important for three reasons. First, the frequent meetings with teams and establishing a routine for the program are vital in nurturing and maintaining working relationships with the teachers as an external professional developer guides a team through the forming, storming, norming, performing, and transforming stages.

Second, this description contributes to research on developing effective teams by understanding how we can prepare members of a team consisting of teachers with various experience in teaching. The professional growth of the more-experienced teachers and the newer members of the team can be made possible by particular elements in the change

environment. Established members may take for granted the premises behind the school's rules and procedures. They cannot take on the role of the newcomer in order to understand the problems that newcomers experience (Jones, 1983, p.465). Teachers who have taught for many years "may not realize how hard it is for a newcomer to enter, explore, understand, and ultimately, find her place among them" (Kardos, Johnson, Peske, Kauffman, & Liu, 2001, p. 256). Also, experienced teachers may have established a system of running their classrooms that dissuades and constrains them from trying new approaches in teaching that might threaten that system. The teacher's seniority may also act to constraint any inclination of experimentation with new practices. This group of teachers should not be neglected, as they also need guidance and support to cope with changes around them.

Schein (1992) noted that "one of the major activities of any new member when she enters a new group" is to decipher the norms and assumptions that are operating" (p. 13). An individual must develop an accurate "mental map" of the organization and "understand other's expectations" (p. 22). However, the newcomer, faced with an ambiguous, uncertain situation and lacking reference points for appropriate behavior, is assumed to experience a breakpoint or reality shock on entering the new situation (Hughes, 1958). This study supports research findings that as a result of the anxiety or stress generated by an encounter with the unknown or unusual (Louis, 1980), newcomers' prime concern is to clarify their situational identity through their work roles (Berlew & Hall, 1966; Feldman, 1976) or by securing the approval of others (Katz, 1978; Wanous, 1980). There was one teacher who was in this particular situation and it is in harmony of this finding. The laboratory class cycle can be a model that offers intellectual

nourishment and renewal to teachers of varied experience, can help more experienced teachers cope with changes around them, and can help usher new teachers into the team by helping them find their role and voice.

Third, this study shows that the administrator's role is important in helping the team to change. Administrators need to endorse and believe in collaboration among the teachers before they can encourage their teachers to change. This study supports the vice-principal's central role in establishing, reinforcing, and realigning the school culture (Bryk, Lee, & Holland 1993; Deal & Peterson, 1999; Fullan, 1991; Metz, 1978), as well as "in promoting collegiality, professional community, and a collective sense of purpose and responsibility among the faculty" (Kardos et al., 2001, p. 257). Administrators should have their own expectations of how a school-based professional development program should be run, but they should also provide the professional developer with space and time to develop the program with the teachers without imposing their own ideas on the team and the professional developer. Instead, administrators should maintain a visible and knowledgeable presence in the school to provide whatever support the professional development requires and to monitor firsthand all school activities. Providing verbal support and encouragement to the team participating in the program and working out incentives for the team can further encourage the teachers' efforts to learn and change through the program (Vaughan, 1993). An administrator should also expect the team to continue to grow professionally after the program and the teachers in the team to assume leadership roles. This expectation gives the teachers greater confidence in their teaching and greater motivation to continue the professional development on their own and grow as a team.

Limitations and Future Research

There are several limitations evident in this study. The first, is the replicability of the program. In this laboratory class cycle model, it was difficult to identify exactly which factors were more effective than others because I attempted to be responsive to the needs and expectations of the participants. Although difficult, it might be possible to replicate the basic elements of the model, using design-based research, independent of the specific context reported here, rather than trying to replicate the entire study. Second, a significant amount of time is required for researchers to work alongside teachers, and it is not practical on a widespread basis. A full mathematics lesson is usually an hour in primary schools. In this study, lesson observations and the first demonstration lessons were conducted for only 30 minutes in each of the teachers' classrooms because of time and resource constraints. To conduct these components of study and program, a full hour would have demanded almost twice the amount of time at the research site. Third, data collection started only during the second year of the program. The data would have portrayed a more explicit picture of the tensions among the teachers if they had been collected in the first year of the program.

Future research could also include student outcome data to provide evidence of effectiveness of the process. Like Fisherman, Marx, Best, and Tal (2003), I believe that the systematic exploration of the design of professional development linking standards to student achievement is a necessary element of future progress in systemic school reform. "Few studies of teacher change in either the individual or organizational literature move toward examining what happens to student learning when teachers change their practices" (Richardson & Placier, 2001, p. 939). Student outcome data could also be used

to determine the effects of teacher change on student learning. Studies could also be conducted for mathematics teachers at higher grade levels to compare and contrast how the basic model of the program might evolve. The laboratory class cycle could also be used in a few primary schools for second-grade teachers to explore the relationships among facilitators, the professional development program, and the teachers as learners. The cycle could also be contrasted with the Japanese lesson study to weigh its benefits in enhancing professional growth and changing mathematics instruction.

Conclusion

> Guided learning is easier to talk about than do. It takes clinical judgment to know when to intervene. Successful teachers must engage continually in on-line diagnosis of student understanding. They must be sensitive to overlapping zones of proximal development, where students are ripe for new learning. Guided discovery places a great deal of responsibility in the hands of teachers, who must model, foster, and guide the discovery process into forms of disciplined inquiry that would not be reached without expert guidance. (Brown, 1992, p. 169)

By the same argument, teachers also need guidance in their learning and teaching. Also, programs need to promote deep-rooted changes in teaching instead of mastery of specific routines. Introductory in-service workshops would not be enough to effect these meaningful changes shifts in practice (Borko & Putnam, 1996; Butler et al., 2004; Perry et al., 1999). What is required are ongoing opportunities to co-construct knowledge through reflection on experience. The laboratory class cycle is one professional development model that can provide guided learning for teachers and model a system of disciplined inquiry over an extensive period.

REFERENCES

Ashton, P., & Webb, R. (1986). *Making a difference: Teachers' sense of efficacy and student achievement.* New York: Longman.

Ball, D. L. (1994, November). *Developing mathematics reform: What don't we know about teacher learning—but would make good working hypotheses?* Paper presented at Conference on Teacher Enhancement in Mathematics K–6, Arlington, VA.

Ball, D. L. (1995). Blurring the boundaries of research and practice. *Remedial and Special Education, 16*(6), 354–363.

Ball, D. L. (1996). Teacher learning and the mathematics reform: What do we think we know and what do we need to learn? *Phi Delta Kappan,77*(7), 500–508.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Towards a practice-based theory of professional education. In L. Darling-Hammond & G. Skyes (Eds.), *Teaching as the learning profession* (pp. 3–31). San Francisco: Jossey-Bass.

Bandura, A. L. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *Journal of the Learning Sciences, 12*(1), 1–14.

Bass, H. (2003). Computational fluency, algorithms, and mathematical proficiency: One mathematician's perspective. *Teaching Children Mathematics, 9*(6), 322–327.

Benner, P. (1994). *Interpretive phenomenology*. Thousand Oaks: CA, Sage.

Berlew, D. E., & Hall, D. T. (1966). The socialization of managers: Effects of expectations on performance. *Administrative Science Quarterly, 11,* 207–223.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8). 3–15.

Borko, H, & Putnam, R. T. (1996). Learning to teach. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). New York: Simon & Schuster Macmillan.

Boudah, D. J., Logan, K. R., & Greenwood, C. R. (2001). The research to practice projects: Lessons learned about changing teacher practice. *Teacher Education and Special Education, 24,* 290–303.

Briscoe, C., & Peters, J. (1997). Teacher collaboration across and within schools: Supporting individual change in elementary science teaching. *Science Education, 81,* 51–65.

Brown A. L., (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences, 2*(2), 141–178.

Brownell, W.A. (1939). Learning as reorganization: *An experimental study in third-grade arithmetic*. Durham, NC: Duke University Press.

Bruner, J. (1985). Narrative and paradigmatic modes of thought. In E. Eisner (Ed.), *Learning and teaching the ways of knowing;* Eighty-fourth yearbook of the National Society for the Study of Education, (pp. 97–115). Chicago: University of Chicago Press.

Bryk, A. S., Lee, V. E., & Holland, P. B. (1993). *Catholic schools and the common good.* Cambridge, MA: Harvard University Press.

Burnette, B. (2002). How we formed our community. *Journal of Staff Development, 23*(1), 54–55.

Busier, H-L., Clark, K. A., Esch, R. A., Glesne, C., Pigeon, Y., & Tarule, J. M. (1997). Intimacy in research. *Qualitative Studies in Education, 10*(2), 165–170.

Butler, D., Lauscher, H. N., Jarvis-Selinger, S., & Beckingham, B. (2004). Collaboration and self-regulation in teachers' professional development. *Teaching and Teacher Education, 20,* 435–455.

Calderhead, J. (1996). Teachers' beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (4th ed., pp. 709–725). Washington, DC: American Educational Research Association.

Charmaz, K. (2000). Grounded theory: Objectivist and constructivist methods. In N. K. Denzin & Y. K. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 509–535). Thousand Oaks, CA: Sage.

Cheng, L. P., & Ko, H. K. (2005, August). *A school-based professional development model for teachers' practice.* Paper presented at the Third East Asia Regional Conference on Mathematics Education, Shanghai.

Clandinin, J., & Connelly, F. M. (2000). Narrative understandings of teacher knowledge. *Journal of Curriculum and Supervision, 15*(4), 312–331.

Clarke, D., & Hollingsworth, H. (1994). Reconceptualizing teacher change: In G. Bell, B. Wright, N. Leeson, & J. Geake (Eds.), *Challenges in mathematics education: Constraints on construction*. Proceedings of the 17th annual conference of the Mathematics Education Research Group of Australiasia (Vol. 1, pp. 153–164). Lismore, NSW: Southern Cross University.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*, 947–967.

Clift, R., Houston, W., & Pugach, M. (1990). *Encouraging reflective practice in education*. New York: Teachers College Press.

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

Cobb, P. (2001). Supporting the improvement of learning and teaching in social and institutional context. In S. Carver & D. Klahr (Eds.), *Cognition and instruction: Twenty-five years of progress* (pp. 455–478). Mahwah, NJ: Erlbaum.

Cobb, P., & Bauersfeld, H. (1995). *The emergence of mathematical meaning: Interactions in classroom cultures.* Hillsdale, NJ: Erlbaum.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9–13.

Collins, A. (1992). Toward a design science of education. In E. Scanlon & T. O'Shea (Eds.), *New directions in educational technology* (pp. 15–22). New York: Springer-Verlag.

Cowen, E. L. (1991). In pursuit of wellness. *American Psychologist*, *46,* 404–408.

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process.* London: Sage.

Darling-Hammond, L., & Sclan, E. M. (1996). Who teaches and why: Dilemmas of building a profession for twenty-first century schools. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education* (2nd ed., pp. 67–101). New York: Macmillan.

Darling-Hammond, L., Wise, A. E. & Klein, S. (1995). *A license to teach: Building a profession for 21st century schools*. Boulder: Westview Press.

Deal, T. E., & Peterson, K. D. (1999). *Shaping school culture: The heart of leadership* (1st ed.). San Francisco: Jossey-Bass.

Demulder, E. K. & Rigsby, L. C. (2003). Teachers' voices on reflective practice. *Reflective Practice, 4* (3), 267–290.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Dewey, J. (1904). The relation of theory to practice in education. *The relation of theory to practice in the education of teachers.* (Third Yearbook of the National Society for the Study of Education, Part 1, pp. 9−30). Bloomington, IL: Public School Publishing Co.

Engeström, Y., Engeström, R., & Kärkkäinen, M. (1995). Polycontextuality and boundary crossing in expert cognition: Learning and proble solving in complex work activities. *Learning and Instruction, 5*(4), 319–336.

Engeström, Y. (1997). Developmental studies of work as a testbench for activity theory. In N. Chaiklin, & J. Lave (Eds.), *Understanding practice* (pp. 221–222). New York: Cambridge University Press.

Engeström, Y. (1999). Innovative learning in work teams: Analyzing cycles of knowledge creation in practice. In Y. Engeström, R. Miettinen, & R. L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 377–404). Cambridge: Cambridge University Press.

Engeström, Y. (2001). Expansive learning at work: Toward activity-theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133–156.

Englert, C. S., & Tarrant, K. L. (1995). Creating collaborative cultures for educational change. *Remedial and Special Education, 16*(6). 325–336.

Farmer, J. F., Gerretson, H., & Lassak, M. (2003). What teachers take from professional development: Cases and implications. *Journal of Mathematics Teacher Education, 6,* 331–360.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record*, *103*(6), 1013–1055.

Feldman, D. C. (1976). A contingency theory of socialization. *Administrative Science Quarterly, 21,* 433–452.

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

Fisherman, B. J., Marx, R. W., Best, S., & Tal, R. T., (2003). Linking teacher and student learning to improve professional development in systematic reform. *Teaching and Teacher Education, 19,* 643–658.

Franke, M. L., Carpenter, T., Levi, L., & Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Journal*, *38*, 653–690.

Franke, M. L., & Kazemi, E. (2001). Learning to teach mathematics: Focus on student thinking. *Theory Into Practice*, *2*, 102–109.

Frykholm, J. A. (1998). Beyond supervision: Learning to teach mathematics in community. *Teaching and Teacher Education, 14,* 305–322.

Fullan, M. G. (1991). *The new meaning of educational change* (2nd ed.). New York: Teachers College Press.

Fullan, M. G. (2001). What makes change work for teachers. In F. Banks & A. S. Mayes (Eds.), *Early professional development for teachers* (pp. 71–77). London: David Fulton.

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

Garmston, R. J., & Wellman, B. M. (1999). The adaptive school: A sourcebook for developing collaborative groups. Norwood, MA: Christopher-Gordon.

Giroux, H. A. (1988). *Teachers as intellectuals: Toward a critical pedagogy of learning.* New York: Bergin & Garvey.

Glaser, B. (2002). Conceptualization: On theory and theorizing using grounded theory. *International Journal of Qualitative Methods, 1* (2). Article 3. Retrieved December 12, 2005, from http://www.ualberta.ca/~ijqm/

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago: Aldine.

Glesne, C. (1999). *Becoming qualitative researchers: An introduction*. New York: Longman.

Goetz, J., & LeCompte, M. (1984). *Ethnography and qualitative design in educational research*. New York: Academic Press.

Gordon, S. P. (2004). *Professional development for school improvement: Empowering learning communities*. Boston: Pearson Education.

Green, T. (1971). *The activities of teaching.* New York: McGraw-Hill.

Grimmet, P. P., & Erickson, G. L. (1988). *Reflection in teacher education*. New York: Teachers College Press.

Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record, 103*, 942−1012.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher, 15*(5), 5−12.

Harris, S. L. (2000). Behave yourself. *Principal Leadership, 1*(3), 36–39.

Hoadley, C. (2004). Methodological alignment in design-based research. *Educational Psychologist, 39*(4), 203−212.

Hord, S. M., Rutherford, W. L., Huling-Austin, L., & Hall, G. E. (1987). *Taking charge of change.* Alexandria, VA: Association for Supervision and Curriculum Development.

Howey, K. R., & Joyce, B. R. (1978). A data base for future directions in in-service education. *Theory Into Practice, 27,* 206–211.

Howey, K. R., & Vaughan, J. C. (1983). Current patterns of staff development. In G. A. Griffin (Ed.), *Staff development.* (Eighty-second yearbook of the National Society for the Study of Education, pp. 92−117) Chicago: University of Chicago Press.

Hughes, E. C. (1958). *Men and their work*. Glencoe, IL: Free Press.

Johnson, N. (1989). *Teachers and change: A literature review.* Unpublished manuscript, Melbourne University, Melbourne.

Johnson, N. (1996, July). School leadership and the management of change. *IARTV Seminar Series,* No. 55, pp 12.

Jones, G. R., (1983). Psychological orientation and the process of organizational socialization: An interactionist perspective. *Academy of Management Review, 8*, 464–474.

Kardos, S. M., Johnson, S. M., Peske, H. G., Kauffman, D., & Liu, E. (2001). Counting on colleagues: New teachers encounter the professional cultures of their schools. *Educational Administration Quarterly, 37*, 250–290.

Katz, R. (1978). Job longevity as a situational factor in job satisfaction. *Administrative Science Quarterly, 23*, 204–223.

Kew, D. W. (2000). Middle level teaming: Strength in collaboration. *Schools in the Middle, 9*(9), 39–40.

Knapp, M. S. (1997). Between systematic reforms and the mathematics and science classroom: The dynamics of innovation, implementation, and professional learning. *Review of Educational Research, 67*, 227–266.

Knapp, N. F., & Peterson, P. L. (1995). Teachers' interpretations of CGI after four years: Meanings and practices. *Journal for Research in Mathematics Education, 26,* 40–65.

Krainer, K. (2003). Editorial: Teams, communities and network. *Journal of Mathematics Teacher Education*, *6*, 93−105.

Lane, S., & Silver, E. (1994, April). *Examining students' capacities for mathematical thinking and reasoning in the QUASAR project.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Lieberman, A., & Miller, L. (1990). Teacher development in professional practice schools. *Teachers College Record, 92*(1), 105−122.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.

Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis, 15*(2), 129–151.

Little, J. W. (2002). Locating learning in teachers' communities of practice: Opening up problems of analysis in records of everyday practice. *Teaching and Teacher Education, 18,* 917–946.

Lord, B. (1994). Teachers' professional development: Critical colleagueship and the role of professional communities. In N. Cobb (Ed.), *The future of education: Perspectives on national standards in education* (pp. 175–204). New York: College Entrance Examination Board.

Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

Louis, M. R. (1980). Surprise and sense-making: What newcomers experience in entering unfamiliar organizational settings. *Administrative Science Quarterly, 25,* 226–251.

Lovitt, C., & Clarke, D. M. (1988). *Mathematics curriculum and teaching program*. Carlton, Victoria: Curriculum Corporation.

McGehee, J. J. (2001). Developing interdisciplinary units: A strategy based on problem solving. *School Science and Mathematics, 101*, 380–389.

McLaughlin, M. W., & Marsh, D. D. (1978). Staff development and school change. *Teachers College Record, 80,* 69–94.

McLaughlin, M. W., & Talbert, J. E. (2001). *Professional communities and the work of high school teaching.* Chicago: University of Chicago Press.

Metz, M. H. (1978). Classrooms and corridors: *The crisis of authority in desegregated secondary schools.* Berkeley: University of California Press.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*, 557–576.

Pepin, B. (1999). Epistemologies, beliefs, and conceptions of mathematics teaching and learning: The theory and what is manifested in mathematics teachers' work in England, France, and Germany. *Thematic Network on Teacher Education in Europe, 2*(1), 127–146.

Perry, N. E., Walton, C., & Calder, K. (1999). Teachers developing assessments of early literacy: A community of practice project. *Teacher Education and Special Education, 22*(4), 218–233.

Peshkin, A. (1988). In search of subjectivity: One's own. *Educational Researcher, 17,* 17–22.

Putnam, R., & Borko, H. (1997). Teacher learning: Implications of new views of cognition. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *The international handbook of teachers and teaching* (pp. 1223–1296). Dordrecht, The Netherlands: Kluwer.

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

Rees, F. (1997). *Teamwork from start to finish.* San Francisco. Pfeiffer.

Richardson, V. (1990). Significant and worthwhile change in teaching practice. *Educational Researcher, 19*(7), 10–18.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula, T. Butery, & E. Guyton (Eds.), *Handbook of research on teacher education* (pp. 102–119). New York: Simon & Schuster Macmillan.

Richardson, V., & Placier, P. (2001). Teacher change. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 905–947). Washington, DC: American Educational Research Association.

Rokeach, M. (1960). *The open and closed mind.* New York: Basic Books.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*, 68–78.

Sandoval, W. A., (2004). Developing learning theory by refining conjectures embodied in educational designs. *Educational Psychologist, 39*(4), 213–223.

Sandoval, W. A., & Bell, P. (2004). Design-based research methods for studying learning in context: Introduction. *Educational Psychologist, 39*(4), 199–201.

Schein, E. H. (1992). *Organizational culture and leadership* (2nd ed.). San Francisco: Jossey-Bass.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action.* New York: Basic Books.

Schwandt, T. A. (1994). Constructivist, interpretivist approaches to human inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 118–137). Thousand Oaks, CA: Sage.

Seago, N. (2004). Using videos as an object of inquiry for mathematics teaching and learning. In J. Brophy (Ed.), *Using video in teacher education* (Advances in Research on Teaching, Vol. 10, pp. 259–289). Orlando, FL: Elsevier.

Smith, M. S. (1997, April). *Riverside Middle School: School reform supported by an innovative curriculum.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Smith, M. G. (2000). *Practice-based professional development for teachers of mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Spiegel, J., & Torres, C. (1994). *Manager's official guide to team working*. San Diego: Pfeiffer.

Stein, M. K., & Brown, C. A. (1997). Teacher learning in a social context: Integrating collaborative and institutional processes with the study of teacher change. In E. Fennema, & B. Scott Nelson (Eds.), *Mathematics teachers in transition* (pp. 155–191). Mahwah, NJ: Erlbaum.

Stein, M. K., Silver, E., & Smith, M. S. (1998). Mathematics reform and teacher development: A community of practice perspective. In J. G. Greeno & S. Goldman (Eds.), *Thinking practices in mathematics and science learning, 14*(1), 21–32.

Stein, M. K., Smith, M. S., & Silver, E. A. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review*, *69*(3), 237–269.

Thomas, G., Wineburg, S., Grossman, P., Myhre, O., & Woolworth, S. (1998). In the company of colleagues: An interim report on the development of a community of teacher learners. *Teaching and Teacher Education, 14*(1), 21–32.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127–146). New York: Macmillan.

Trimble, S. B., & Miller, J. W. (1996). Creating, invigorating, and sustaining effective teams. *NASSP Bulletin, 80*(584), 35–40.

Trimble, S. B., & Peterson, G. W. (1999, April). *Beyond the process of teaming: Administrative support, classroom practices, and student learning.* Paper presented at the annual meeting of the American Educational Research Association, Montreal.

Truscott, D. M., & Truscott, S. D. (2004). A professional development model for the positive practice of school-based reading consultation. *Psychology in the Schools, 41*(1), 51–65.

Tuckman, B. W., & Jenson, M. A. (1977). Stages of small group development revisited. *Group and Organizational Studies*, *2*(4), 419–427.

Vann, A. S. (2000). Shared decision-making committees: Power without power. *Education Digest, 65*(6), 67–69.

Vasudeva, A., & Ryan, S. (1997, March). *Why some teams work: The role of social capital in teacher efficacy*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Vaughan, M. E., (1993). Why teachers change: An analysis of consequences and rules. In P. Kahaney P., L. A. Perry, & J. Jananglo (Eds.), *Theoretical and critical perspectives on teacher change* (pp. 113–127). Norwood, NJ: Ablex.

Voigt, J. (1995). Thematic patterns of interaction and sociomathematical norms. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning* (pp. 163–201). Hillsdale, NJ: Erlbaum.

Wanous, J. P. (1980). *Organizational entry: Recruitment, selection, and socialization of newcomers.* Reading, MA: Addison-Wesley.

West, L., & Curcio, F. R. (2004). Collaboration sites: Teacher-centered professional development in mathematics. *Teaching Children Mathematics, 10*(5), 268–273.

Wilber, K. (2000). *Integral psychology*. Boston: Shambhala Publications.

Wilson, S. M., & Ball, D. L. (1996). Helping teachers meet the standards: New challenges for teacher educators. *Elementary School Journal, 97*(2), 121–138.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. In A. Iran-Nejad & P. D. Pearson (Eds.), *Review of research in education* (pp. 173–209). Washington, DC: American Educational Research Association.

Winn, J. A. (1994). Promises and challenges of scaffolded instruction. *Learning Disability Quarterly, 17,* 89–104.

Wood, F. H., & Thompson, S. R. (1980). Guidelines for better staff development. *Educational Leadership, 37,* 374–378.

Zeichner, K., & Gore, J. (1990). Teacher socialization. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 329–348). New York: Macmillan.

APPENDIX

THE USE OF A CRUTCH IN SUBTRACTION AND ADDITION WITH RENAMING

Subtraction Algorithms

Brownell (1939) found that students using a "crutch" in the algorithm of the subtraction problems were more accurate and faster than students who did not use the crutch. The crutch involved marking through numerals from which an amount was borrowed in order to keep track of the steps when working a problem. Figure 8 illustrates the different forms of the crutch that the teachers used in the present study.

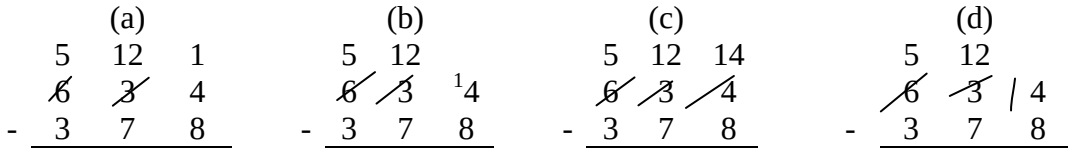


Figure 8. Forms of the crutch that the teachers used in subtracting 378 from 634.

The forms of the crutch in the figure illustrate the decomposition method for subtraction with renaming for three-digit whole numbers commonly found in children's textbook. Writing out the steps of the algorithms in words and in detail is long, and time-consuming but when recoded in symbols using the algorithm, it is elegant, and compact. The compactness, however, hides the meaning and complexity of the steps involved (Bass, 2003). Even though the crutch is used to help children keep track of the algorithm, it does not help them understand the implicit meaning behind the crutch and the algorithm unless we use them more carefully. In Figures 8a, and 8b, the forms of the crutch do not carry the meaning of place value consistently. The 5, and the 12 in Figures 8a, and 8b clearly

represent 5 hundreds and 12 tens, and their value is dependent on where the numeral resides. However, the 'carried' 1 does not represent one 1 although it resides in the ones column. This placement may explain why some children add the carried 1 to 4 instead of computing 1 ten + 4 ones. Figure 8c, in this sense, conveys the concept of place value more accurately, as 4 is striken out, and replaced by 14. Here, since 14 resides in the ones place, it represents 14 ones. We then take 14 ones minus 8 ones in the ones column. In Figure 8d, instead of striking out 4 and replacing it with 14 ones above 4 ones, the numeral 1 is placed in front of the 4 to represent 14 ones. This placement is conceptually sound as long as we take the new 14 to be 14 ones. In many classrooms, children are taught to check by adding the difference to the subtrahend, and if the result is equal to the minuend, the work is correct. Figure 8d may give rise to some confusion as to the original minuend.

Addition Algorithms

In the mathematics topic "addition of whole numbers with renaming" in schools, the most commonly used approach is by regrouping. For example, the algorithm in Figures 9a, and 9b are widely used:

(a)

Thousands	Hundreds	Tens	Ones
	1	1	
	6	3	4
+	3	7	8
1	0	1	2

(b)

	$^{1}6$	$^{1}3$	4
+	3	7	8
1	0	1	2

Figure 9. Commonly used algorithms for adding 634 and 378.

The above addition algorithms when described in words are as follows:

> Add the ones. 4 + 8 = 12. There can be no more than 9 ones in the ones column, so you regroup 12 to make 1 ten and 2 ones. Write 2 in the ones column, and write the 1 above the tens column. Add the tens. 1 ten + 3 tens + 7 tens = 11 tens. There can be no more than 9 tens in the tens column, so you regroup 11 tens to make 1 hundred and 1 ten. Write 1 in the tens column, and write the 1 above the hundreds column. Add the hundreds. 1 hundred + 6 hundreds + 3 hundreds = 10 hundreds. There can be no more than 9 hundreds in the hundreds column, so you regroup 10 hundreds to make 1 thousand and 0 hundred. Write 1 in the thousands column and 0 in the hundreds column.

Both forms of the crutch in Figures 9a, and 9b are consistent in conveying the meaning of place value. The 1 in the tens column represents 1 ten, and the 1 in the hundreds column represents 1 hundred. In the elementary school curriculum, addition is introduced before subtraction, and if we examine closely how the crutches are used in addition and subtraction, those crutches may lead to some confusion especially when children are learning the algorithm for subtraction. In Figure 9b, the 1 is written as a superscript to the left of 3 and 6. In the tens column, the 1 represents 1 ten. We add 1 ten + 3 tens + 7 tens to give us 11 tens, which we decompose into 1 ten and 1 one. In the hundreds column, the 1 represents 1 hundred. The position of the 1 is determines its value. The same crutch is used in subtraction with renaming in Figures 8a, and 8b although it carries a different meaning in subtraction and this is where the confusion may occur for young children. In Figures 8a, and 8b, the 1s are written as superscript to 4. In subtraction, the 1 represents 1 ten and not 1 one although it is in the ones column. In addition with renaming, this crutch reminds children to add “1 + 4,” however, in subtraction, this crutch means “1 ten + 4” as illustrated in Figure 10.

$$\begin{array}{rccc} & & 2 & 14 \\ & 6 & \cancel{3} & \cancel{4} \\ - & 3 & 7 & 8 \\ \hline \end{array}$$

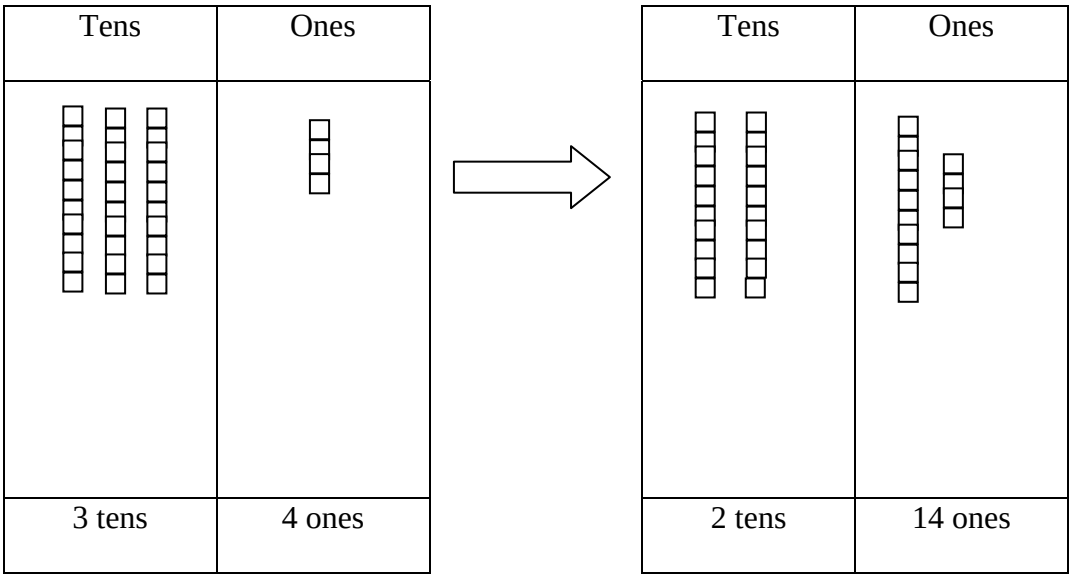


Figure 10. Meaning of crutch in subtraction with renaming.

Figure 11 illustrates the suggested crutch with renaming. I explained to the teachers that the crutch shown in Figure 11 would be more appropriate if we were to be consistent about its meaning and use into the hundreds and higher places.

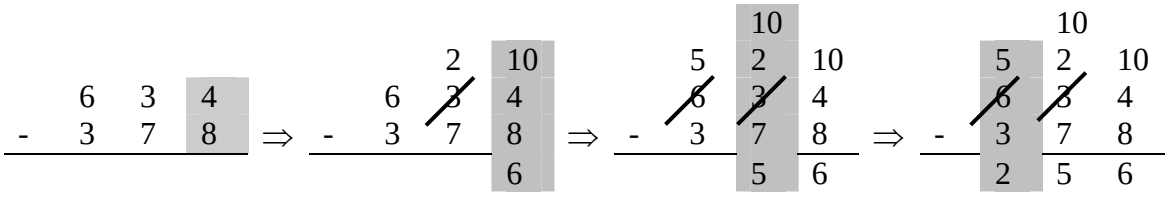


Figure 11. Suggested crutch for subtraction with renaming.

Also, we need to be careful with how we articulate the procedures in solving the problems. For simplicity, many of us tend to read in subtraction problems, “In the tens column, 6 minus 1 gives 5.” The more accurate way is to read it as “6 tens minus 1 ten, which gives us 5 tens.” This reading will offer children an opportunity to recognize that in the tens column they are subtracting 6 tens and not 6. Similarly, in addition, for young children, we should read “1 ten plus 7 tens in the tens column,” instead of “1 plus 7.” By

stressing where the numeral resides, the concept of place value and the numeral system will be better understood.