Collaborative Action Research on Enhancing Student Communication in Mathematics: Building a teacher-researcher community

by

Catherine Diane Bruce

A thesis submitted in conformity with the requirements for the degree of Master of Arts
Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education of the University of Toronto

© Copyright by Catherine Diane Bruce, 2001
The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author’s permission.

L’auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

L’auteur conserve la propriété du droit d’auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.
ABSTRACT

Collaborative Action Research on Enhancing Student Communication in Mathematics: Building a teacher-researcher community

Catherine Diane Bruce
Master of Arts, 2001
Department of Curriculum, Teaching and Learning
University of Toronto

The purpose of this study was to explore the relationships of three teacher-researchers as they developed a small community of practice while conducting action research on student communication in mathematics. The teachers set specific goals for instructional improvement. Their reform-based interventions were monitored, as were student mathematics learning logs. Simultaneously, activity and reflections of the teacher-researchers were documented over eight months. A grounded theory approach was used to analyse data through the processes of open, axial, and selective coding. An overarching model for collaborative action research was generated from the data. Sources of data included interviews, observations, group meetings, learning logs, and teacher-researcher journal entries. The main finding of this study was that successful instructional change required: 1) an active reflective stance by the participants; 2) a small supportive community of practice; and 3) the obviation of sources of tension.
Collaborative Action Research on Enhancing Student Communication in Mathematics: Building a teacher-researcher community

TABLE OF CONTENTS

Chapter 1. Introduction
- Overview ........................................................................................................... 1
- Initial Impetus for the Study ........................................................................... 2
- Background and Motivation .......................................................................... 3
- Themes of the Study ....................................................................................... 5
- Limits of the Study ......................................................................................... 6

Chapter 2. Literature Review
- Collaborative Action Research ................................................................... 8
  - The teacher-researcher relationship .............................................................. 8
  - Collaborative action research .................................................................... 12
  - The personal professional landscape .......................................................... 13
  - Communities of practice ........................................................................... 14
  - Issues of identity ......................................................................................... 17
  - Tensions and negotiations ......................................................................... 19
  - Issues of power .......................................................................................... 20
  - A relationship of caring ............................................................................. 21
- Writing in Mathematics ............................................................................... 23
  - Reform approach to mathematics ............................................................... 24
  - Use of student learning logs ...................................................................... 26
  - Intersecting research .................................................................................. 28

Chapter 3. Method
- A. Grounded Theory .................................................................................... 31
- B. Data Sources ............................................................................................. 33
- C. Ensuring Rigour of the Study .................................................................. 40
- D. Data Analysis ........................................................................................... 42
- E. Researcher Background .......................................................................... 43
Chapter 4. Results

- The Coding Process .......................................................................................... 48
- Axial Coding Summary ...................................................................................... 49
- Dana .................................................................................................................. 50
- Steven .................................................................................................................. 51

Broad Study: Action Research and the Teacher-Researcher Community

- Model for collaborative action research ............................................................ 53
- A. Reflection leading to professional growth ...................................................... 54
- B. Establishing a community of practice ............................................................. 61
- C. Sources of tension .......................................................................................... 73

Sub-Study: Enhancing Student Written Communication in Mathematics

- Observations and interventions ......................................................................... 83
- Rubric generation and use .................................................................................. 90
- Summary chart of teacher-researcher intervention and resulting evidence of student improvement ................................................................. 92
- Further analysis .................................................................................................. 96

Chapter 5. Conclusion and Implications

- Key insights ........................................................................................................ 99
- Implications for practitioners ............................................................................ 102

References

Appendices

- Appendix A: Chart of Data Sources and Chronicle of Events
- Appendix B: Teaching Interview Questions – Initial and Final
- Appendix C: Groupings and Organization of Data Sources
- Appendix D: Axial Coding Summary
- Appendix E: Flow (Steven), Sample Centre Tasks (Donna)
- Appendix F: McNiff’s Action Research Cycle
- Appendix G: Proposal for Staff Presentation
- Appendix H: Grounded Rubric for Assessing Student Learning Logs
- Appendix I: Sample Student Learning Log Entries
Chapter 1. Introduction

One path leads to another.
When we reach a fork in the path, we make a choice.
Sometimes we turn around and go back to where we were
because it’s not what we expected.
Other times, we try to straddle both paths so as not to miss anything,
but then can’t walk on either path well.
Some follow one path or the other, but how do we choose?
And then what do we do later on when the paths intersect again?

Such is the way of qualitative inquiry as we start with a single focus and then
watch it expand and turn and skip ahead of us,
and circle around us
and lead us on.

Overview

This study presents the story of two junior grade (grades 4-6) teachers of
mathematics and one researcher (on leave from teaching). The transformations
that resulted from engaging in collaborative action research were documented.
This study centered on investigating the outcomes of their instructional shifts
toward reform practices in order to enhance student communication in
mathematics. This mathematics study, which is briefly described in this paper,
served as a vehicle for examining the teacher-researcher relationships,
professional growth, and learning throughout the collaborative process. Thus, the
investigation of enhancing student communication in mathematics through
teacher interventions can be seen as the sub-study within the broader study of
the effects of collaborative relationships between teachers and researchers in a
small community of inquirers.

Cathy Bruce, MA Thesis: Introduction
Initial Impetus for the Study

How do we use language in mathematics to clarify understanding and make meaning of mathematical concepts? In recent years, and particularly since the introduction of the 1989 National Council of Teachers of Mathematics (NCTM) Standards, a strong emphasis has been placed on the communication of mathematics in the classroom. In particular, students are expected to communicate their mathematical understandings to one another and to the teacher through both oral communication strategies and through writing and representing ideas. Communication in mathematics has been further emphasized in the 2000 Standards by NCTM and is a key component of provincial mathematics assessments in Ontario. At the same time, the area of communication in mathematics is proving to be a challenge across Ontario. This can be substantiated by provincial assessment scores in mathematics in the category of communication (see Education Quality and Accountability Office provincial mathematics assessment results for Ontario at www.eqao.com). The data indicate a downward trend (with consistency from 1997-2000 indicating a high degree of reliability) over time and highlight students' continued struggle with communicating their mathematical thinking. However, after a decade of mathematics reform in the 1960s, the Conference Board of the Mathematical Sciences (1975) found that teachers were fundamentally teaching the same way they were taught in school and in the midst of current reforms, the average classroom is showing little change (Hiebert, 1999). If teachers are expected to make program shifts which emphasize communication in mathematics but have not seen or experienced this type of program themselves, how exactly can it or will it occur? Further, what are the conditions that enhance communication in the mathematics classroom?

The elementary teachers of one Ontario school involved in this research project indicated that although they were attempting to emphasize communication in mathematics in their classrooms, their students continued to experience difficulty
representing and writing about their ideas. In fact, staff at the school selected communication in mathematics as a focus for the school year 2000-2001 due to both low assessment scores in this category and the identification of this area as a challenge both for students and teachers in the classroom.

Background and Motivation

The research project spans a time period of approximately one year. The purpose of the study was to examine two cases in which teachers wanted to make shifts in their mathematics programs toward reformist principles and strategies with an emphasis on communication in mathematics. (For characteristics of a reform based mathematics program, see page 24 of this manuscript.) Both the NCTM standards of 1989 and 2000 (and their respective researched viewpoints) support the emphasis on mathematical communication. My personal interest as a researcher was to examine student communication in mathematics, and how it could be improved through a range of teaching, learning, and assessment strategies. The two teachers that became my research partners, Donna and Steven, shared my focus. They were clearly strong teachers, and yet they saw significant room for improvement in student communication skills. The school results on the provincial assessment initiatives (Grades 3 and 6 EQAO mathematics investigations components) indicated that students at the school were experiencing difficulty communicating their mathematical thinking. Our overall question was common: How can we assist students in improving their mathematical communication? However, each of us brought different perspectives to the project.

Donna is a Grade 4 teacher with expertise in the area of special education. She is highly skilled at classroom management techniques and at establishing respect in the classroom for all learners. Donna is a clear and practical thinker. Her voice, in the trio, was one of reason and focus.
Steven is a Grade 6 teacher who has expertise in language learning. He weaves language throughout his program as a common thread. His students are engaged in rich tasks that encourage depth and breadth of learning. Steven is an intellectual and broad thinker. His voice in the trio, was one of complexity and 'what ifs'.

I have expertise in the areas of teaching mathematics and assessment practices. My recent experience as a consultant for the local district board of education gave me a wide range of opportunities to work with teachers in implementing shifts in practice. Mine was the voice of an inquirer. I was asking Donna and Steven to inquire with me. I acted as a facilitator in making suggestions of possible ways to proceed, soliciting thinking and reflection, communicating back to Donna and Steven what I thought I was observing and experiencing. Our voices, together, brought a multi-textured, multi-layered melodic strength to this project.

Donna and Steven were working with their students to improve written communication primarily through the use of mathematics learning logs. In this case, mathematical writing skills include the use of words in the form of sentences, labels, lists which describe mathematical ideas, and drawings which illustrate mathematical concepts. The learning logs, similar to journals, were designed as a way for students to communicate their understandings of mathematics ideas in a form that was less controlled, or pre-designed, than a notebook or a teacher directed task. The effects of the use of math journals, or logs, has recently been documented through comprehensive studies (see pages 26-28 of this manuscript), with a general finding that when students are given the opportunity to write about mathematics, and when intellectual risks and sense making are encouraged, the results will include improved communication in mathematics. In our project, the learning logs were used by students at least once a week. They reflected mathematical thinking and student learning. Sometimes the students were given specific prompts, while at other times the
students were given a choice of topics or an open-ended question such as, "What have you learned about -?", or "What more do you want to learn about -?". The prompts were intended to broaden and/or deepen student thinking about their understandings.

In addition to the use of student learning logs, Donna chose to focus on creating a range of quality tasks in a learning centres approach with the use of extensive manipulatives. This was a goal Donna identified very early in the project and she continued to work on the centre tasks over time. The challenges for Donna were in creating the tasks so that students could demonstrate a range of levels of performance and understanding, and in sharing the power structure with the students so that students led one another in the learning.

Steven chose to focus on the structure of mathematics class activities as they relate to building a mathematical community. Issues of timing, roles of students and the teacher, types of tasks and groupings were all examined with a view of developing a community of learners who create collective understanding in mathematics.

**Themes of the Study**

Together, Donna, Steven and I worked as a triad, developing strong collaborative working relationships which also matured into strong professional and personal relationships. The degree of professional learning was unanticipated and presented a surprising and important finding for us all. In fact, the original question of the study: "How can we assist students in improving their mathematical communication?" shifted to a different focus - that of exploring the teacher-researcher relationship in collaborative action research as a community of practice becomes established.

Thus the guiding questions for this study became:

- How do teachers and researchers go about negotiating relationships and
working together in order to conduct action research? (Broad study)

and

How can student written communication in mathematics be improved by the collaborative action research between teachers and researchers"? (Sub-study)

The shift in emphasis to collaborative action research became a new area of reading (Connelly and Clandinin 1999; Conle 1999 and 2000; Ross, Rolheiser, and Hogaboam-Gray, 1999; Denzin 1997; and, Wenger 1998), research, and activity for the project. Thompson and Gitlin (1995) suggest that an ethic of care is required to establish relationships among those involved in a research project. The relationships became as important to the work as the results that students were able to achieve. Our attention to our relationships with one another and to our collective learning was critical to the sustaining impact of the experience and interventions.

Together, we explored a range of teaching/learning strategies, documenting their use and impact. In addition, we documented our own growth and learning as educators and co-researchers establishing a small, productive community of practice.

Through this study we sought to understand the lived experience of teachers working with a researcher in order to make reform-based shifts in mathematics programs to enhance student communication. This study led to the generation of a theoretical model for the ways in which the business of improved instructional practice and professional learning can be facilitated.

Limits of the Study

This study has several limits that require obviation. First, the teachers involved in this study were junior grade teachers within the same school. Both teachers were experienced and comfortable in their roles as teachers. Both teachers were also
committed to making instructional shifts to support improved student communication in mathematics. These circumstances are particular to this study and therefore, results will likely vary with other teachers in other circumstances.

Second, the data were coded by the researcher only, for this thesis paper. Rigour was ensured as much as possible by:

- using multiple sources of data (including site observations, teacher-researcher journal entries, student learning log entries, interviews, etc.);
- allowing for the emergent construction of categories from the data themselves through the use of key words and phrases from the data;
- keeping data sets discrete in order to test the recurrence of categories between data sets; and
- discussing interpretations of site observations and other activities with the teachers regularly for input and modification.

Further assurance of rigour is described in Chapter 2 of this study (pp 40-42).

Third, the model developed through this study (see Chapter 4, p 53) may not be generalizable. The model has not been tested in other contexts. Consequently, other studies were examined in the literature review of this thesis to determine whether the model and themes of this study are in alignment or in misalignment with other research (see Chapter 5, pp 98-102, for further discussion).

The following chapters describe this study in detail. They include: literature reviews on collaborative action research and writing in mathematics; a description of methodology used for data collection and analysis; a detailed analysis of the results; and, a discussion of the implications of the findings.
Chapter 2. Literature Review

The following literature review establishes the context of this study by highlighting research related to collaborative action research and the development of communities of practice, as well as research related to student writing in mathematics.

Collaborative Action Research: The Development of Communities of Practice Amongst Teachers and Researchers

Forging mutually beneficial relationships between teachers and researchers in the education community has been a challenging enterprise over the past few decades. The communication gap identified by many educators and researchers highlights the rift between what the research says and what practitioners do. Historically, teachers and researchers have established their own worlds, their own communities of practice, their own ways of operating and communicating. There has been little overlap.

Specifically, the emphasis on research in higher education helped establish a division of labor between those who did conceptual work (researchers) and those who executed the ideas established by others (teachers).

(Hayes and Kelly, 2000, p.454).

Some argue that teachers do not know what the research says because it has been communicated in ways that are ineffective for the practitioner. In other cases, it has been suggested that the research communicates information the practitioner see as unimportant (Bracey, 1989). There are also claims that practitioners doubt the validity of findings when they are not personally relevant or immediate (Hubbard and Power, 1999)

The Teacher-Researcher Relationship

One of the primary roles of the classroom teacher is to assist students in learning. It would make obvious sense then, that teachers would want to use the most effective methods available to support students in their learning. Research
can provide a definite window into effective practices. And yet, research-based practices are sporadic and not sustained (Vaughn, Klingner, and Hughes, 2000). Three key factors are highlighted by Vaughn (et. al.) to explain the lack of sustained connection between research and teacher practice:

1. Teachers require opportunities to weave their knowledge and experience with that of the research.
2. Teachers must believe that the research proves the effectiveness of studied methods in order to be influenced to change their teaching practice.
3. Teachers experience significant pressure on their time through things such as multiple directives, curricular changes, and administrivia.

As a teacher for the past twelve years, I would add that:

4. Teachers do not see themselves as relating to the context of the research. For most teachers, the studies seem to describe other people in other circumstances and are thus, not contextually grounded for the teacher. This is also supported by Bozstrom, Hansen and Jackson (1993), who detail one of the key problems as being a lack of practitioner involvement in defining the questions and the contexts.

5. Learning to teach using different strategies, materials, and ways of operating requires support for the teacher in the form of modeling, shared discussion, provision of opportunity to learn, and opportunity to practice and meet success. This complex process of teacher learning and shifting practice is an enormous undertaking.

One of the primary roles of the educational researcher is to investigate the classroom environment, the teaching, and the student learning within that environment. Yet, some argue that researchers have traditionally researched issues of interest to themselves, and have designed practices that do not reflect classroom realities.

Those researchers who study teaching but who, at the same time, show no concern with the practical applications of their work have a tough job justifying what they do and an even tougher one giving teachers a reason.
to care about their findings. Moreover, even pointed advice can seem distant when the research does not deal specifically with the familiar elements of a given teacher's work. (Boostrom et al., 1993, p.36)

Further, teachers feel they have been treated as 'subjects' in the research studies, with unrealistic demands of what the teacher should be doing or are capable of doing (Vaughn 2000). Hayes and Kelly describe efforts at establishing a collaborative relationship between public school teachers and a university-based researcher that failed despite the researcher's egalitarian intentions and efforts to work as a team. The work was deemed productive by the researcher and teachers alike, but was clearly not considered collaborative. At one point, in the context of a teasing remark, one of the teachers involved in the study joked:

You know we like you Mike, but sometimes it seems like the only time we get some space to work is when we shut the doors to our classrooms and don't let anyone see what we're doing. (Hayes and Kelly, p. 464, 2000)

In order to close the gap between 'the research' and 'the practice', there are two basic approaches that have emerged (Boostrom, Hansen and Jackson, 1993), representing opposite ends of a continuum. One suggested approach to closing the theory/practice gap is to produce research that is more relevant, practical and meaningful to teachers so that they see value in shifting their practice. Gerald Bracey (1989) believes that the majority of the research itself is essentially unimportant to the practitioner. He calls on researchers to engage in topics of importance to the practitioner. Journals such as Phi Delta Kappan, Educational Leadership, and Orbit have attempted to provide the practitioner with practical articles which are clearly grounded in research but also connect to teacher stories of practice in their efforts to bridge the theory/practice gap. At the other end of the continuum, a second approach argues that closing the gap requires a direct involvement of practitioners (the teachers) in the research (Hubbard and Power, 1999, McNiff, Lomax and Whitehead, 1996, Newman, 1998). The personal practical knowledge of teachers (Connelly and Clandinin, 1999) is a celebrated piece of the research puzzle, and has begun to generate some excitement in the research community. When the findings are directly relevant to
the practitioner, such as those generated in classroom action research, the
teacher will have a vested interest in, and respect for, those data. Teachers
defining their own questions and adopting a researcher perspective take the
research agenda into their own hands. In so doing, they relate to their own
findings and, in turn, become more open to research in general.

There comes a time when the teacher-researcher needs to read about
other people's research and about the theories they have used to interpret
their data. Now those books and articles, that before seemed so remote
and irrelevant, suddenly take on a completely different significance.
(Wells, p. 31, 1994)

Currently, a third view is emerging, and represents a mid-point in the continuum
of approaches for bridging the teacher-researcher gap. The third approach to
bridging the theory/practice gap lies in researchers and teachers working
together intensively, collaboratively, and intimately, each bringing strengths, and
knowledge to the relationship, each prepared to learn from the experiences of
working together. Proponents of this approach believe that the professional
learning community has room for, and indeed the necessity for, both practitioners
and researchers within the same environments, namely within school settings
and classroom settings. This approach is gaining the attention of some well
published researchers (Wells, 1994; Connelly and Clandinin, 1995; Lieberman,
1999; and Ross, Rolheiser, and Hogaboam-Grey, 1999). With new efforts in
bridging the gap, this insightful body of writing is emerging which illustrates the
struggles and successes that researchers and practitioners are beginning to
share.

Given the history of their shaky relationship, how do the practitioner and the
researcher come together?

Collaborative Action Research
According to Ross, Rolheiser and Hogaboam-Gray, collaborative action research can be defined as “systematic inquiry into teacher practice that is conducted by a team of teachers and university researchers working as equal partners.” (Ross et. al., 1999, p. 256) The equality of the relationship is based on the notion that each partner in the research has a specific body of knowledge that is complementary, allowing for a mutually beneficial and interdependent cooperative grouping. There are many goals in action research, however two of the main goals are to:

1. Help teachers improve their practice through obtaining personally relevant data in their own environment. Case studies of action research show that teachers “become more reflective about their instructional practices during the inquiry” and gain greater insight into student thinking and learning (Ross et. al., p. 256, 1999);

2. Identify issues and questions that are important to teachers, but have been neglected by researchers. Little research has appeared to date that describes the specific types of questions and knowledge obtained by teachers and researchers through collaborative research.

Wiesenfeld (2000) sees the forging relationships between researchers and practitioners as a situation where a climate of equality and mutual respect will allow both parties to engage in a common dialogue.

“The aim is not to idealize the other's knowledge or underestimate one's own knowledge as a researcher by viewing oneself as ignorant of the common-sense knowledge one seeks to understand, but rather, to try to share knowledge, reflect jointly on it, and derive learning from it which can be turned into useful knowledge and actions capable of inducing transformations in the informants' lives and in the theoretical development of the discipline through publications and exchanges between the researchers and their peers.” (Wiesenfeld, 2000, p.7)

In exploring this notion of teachers and researchers as collaborative partners in research, the figurative bridge between practice and theory is physically represented in the partnership, that is, the teacher and researcher literally working side by side. This proximity brings to the forefront a large minefield of
possible tension, conflict, frustration, negotiation, misunderstanding, shift in roles, belonging, discovering and learning. Some of the key dynamics of the teacher/researcher relationship are now being investigated as partnerships develop and mature, and are becoming legitimately documented as a point of research in and of itself. Ross (et. al., 1999) identify three main benefits to action research partnerships. First, partnerships help overcome obstacles such as a lack of skill in research methods and a lack of teacher time. Second, contact with professional researchers through joint research strengthens the image of the teacher as a researcher, thus fostering on-going inquiry by the teacher. A third benefit is that the heightened attention given to a project with external resources can provide teachers with further motivation to persist and be accountable, while also providing support through release time to conduct the action research.

The Personal Professional Knowledge Landscape

Connelly and Clandinin have developed several new frames of reference for examining teacher practice. To begin, they acknowledged the personal practical knowledge of the practitioner; that is, the valuing of teachers as knowledgeable, and knowing persons (Connelly and Clandinin, 1988).

As work progressed, Connelly and Clandinin (1995) developed a more complex understanding of the practitioner in the school context. They adopted a metaphor of “professional knowledge landscape” to describe the vast and textured terrain which makes up the wide variety of people, places and time involved in the world of teaching and learning. This is seen as a place of story – lived stories of practitioners that include personal, secret stories, and overt cover stories. The researchers noticed over time that the questions of the practitioners were different from those of the researchers. The teachers were asking themselves questions about personal identity and professional identity: Who am I in the story?
of teaching? Who am I in my school setting? How is that different from what I was thinking a year ago?

In asking these questions and seeking answers, the practitioner creates, sustains, and changes their own identity through the landscape that is their work world. Through telling their stories, the professional identities are shaped and re-shaped. Connelly and Clandinin examine these stories for larger themes of spatial and temporal borders, themes of coping with change, themes of hopefulness and hopelessness. The researchers question their own purpose in gathering these practitioner stories. They reconcile with themselves that their purpose is to see how and when stories weave together to make a recognizable cloth, or how the various aspects of the mountains, water, and land, work together to create landscapes that resonate with others as they re-shape themselves in varied contexts and times (Connelly and Clandinin, 1999). Further, they are looking to see where their stories as researchers overlap or inter-connect with the stories of practitioners. In some respects, I believe that Connelly and Clandinin are attempting to capture a dialogue that enables researchers to see through the eyes of the practitioner, and thus, find the commonalities. This can be seen as an early stage of developing trust amongst the parties. This approach is a good start, but it falls short in making explicit and permanent links between practitioners and researchers.

Communities of Practice
Etienne Wenger (1998) takes a somewhat different approach to bridging the theory/practice gap. Instead of looking for thematic linkages between researchers and practitioners, Wenger attempts to make sense of the roles that individuals play when they are involved in practical learning situations. He establishes a fairly clear but sophisticated series of frameworks within which he is able to describe learning situations. These frameworks span the learning situations of both practitioners, researchers and trade-workers in general. Wenger uses a
socio-cultural perspective to build understandable frames that describe and analyse learning relationships.

In the early stages of development Wenger, with Lave (1991), looked to the structure of apprenticeships in a broad context. They explained that "the mastery of knowledge and skill requires newcomers to move toward full participation in the socio-cultural practices of a community" (p.29). The term 'Legitimate Peripheral Participation' was used to describe relationships between newcomers and old-timers in communities of knowledge and practice. Periphery in this sense, suggests an opening for the newcomer. Through growing involvement and participation, the newcomer learns as a constituent, and works toward full potential and legitimacy within the community. Wenger and Lave see unequal relations of power as a natural element of the community of practice. They do not deny their existence but note that interchange and articulation within the community are directly connected to issues of power and powerlessness. In a positive learning environment, where power is not used to control the relationships extensively, understanding and experience are in constant interaction as we negotiate meaning for ourselves, about ourselves, and about our communities.

Wenger (1998) extended his thinking about socio-cultural learning frameworks in describing 'Communities of Practice'. The following diagram presents Wenger's overall view of the components of learning within a community of practice.
This diagram highlights the multifaceted nature of learning in a community. For the individual, learning is a process of engaging in and contributing to the practices of the community. In so doing, the individual develops a sense of identity through negotiated experience, community membership, learning trajectories, multi-membership and local/global relationships. For the community, learning is a process of refining their collective practice or enterprise and ensuring the association of new members. Thus a community is created over time and sustained through shared activity. Adoption of the learning stance as suggested by Wenger in Figure 1 places the focus on learning for all parties – practitioners and researchers alike.

This simple diagram clarifies the process of learning as experienced during some periods of action research. The establishment of an equal, cooperative teacher-researcher community within the existing school community supports the socio-cultural theory that Wenger has generated. This is further illustrated in Wenger’s treatment of identity within the community of practice.
Issues of identity

In a community of practice, the individual is in the process of negotiating personal and professional identities. Wenger describes the negotiation of identity in detail. He states:

Practice entails the negotiation of ways of being a person in that context. This negotiation may be silent; participants may not necessarily talk directly about that issue. But whether or not they address the question directly, they deal with it through the way they engage in action with one another and relate to one another. Inevitably, our practices deal with the profound issue of how to be a human being. (Wenger, 1998, p. 149)

Wenger characterizes the negotiation of identity through five descriptors, each of which merits definition and attention. It is worth emphasizing that these characteristics of identity of the individual also describe the dynamics of identity for a collective community of learners.

Identity as negotiated experience:
An identity is a layering of events, where we build upon our relations with others to establish our sense of self. Identity exists through the constant work of constructing who we are as we make sense of our experiences.

Identity as community membership:
"We define who we are by the familiar and the unfamiliar" (Wenger, 1998, p. 149) by the obvious and the mysterious, by the transparent and the opaque. It is in using past experience of the familiar to navigate the present and future unfamiliar that we establish, clarify, and modify our identity.

Identity as learning trajectory:
Identity is essentially temporal in nature, although it is more complex than linear time. We experience multiple trajectories of learning simultaneously as we incorporate our past into the present to imagine our future. Thus identity is a constant becoming.

Identity as a nexus of multi-membership:
Our membership in a given community is only one part of our identity. We belong to many communities and call on a range of self-identities depending on the
community of engagement. The difficulty lies in reconciling these various identities within one body. It entails struggles and resolutions and reconciliation. The bridges we construct between our identities help us to navigate the various landscapes (communities) we engage with.

Identity as a relation between the local and the global:
Identity is rich in texture. An important aspect of developing a sense of identity lies in examining how the individual, local practice relates to the collective and global practice.

Identity of the researcher and the practitioner can be seen within these frames of communities of practice. When the researcher and the practitioner come together to form a partnership, a third new community of practice emerges, and all of these characteristics of identity and practice resurface and are renegotiated once again. This view of identity and communities of practice blurs the lines between the researcher and the teacher in that both parties experience similar processes. The iterative nature of these negotiations is further explored by Newman (2000) when she describes critical incidents which trigger participants to re-examine and re-negotiate identities and begin the cycle of identity-finding within the community once again. The exploration of researcher learning is now beginning to become a point of inquiry in and of itself. "We are our own subjects. How our subjectivity becomes entangled in the lives of others is, and always has been, our topic." (Denzin, 1997, p. 27). In the case of this study, the role of the researcher was a temporary role with a new identity. That is, the researcher was a teacher who took a leave of absence to conduct research and do graduate coursework.

How then, is this new relationship between teacher and researcher represented in text? Traditionally, in published research, the learning and identity of the researcher has been opaque, rather than transparent. Some exploration of the role and identity of the researcher and their learning is appearing in ethnographic studies (Denzin & Lincoln, 1998), although Wiesenfeld (2000) argues that the discussion of researcher experience is generally "relegated to prefaces and
Some researchers push this notion further (Lather, 1994; Wagner, 1999; Olesen, 1998) to suggest that only through immersion in the population being studied, shared research, and explicit inclusion of both researcher and practitioner activity and reflection in publications, will true understanding of ‘other’ be achieved. Thus researchers and teachers enter into a parallel or double study. Jon Wagner (1999) describes his work as a researcher working with practitioners in one school. He argues that in order to sustain and fully implement research that creates ‘new knowledge’ for the practitioners and the researchers, it is important that they work together. He details three ways to link research knowledge to practice in action research:

1. The teacher-researchers participate in action research with a researcher as support to create new knowledge about a mutual topic, in the same site.
2. The teacher-researchers gain new knowledge through their own efforts in different sites and communicate with one another about their findings as a teacher-researcher group. In this case, Wagner suggests that the knowledge acquired may be ‘new’ knowledge to the practitioner, but not ‘new’ to the research community. An ‘outside’ researcher may be examining other dynamics such as functioning of the teacher-researcher group.
3. The community gains new knowledge “through personal and mediated presentations by researchers” (Wagner, p.167, 1999) – for example, oral (and written reports), accounts (tellings), workshops, policies and materials - to practitioners working at other sites.

**Tensions and Negotiations**

The ‘coming together’ of practitioners and researchers to close the theory/practice gap poses a series of new tensions and negotiations amongst the parties involved. Boostrom (et.al.,1993), describes a three year collaborative research venture between “two different kinds of knowers”: the practitioner teachers and the researchers. The researchers, in this case, acknowledge the gap, and suggest that it requires a deepening of appreciation for the distinct
professional roles. Thus, efforts should not be placed on explicitly eliminating the gap, but in paying attention to how the various parties in the research bring different perspectives to the work.

Boostrom (et. al., 1993) highlight the tensions that emerged through a three-year study. Some of the tensions were individual and internal (e.g. What is my role within the group?). Some tensions were collective and external (e.g. How will we proceed? How are we the same and different? Who is in charge and who has the power to make decisions?). The researchers and participants worked through these and other questions through their development as a community over the three years. Boostrom suggests that:

The research/practice gap involves more than the problem of how to rectify faulty communication, more than the problem of how to make theory practical, more even than the problem of who shall have authority over the aims and methods of research. It also includes the problem of how researchers and practitioners can first admit and then see beyond their insecurity, their self-satisfaction, and their mutual mistrust. The history of our meetings highlights the sources of tension that keep teachers and researchers apart and show that meeting together over time, openly and informally, can reduce the tensions and make the gap bridgeable.

(Boostrom et. al., p.42, 1993)

Bridging the gap is a delicate process. Trust can be quickly broken as re-surring tensions and issues of hierarchy and authority arise.

Issues of Power
Michael Hayes (Hayes and Kelly, 2000) reflects on his experiences attempting to develop a collaborative relationship as a researcher with some elementary teachers. Hayes entered the relationship as an 'expert' from the university setting to help teachers with their science teaching, thus "presuming a hierarchical relationship in which [Michael] had more to offer because of [his] expertise." (p. 458-9). The teachers experienced discomfort with science (the subject area of investigation) and tended to defer to Michael. At the same time, the teachers held
a degree of expertise as practitioners that excluded Michael from their local
classroom teaching knowledge. The dynamic of inside circles and outside circles
began to take form. Hayes explored situations of humour and resistance during
the project. Comments were made in small group and large group meetings that,
on the surface, were fun and teasing in nature. Upon further analysis, Michael
determined that this could be interpreted as a form of acceptance or alternately,
one of keeping the researcher ‘in the outside circle’ through the teasing. One of
the teachers stated: “We hope that our teasing doesn’t make you feel bad, but
we do have to keep you in your place you know” (p. 464). Thus the humour acted
as a form of resistance to complying with the role of authority that Michael
inadvertently and unconsciously established at the onset of the project.

Wiesenfeld (2000) suggests that collaboration is quite a stretch in any
practitioner/researcher relationship. She sees the relationship as inherently
asymmetrical because:
1. In general, the researcher asks and the informants answer, but not the
reverse.
2. Most often, the researcher publishes findings based on the lives of other
people – the researcher maintains the authority of representing the community or
situation of study.
3. In most cases, the researcher proposes a starting of the research and from
that point on, becomes the ‘bell ringer’ for stopping, starting, and sustaining the
project.

A Relationship of Caring
The negotiating of researcher and teacher relationships creates a minefield
through which the involved parties must navigate with care. This is especially
ture when one considers the complexity of identity of the self and the community
of practice, the potential tensions and frustrations, and the issues of hierarchy
and power of the traditional researcher/practitioner relationship (Hayes and Kelly,
The notion of developing a caring relationship becomes of utmost importance.

Treating each other as equals at the dinner table or around the discussion circle does not get rid of the various forms of institutionalized hierarchy that are embedded in the structure of the educational system...The trust required to reach across this gap must be won and re-won with every such effort...

(Bostrom et. al., p.44, 1993)

The notion of trust being earned and re-earned is an on-going theme in action research partnerships. How can the relationship be managed so that participants come to trust one another and share a vision of the work at hand? Humility, listening, courage and consideration become primary traits for success in negotiating an effective relationship between the practitioner and the researcher. Thompson and Gitlin (1995), outline an ‘ethic of care’ which must permeate the relationship so that problematic issues such as power relations and authority can be openly addressed.

In returning to the frames of communities of practice and legitimate peripheral participation, I see an opportunity to wrestle with the issues of authority, power, tensions, identity, on a relatively neutral playing field. In joint teacher-researcher projects, all parties face shifts in understanding of self and other, in the negotiating meaning of the practice, in the creation of a productive community, and in the sense-making of the inquiry itself.

“We seek to create new forms of versimilitude and new forms of truth – a truth from experience.” (Denzin, p.26, 1997)
Writing in Mathematics

The three teacher researchers of this study agreed that student writing in mathematics would be our subject focus and became the vehicle for examining collaborative action research activity. Thus, the literature related to writing in mathematics is critical to the context of this study.

Over the past decade there has been an increasing recognition of the importance of communication in the learning and teaching of mathematics.

The language used in mathematical practices, both in and out of school shapes the ways of being a mathematician and the conceptions of the nature of mathematical knowledge and learning that are possible within those practices.

(Burton and Morgan, p. 429, 2000)

In Ontario, communication in mathematics has been underlined and re-emphasized through the Ontario Curriculum for Mathematics (Ministry of Education, 1997) and with provincial assessment initiatives since 1996 through the Education Quality and Accountability Office (EQAO). Yet, there is a significant amount of research indicating that very little has changed in the teaching and learning of mathematics throughout the reform movement (Hiebert, 1999).

With the introduction of the National Council of Teachers of Mathematics (NCTM) Standards in 1991 in the United States and the Ontario Curriculum in 1997 there is an emphasis defining communication in mathematics, and determining how mathematical communication is fostered with students in the classroom. The NCTM Standards for 2000 continue to emphasize communication in mathematics through two standards in particular:

Standard 8: "Communication", emphasizes communication as a dialogic tool for constructing understandings (as per Wittgenstein's understanding of speech as a means of constructing understanding, and Vygostsky's notions of the intimate meaning-making connections between writing and

Standard 9: "Representations", emphasizes transmission, explanation and expansion of information and ideas through the use of precise tools and symbols.

Reform Approach to Mathematics
The characteristics of the learning environment where communication is emphasized is framed within the larger context of a reform approach to mathematics. Ross, Hogaboam-Grey, McDougall, and Bruce (2001, in press) have described the characteristics of a reform based mathematics program, within which communication is embedded. These characteristics are not simple components of a quality program, they are overlapping and intersecting dimensions which work together to create a significantly different learning environment than that of the traditional mathematics classroom.

The characteristics are:

1. Scope: A broader scope, (e.g. multiple math strands with increased attention on those less commonly taught such as probability, rather than an exclusive focus on numeration and operations) with all students having access to all forms of mathematics.

2. Rich Tasks: Student tasks are complex, open-ended problems embedded in real life contexts; many of these problems do not afford a single solution. In contrast, in traditional mathematics, students work on routine applications of basic operations in decontextualized, single solution problems.

3. Discovery: Instruction in reform classes focuses on the construction of mathematical ideas through student discovery contrasting with the transmission of canonical knowledge through presentation, practice, feedback, and remediation in traditional programs.

4. Community: The teacher's role in reform settings is that of co-learner and creator of a mathematical community rather than sole knowledge expert.

5. Manipulatives: Mathematical problems are undertaken in reform classes with the aid of manipulatives and with ready access to mathematical tools (e.g., calculators and computers). In traditional programs such tools are not available or their use is restricted to teacher presentations of new ideas.

6. Student-Student Interaction: In reform teaching, the classroom is organized to promote student-student interaction, rather than to discourage it as an off task distraction.
7. **Assessment:** Assessment in the reform class is authentic (i.e., relevant to the lives of students), integrated with everyday instruction, and taps multiple-levels of performance. In contrast, assessment in traditional programs is characterized by end of week and unit tests of near transfer.

8. **Conception of Math:** The teacher's conception of mathematics in the reform class is that of a dynamic subject rather than a fixed body of knowledge.

9. **Attitudes to Math:** Teachers in the reform setting strive to raise student self-confidence in mathematics rather than impede it.

All of these characteristics involve mathematical communication, with characteristics 2, 4, and 6 being particularly grounded in student communication of mathematical thinking and learning. Many recent research studies support the reform approach to mathematics citing improved student performance. Campbell (1996) matched pairs of schools with a treatment group and a control group. Over time, the impacts of a program that included encouragement of student talk, extensive use of manipulatives, high expectations for all students and the use of rich tasks, demonstrated that students in such a program outperformed students of the control group in both traditional and non-traditional mathematics objectives. In a meta-analysis of the implementation of mathematics reform practices, Ross (1999) found that:

> There is persuasive evidence that reform contributes to the achievement of objectives given less attention in the traditional approach (e.g., communicating mathematical ideas) and to a lesser degree to the attainment of objectives that have traditionally defined mathematics achievement (e.g., basic numeracy). (Ross, p. 7, 1999)

Both quantitative and qualitative research results indicate that students learn mathematics with greater understanding in classrooms when they are allowed to explore, investigate, reason, and communicate their ideas (e.g., Hiebert and Wearne, 1993; Wood and Sellers, 1996; Wood, 1998; Clarke, Waywood and Stephens, 1993 as cited by Wood, 1998; Ross, 1999).

Although the research points to the value of implementing a reform approach to teaching and learning mathematics, the traditional emphasis on transmission
The traditional model, with an emphasis on teaching procedures, and especially basic computational procedures, continues to be the common instructional approach. Ideas are not developed and students spend the vast majority of their time doing seatwork. There continue to be a significant number of barriers (Ross, 1999) to the implementation of reform-based mathematics teaching including the level of teacher comfort and disciplinary knowledge (Bibby, 2000), lack of sustained professional learning opportunities, and limited personal experiences with reformist practice. Most teachers did not experience a reform-based approach to mathematics in their own schooling, nor do they have many opportunities to see such a program in place. “The research evidence strongly favours reform, when it is implemented as intended... The problem is that mathematics reform is very difficult to implement. A large number of studies found evidence of non-implementation” (Ross, p. 7, 1999).

The Use of Student Learning Logs
One possible approach to shifting instructional strategies toward a mathematics reform practice is to begin by focusing on one particular aspect of mathematics reform, such as a heightened emphasis on communication in mathematics. Currently, classroom research is beginning to appear which highlights the specific use of student learning logs / journals in mathematics with some very interesting findings. Shield and Galbraith (1998), for example, found that the writing products of students:

Cathy Bruce, MA Thesis - Literature Review
...appear to be constrained by the models of mathematical presentation to which they have become accustomed. It will be a long-term task for teachers of mathematics to increase the meaningfulness of their students' mathematical writing in a way which promotes a higher level of thinking about the ideas. Such a change implies major shifts in the teaching practices and textbooks to which students are exposed throughout their school lives. (Shield & Galbraith, 1998, p. 45)

The Grade 8 students of this study showed little ability to justify their reasoning or provide elaborations in the journal writing samples analyzed. Further, student writing seemed to follow the same structure as the textbooks that they were using. No intervention activity for the students occurred during this study. "The two teachers of the classes noted that they made use of short writing activities in their mathematics teaching but neither teacher had a plan for the development of the students' mathematical writing". (Shield & Galbraith, 1998, p. 36)

On the other hand, a second research project from Australia (Clarke, Waywood, and Stephens, 1993) describes research conducted in the mathematical writing of students at an all-female school in Australia over four years. Findings indicated that:

through the process of their journal writing, students increasingly interpret mathematics in personal terms: constructing meanings and connections...Articulating their own thinking, in their own terms, appeared to be both challenging and empowering to students. As they moved into this mode of journal writing (a summarizing mode as opposed to a recounting mode), teachers reported that many students commented on realizing 'just how valuable the journal has become'.

(Clarke et. al., 1993, p. 243 & 248)

In this case, the researchers observed significant shifts in student writing from a recounting of events and procedures toward a summarizing of their thinking about the math concepts.

These examples of cases lead to the conclusion that intervention is effective in enhancing student communication in mathematics. In a third case, Jurdak and Zein (1998) demonstrated that journal writing contributed to conceptual
understanding, knowledge of procedures, and the ability to communicate mathematically. Other documented studies (e.g., Austin, 1998; Countryman, 1992) have found that helping students to improve their mathematical thinking and writing is possible and useful. Intervention, with a focus on meaning-making in the classroom and attention to journaling, can lead to improved student communication in mathematics. What is critical to success is finding ways to support teachers in making the necessary shifts in their classrooms. Ross (1999) offers some suggestions for removing barriers. These include providing sustained professional development opportunities with more than one teacher involved in the in-service, activity, and instructional improvement strategies.

What is needed is sustained interaction of classroom teachers with professional development leaders external to the school and the provision of local support such as district/school consultants. There should also be a dual focus on developing teachers' disciplinary knowledge and their pedagogical content knowledge. (Ross, 1999, p. 24)

Intersecting Research – Teacher/Researcher Collaboration and Communication in Mathematics

Collaborative action research projects set in the mathematics classroom have not been reported in large numbers. However, three studies in particular examine this specific combination. Raymond and Leinenbach (2000) report their findings in working together in a collaborative action research study related to the teaching of Algebra in the intermediate grades. In this case, the researcher and the teacher work collaboratively to examine the effectiveness of a new program for teaching and learning Algebra using manipulatives. The research is framed as a study within a study where the effects of collaborative action research of the mathematics teacher is the broader topic, and the teaching and learning of Algebra acts as the ‘sub-study’ and the vehicle for examining the broader topic. The framework of a study and a sub-study parallels the framework of this particular thesis. One of the key conjectures that Raymond and Leinenbach (2000) make is that:
Teachers who engage in action research are generally teachers who are at a critical juncture in their teaching practice and are in a state of mind where they are open to change. Not every mathematics teacher reaches this point of questioning or change... However, for Marylin, and other mathematics teachers who are ready for change, action research is truly a vehicle for teacher development. (p. 305)

A second study by Edwards and Hensien (1999), describes a collaboration between a math teacher and a math teacher educator. The teacher of this study attempted to change her instructional practices in order to better meet the goals of the NCTM Standards (1989, 1991). The teacher wrote a narrative description of the collaboration and the shifts in her program. The researcher conducted an interpretive analysis of the teacher narrative finding that the collaboration itself was in fact extremely important to the process of change. This three year study emphasizes the importance of reflection-in-action; linking teacher reflection with experiences and action. Edwards and Hensien cite three main variables that were critical to successful instructional change:

1. collaboration and support;
2. a non-threatening context within which to examine beliefs; and,
3. regular opportunities to reflect on practice.

Also highlighted was the extended length of the relationship between the teacher and the teacher educator. Over the three years, sustainable changes in instructional strategies were reported.

Borko, Davinroy, Bliem, and Cumbo (2000), explore teacher change of two Grade 3 mathematics and literacy teachers attempting new assessment strategies with their students. They believe that professional development will only be effective when carried out with long-term support of the teachers and joint exploration of issues. Site-based teams are also cited as a key feature of supporting the process of teacher change. Most importantly, Borko et. al. suggest that a dual focus on beliefs and practices must be in place: We need to examine and reflect on our beliefs and our practices in order to truly integrate new ideas and practices into instruction.
Although research in the area of teaching mathematics which pays particular attention to teacher-researcher collaborative action research is limited in volume, the findings do promote collaborative partnerships as a key element to facilitating instructional change and improved student learning.
Chapter 3. Method

The methods used for data collection and analysis in this study, as well as the sources of data gathered, are described in this chapter. In addition, the rigour of the study, and the researcher's background are made explicit.

A. Grounded Theory

"Qualitative research methods are particularly suited to uncovering meanings people assign to their experiences" (Morrow & Smith, 1995). This qualitative study employs the methodology of Grounded Theory (Strauss, 1987; Strauss and Corbin, 1990; Creswell, 1998) in order to explore themes of the development of teacher-researcher relationships and clarify dimensions of professional learning related to mathematics instruction and student communication. In this approach, the findings and theories developed are grounded in the data collected in the field. The researcher conducts extensive interviews, as well as collecting and analyzing observations in the field (theoretical sampling) and documents activity over an extended period of time (6 months to a year). The data is analyzed to find categories that represent "a unit of information composed of events, happenings, and instances" (Creswell, 1998, p. 56). The process of data analysis involves a systematic series of steps known as coding:

- Open coding is the process in which the researcher forms initial categories about the phenomenon being studied. There are sub-categories within the categories that further illustrate and extend the category.

- Axial coding is the process through which the data is reassembled in different ways to find relationships among the categories. At this stage, causal conditions and the context are identified. Part of the process of axial coding includes the identification of incidents, events and activities which must be compared to the emerging categories in order to saturate the category. This is known as the constant comparison process and leads to the confirmability of claims.

- Selective coding occurs when the researcher identifies the story that integrates the categories of the axial coding stage.
Finally, a theory or hypothesis is articulated which reflects the coding stages and findings. This theory "can assume the form of a narrative statement (Strauss & Corbin, 1990), a visual picture (Morrow & Smith, 1995), or a series of hypotheses or propositions (Creswell & Brown, 1992)." (Creswell, 1998, p. 56)

It is important to emphasize that when using a grounded theory approach, the primary outcome of the study is a theory or hypothesis grounded in the data of the study. There will be several specific components to the theory: a central phenomenon, causal conditions and context, and implications.

Participants:
In this study, two individuals, Donna and Steven, were nominated to participate because it was believed that they would actively support the exploration of the development of communities of practice for teacher-researchers and the development of strategies to enhance student communication in mathematics. The criteria for selection in the study were that the teachers be experienced, well respected as exemplary teachers by colleagues and school board personnel, and keenly interested in participating in the study.

The teachers selected worked at an elementary school (Grades JK-6) of more than 350 students. The school acts as a catchment for students with special needs (including severe mentally and physically challenged students) in the area. Teachers are responsible for writing and maintaining approximately 6-12 Individual Education Plans per class. The population of students is somewhat transient (3 of 26 students in the Grade 6 class had been at the school since Junior Kindergarten, for example). The school is located in a working class neighborhood with a mixture of small single dwelling homes and more dense housing.

The teachers in this study were not required to be expert mathematics teachers, but were required to have a desire to change their mathematics programs in order to enhance student communication in mathematics. The individuals may
represent extreme cases, however the criteria used enabled an insightful study and the development of hypotheses related to the specific purpose of the study. That purpose is: to understand the lived experience of teachers working with a researcher in order to make reform-based shifts in mathematics programs to enhance student communication, and to generate a theoretical model for the ways in which the business of improved instructional practice can be facilitated.

Entry into the field:
I approached Donna and Steven as colleagues whom I had met through professional development activities. Donna and Steven happily agreed to participate. When the participants were contacted, I provided the teachers with the ethical review package that had been submitted to OISE/UT and approved. Together we went through the package, which included timelines, purposes, and background information for the study. Issues of confidentiality and consent were discussed as well as the details of when I would interview the teachers and students, when I would be conducting site visits and what I would be observing. It was made clear to the teachers that I was interested in supporting their goals for program shifts and that we would use those goals as our primary focus. As the initiator of the study, I was in close contact with the principal, seeking and receiving permission to conduct the study at the school, providing regular updates on the progress of the study, and providing support to other staff members upon request of the principal and the staff members. This included three presentations/dialogues with staff and several individual junior grade classroom visits on request.

B. Data Sources
Forms of Data Collection:
The six main forms of data collection in this study were: 1) interviews of teachers; 2) interviews of students; 3) observations of mathematics classes in both classrooms; 4) student learning log samples collected over time; 5) records of group meetings with the teacher-researcher team; and 6) journal entries of the
three teacher-researchers (Donna, Steven and me). All forms of data collection are further outlined in a chart, which identifies dates, nature of the activity, form of the data collection and the purpose of the data collection (see Appendix A).

**Teacher Interviews**

A series of questions about teaching mathematics using reform-based instructional strategies was prepared (see Appendix B). Both teachers were interviewed separately on two separate occasions for approximately one hour (at the beginning of the study in February/March of 2000, and toward the end of the study in February 2001). Donna and Steven also participated in a one-to-one goal setting meeting to establish specific goals for the study (September 2000). These interviews were audio-taped and transcribed. The first interview and the second interview had several questions that were exactly the same in both interviews. The first interview focused on questions about the teacher's implementation of each of the dimensions of math education reform outlined in Chapter 2 of this paper (e.g., how do you structure your lessons to promote student discovery of mathematical ideas?). The second interview varied from the first in order to gain clearer information on particular aspects of the teacher learning process and to gather data on the teachers' opinions of the degree of success they experienced because of their shifts in practice (see Appendix B).

**Student Interviews**

Focus group interviews were conducted with students in groups of three and four. The same questions for each group prompted students to describe their experiences of mathematics. Over twenty-five students were interviewed between the two classes during the study. The students were selected randomly although attention was paid to ensure a mixture of boys and girls and students at levels of achievement in the high, middle and low ranges. The interviews occurred near the beginning of the school year, in October of 2000 and in December of 2000. The student interviews were audio-taped and transcribed.
Samples of this data were shared with the teachers without referring to the names of pupils involved.

**Site Visits: Classroom Observations**
In order to triangulate interview data with observation, I visited each classroom for 7 or more math periods. During these observations, I recorded student-teacher dialogue, student and teacher activity, and in some cases, the timing of events. I submitted the observations to the respective teachers within three days of the observations and requested comment and input where they believed that the events were not accurately recorded. As an observer I was silent at the back of the room on some days, I entered into dialogue with the teacher on some days, and I entered discussions with small groups of students on other days. These activities are recorded in the field notes and became an interesting dynamic tension related to the role of researcher. In one case for each classroom, I acted as the instructor while the teacher recorded classroom activity.

**Records of Group Meetings**
The teacher-researcher group met for three to six hour discussions on five occasions between May 2000 and April 2001. These meetings were audio-taped and partially transcribed, or in some cases, recorded as field notes. These notes were then shared with the teachers for further input and revisions so as to accurately reflect the group activities and discussion. Although site visits ended in December 2000, the teacher-researcher group met again in February and in April, 2001.

**Student Learning Log Samples**
The student learning logs were collected by the teachers for review as part of ongoing student assessment strategies. In September 2000, November 2000, January 2001, and April 2001 the learning logs were gathered for review by the researcher. Photographs were taken of student work stored on disk as pulses.
over time. In December, the teacher-researcher team used a teacher-researcher generated rubric to score samples of student work. The rubric developed for assessing student learning logs is included as Appendix H of this thesis. The samples included high, middle, and low achieving students as well as both male and female students. We also compiled student learning log samples using the same criteria to share with other teachers at the school in a staff meeting. The staff members were asked what they observed in the samples and the information was recorded on audio-tape and transcribed.

Teacher-Researcher Journal Entries
In late October 2000, Donna and Steven and I realized that we were experiencing some major shifts in our thinking about the research study, about our roles in the study, and about the impact that the project was having on our personal and professional lives. At this point, we decided to all maintain journals to record our thoughts and feelings related to activity during the study. These journals became a foundational component of our relationship-building as we regularly shared the journal entries with one another. The journal entries were gathered into a common log for review and entered into a word processing package on the computer for future analysis. The entries varied from one paragraph to five pages in length and varied from once a month to twice a week depending on the circumstances, the timing, and the person writing. The final entries occurred in April 2001 when each of the three of us wrote in our journals about our perspectives of self and others from the beginning of the study compared to the end of the study.

Grouping of Data:
The data were grouped into two distinct sets. The first set consisted of data from teacher interviews, teacher-researcher journal entries, and group triad meetings as well as staff meeting transcripts. The second grouping of data consisted of field notes from extensive site visits and student learning log entries. (See Appendix C for a summary of the data source groups and process of analysis.)
Support of the Case Study Teachers

On an on-going basis, the researcher supported the teacher participants in making changes they wanted to make in their programs. It was the intention of the researcher and the teachers to ‘work at’ making shifts during the study in order to observe the impact of the changes on students and the teachers.

For Donna, the support included the following:
May 5th, 2000: Donna requested that we work together to design some centre tasks. We met for 2 hours and 45 minutes to brainstorm a set of math centre tasks related to Patterning and Algebra concepts. For each task, students used manipulatives and were expected to complete a written entry about their work and/or thinking. One task required the use of the computer software program “Math and More”. This became a template for Donna to use in developing centres in the future.

September 19th, 2000: Donna and I met for one hour to talk about her goals for the mathematics program for the school year 2000/2001. She established two main goals: a) to get the centres operating as a regular component of the mathematics program, and b) to use mathematics learning logs to encourage student communication in mathematics. Donna indicated a strong desire and determination to make shifts in her math program at this meeting.

September 29th to December 14th, 2000: The site visits occurred weekly over this period of time. During the site visits, Donna and I discussed:
• particular aspects of the instructional strategies used (such as evolving issues of control of the class and ways to move from manipulation to abstraction that allows students to increase their understanding)
• tasks students were engaged with (and how to refine them to elicit higher order thinking skills)
• student learning observations (to determine which students were showing improvements and why).
In addition we had discussions about how the student groups were functioning in the classroom (evaluation of the successes and difficulties of various members of the groups) were held. We also discussed Donna's frustrations and confusion over staff member interactions with Donna where Donna was surprised by particular comments and activities of colleagues.

For Steven the support included the following:
January 17th and February 4th, 2000: Guest speaking at two junior division meetings (Steven is the chair of the junior division) to initiate collegial dialogue about ways to improve mathematics programs including 'designing and using rich tasks in mathematics' and 'key components of a strong math program'.

August 31st, 2000: Steven and I met for one hour to discuss his goals for his Grade 6 mathematics program for the school year 2000/2001. He identified two main goals: a) to use mathematics learning logs to encourage student communication in mathematics, and b) to 'get inside the math' and build a community of learners with his students. By this Steven meant that he wanted to be so comfortable with the concepts and skills of the mathematics he was teaching, that he would be able to improvise to meet student needs and to allow students to explore self-selected concepts with guidance.

September 26th – December 15th, 2000: The site visits occurred weekly over this period of time. During the site visits, Steven and I discussed:
- instructional skills and strategies (such as the timing of lessons and their flow, and the back and forth activity of teacher instruction, group discussion and investigation, and individual student work)
- his frustrations with the lack of student prior knowledge (on several site visits students clearly demonstrated a lack of understanding of mathematical concepts which should have been learned much earlier. For example, over five of the Grade 6 students did not know whether to measure using a ruler by starting at the end of the ruler '0' or at the 1 centimetre mark.).
In addition, Steven and I discussed how to implement a mathematics portfolio program with students (which is a focus of the junior division for the 2001/2002 school year), and the emerging structure of lessons in his room (for which Steven created a template to summarize his activity and to assist him in creating new lessons using the same structure – see Appendix E).

**Support for Other Staff at the School**

In order to ensure that the project was clearly understood by other staff members of the school, three meetings were organized. At the first meeting on January 17th, 2000, the junior division discussed their dissatisfaction with their math programs and how they could work at building in tasks to promote higher order thinking skills. I led the session as an experienced mathematics consultant with the intention of getting to know some of the staff, making myself transparent to the group, and offering support to more than just the teachers involved in the study.

On February 4th, 2000, the junior division met again and we generated a list of items that we thought constituted a strong mathematics program. This was an awareness, problem-finding session where teachers identified what they were doing in their existing programs and what they wanted to change in their programs. I facilitated the discussion through small group and whole group prompts.

On December 5th, 2000, the whole staff met to receive a presentation by Donna, Steven and myself to describe what we were doing in the research project. We shared our work to date, and gave the teachers samples of student learning logs to review. We solicited feedback from the group. One of our main goals of this meeting was to de-mystify the project and to invite others to consider conducting action research in their classrooms. The principal was extremely supportive of Donna and Steven and the project in general at this meeting.
It is important to note that the principal supported the research project from the on-set and provided four days of release time so that Donna, Steven and I could during the school day.

Use of the Action Research Cycle:
In order to frame our activity, the teacher-researchers used the action research cycle as proposed by McNiff et. al. 1996 (see Appendix F). This allowed us to define stages in our action research and to explain the process to colleagues as an inclusionary and informing strategy. It was very helpful to use this cycle when presenting our activity and findings to interested others (staff at the school, and fellow graduate students conducting action research).

C. Ensuring Rigour of the Study
Creswell (1998) summarizes the characteristics of a “good” qualitative study. These traits have been employed and are described as they relate to this collaborative action research study in order to illustrate the rigour of the study.
1. The employment of rigorous data collection procedures was used, including the collection of multiple forms of data, and ample time within the field to ensure accurate recording of events. As described in Section B of this chapter, six major types of data were collected over a period of thirteen months (March 2000 – April 2001).
2. The study is framed as an evolving design with multiple realities, a focus on participant views and inclusion of the researcher as an instrument of data collection. This study certainly evolved over time and presented significant surprises and shifts along the way. The teacher-researcher journal entries are a specific record of the multiple realities experienced during the study and allowed us to include participant views through incorporating their voices regularly as citations and researcher views in the final writing of the text. Further, the background experiences and values of the researcher are made explicit in Section E of this chapter.
3. There was a focused use of specific and appropriate traditions of inquiry. This particular study falls into two categories simultaneously: that of action research, in that our work evolved around the activity of two particular junior level classrooms and their respective membership; and that of a grounded theory study which employs the use of categories to find emerging themes, storylines, and hypotheses.

4. The project begins with a single focus or problem that the researcher seeks to understand. Initially, the focus of this study was on written communication of students in mathematics. This focus was maintained and became the vehicle for a larger focus on developing a community of practice as teacher-researchers and learning together.

5. The study includes a detailed description of the methods used for data collection, analysis and report writing including the use of verification methods. Chapter 3 of this thesis describes the methods used for data collection and analysis. The report itself has been verified by the teacher participants through dialogue and the sharing of sections of the thesis. In addition, an audit trail was conducted using large colour coded cards to record all contact dates and activity. These were shared with the participants as well.

6. The use of thick description in this study attempts to include the reader as a voyeur-participant. Denzin (1998) describes this form of text as the “journalist text form” (p. 131), which includes a ‘scenic method’ of showing rather than telling and incorporating multi-sensory and multi-perspective acoustic tones to create a ‘truth from experience’; so the reader has a sense of ‘being there’.

7. The data is analyzed using multiple levels of abstraction from particular observations and conclusions to generalized abstractions. The analysis of data in this study begins with simple categories using open coding and then moves to axial coding where data is reassembled and resorted to look at causal conditions and consequences and then reorganized once again to look for the corroboration of the analysis in seeking the storyline of the data. Finally an abstract hypothesis is generated in the form of a model which reflects the data. Disconfirming
evidence was actively sought in all cases of data analysis to ensure that common categories were indeed representative of the activity which occurred.

8. The writing is clear and full of unexpected ideas, reflecting real life complexities and experiences. This is particularly true, I believe, in the excerpts of journal entries of the teacher-researchers and in the statements made in interview settings.

9. The researcher explicitly declares personal values. My values are declared in section E of this chapter in order to establish how they may affect the data collection and analysis processes and how I have attempted to ensure they do not impede the results of this study.

D. Data Analysis

The analysis of data related to the teacher-researcher community of practice was conducted through immersion in the data and subsequent codings and comparisons that are characteristic of the grounded theory approach. Analysis began with open coding as individual words (using the find feature on the computer), phrases and sentences were examined to find simple discreet categories. Saturation of categories was achieved by reviewing all sets of data once, and then several times again to look for further examples of each category, until no new examples could be found. (See Appendix C for a summary of the data groupings and analysis procedures.)

Axial coding was used to merge categories together to find larger categories and sub-categories that were found amongst the data sets. A four-page hand written chart was created and then reproduced on the computer to examine all themes and their inter-relationships.

Selective coding allowed for the data to be integrated to find core categories, relationships, confirming and disconfirming examples, and further refinement of the categories. Criteria for the permanency of a category followed those outlined by Morrow and Smith (1995) and included:

a) a category's centrality in relation to other categories;
b) frequency of occurrence;
c) inclusiveness of the category and in relation to other categories; 
d) clarity of its implications for a more general theory; and 
e) the power of the category to support a theory.

The analysis of data related to student communication in mathematics was conducted through examination of student learning log entries and site observations that occurred between September and December, 2000. Student data reflects both male and female students of high, middle and low achievement levels. For the student learning logs, the samples were reviewed and analyzed to measure progress over time. Thus, student log entries are compared from the September entries through to the December entries. Analysis of the quality of student log entries was measured against a learning log which was generated by the teacher-researchers using a grounded theory approach (see Chapter 4, Results, page 40). Field notes from site observations were used to corroborate teacher shifts in practice and interventions during the action research with the evidence of improvement in the student learning logs.

E. Researcher Background Experience
As a young child, I loved games of any kind. I would attempt to engage anyone in a game of cards. I had one uncle in particular that made games absolutely exciting. We would scheme together or against one another in determining mathematical permutations and combinations, probabilities, and opportunities to close down the game with a spectacular move. This intense gaming interest as a child made me keenly aware of the power of mathematics, not just for playing games, but in the way it made my mind expand and glow with activity.

In elementary and secondary school, I did not experience particular difficulties in mathematics classes, although I found them abstract, dull, and uneventful and therefore tended not to participate or even attend class. It was not until I entered a University level undergraduate course in mathematics that I really grasped the fundamental properties of mathematics and how they could be combined to
create new mathematics. Olive Fullerton, a mathematics educator in Toronto, was my teacher. Each day she started the class with a basket of manipulatives for each group to explore. We began reviewing basic concepts in new ways such as multiplying fractions with elastics and geoboards and exploring properties of two dimensional shapes and three dimensional solids through motion. Olive helped me to see that math is a way of understanding our world, and a way to inquire about our world. This was powerful learning that became an underlying principle of my own teaching/learning experiences with students. The 'facts', in mathematics, in my opinion, are social agreements, which have changed through time, discourse, discoveries, and inventions and will continue to change in the future.

As a teacher of Mathematics, I wanted to somehow capture and pass on a deep respect for the power of math and at the same time, make it accessible and interesting to the students. My students were exposed to and explored manipulatives extensively and they were able to grasp the concepts. However, I was having difficulty capturing student mathematical thinking. I needed to find ways for them to manipulate objects and ideas and then communicate their ideas to one another and to me. I introduced the use of student learning logs primarily to capture that thinking so that I could access and assess the thinking. To my surprise, many other things began to occur with that simple shift. The students wanted to share their learning logs with one another. The students wanted to discuss their ideas with the entire class. At the time, I had no known way of recording my findings. I knew they were important but I did not have the inclination, nor the ability to analyse this situation.

When I accepted a role as consultant for the local district of education, I had the luxury of spending some time learning more about communication in mathematics. In retrospect, some of the most personally meaningful contributions I made as a consultant were actually with individuals in intense, long term learning relationships. For example, I worked with the primary division at one
school for a year and a half. Their request was that I support them in the area of fostering communication in mathematics. We met as a group for a half day every other month and then had smaller individual meetings, conversations and practise sessions. This intimate professional relationship amongst colleagues provided the teachers with the supports required to make changes in their programs. I believe teachers need intensive support in order to make significant and sustainable positive change. Sometimes that can occur within a given staff, but it is rare in my experience.

In the summer of 1999, I began taking courses toward a Masters degree. The most important part of that summer was a personal re-connection with language. Writing is something that I love to do for myself, and language is something that I love to explore, as a teacher, with students. This re-connection to language has been coupled with my continued love for mathematics.

I knew that I wanted to combine mathematics and language in my own research. I made my claims known to teachers and principals in the region through some case study work as a research assistant to John Ross of OISE/UT for a primary mathematics case study project. My hope was that I would find a few teachers who were interested in conducting some research in the area of mathematical communication. I found some of these people at a local elementary school. Two teacher colleagues, Donna and Steven, were looking to make some shifts in their own mathematics programs, and agreed that it would be mutually beneficial to participate in the project. I was clear with Donna and Steven that I didn’t know exactly how the work would proceed, but that I would commit to visiting the classrooms regularly, conduct interviews, and that we would construct a way forward together. The principal was in full support of the project.

F. Current Understanding
My understandings and values related to learning, communication, mathematics, and research, naturally stem from these past experiences as a student, as a
teacher, and as a consultant. These values are described in this thesis in order to make my stance transparent. Peshkin (1988) stresses that as a researcher, one must not miss important findings because of the particular lens one is looking through. In order to identify the lens I use habitually and then in attempting to overcome the potential biases of using that lens, I have identified the following items and in some cases, describe how those beliefs can be counterbalanced:

About learning -

1. I believe that we learn best in a positive, creative setting where individuals in the community of learners work with themselves, with one another and with resources. We develop understanding through individual and collective inquiry (finding problems, posing questions, investigating, seeking answers and ideas). I model that approach in my own work.

2. We also develop understanding through language. In its broadest sense, language includes verbal and non-verbal gesture, intrinsic and extrinsic dialogue, symbol, and representation. I am interested in the language aspect of mathematics because it is the means by which we communicate our understandings to others and to ourselves.

3. I am a learner. I am learning along with the teachers in this project. It is important for me to acknowledge my fears publicly. As a collection of learners, our anxieties, frustrations, and successes are shared.

About Mathematics -

4. I believe that math is not a fixed body of knowledge. It provides us with another perspective from which we can view our world. In the educational community, mathematics needs to be a shared discovery zone for students and teachers, requiring a learner stance for both the teacher and the student.

5. The National Council of Teachers of Mathematics (NCTM), and the research and support materials that they create, publish, and present in a variety of forms, generally reflect my own beliefs about mathematics
teaching and learning. In my opinion the following NCTM thrusts are of particular importance:

- the development of a community of learners
- the emphasis on problem solving, communication, representation, and reasoning, as well as a wide range of strands of mathematics concepts
- the attention to research in the educational community to support claims.

6. I have personally had very positive experiences in teaching mathematics. Upon entering the research, I wanted to expand my understanding of how to effectively implement student learning logs, but I also thought that I could share strategies with others. Of course this was a premise that soon presented itself as an inappropriate goal. What worked for me would not, could not, work in the same way for others. This recognition of my own way not being the only way created an internal tension for me that I had to manage during the study in order to encourage the teachers to explore their 'own ways'.

About the Way I Work -

7. I get very excited about teaching mathematics and about student discovery in a supportive environment. I believe that creating a community of learners is critical in the math classroom in order to establish a love for mathematics. This energy and excitement has probably rubbed off on my teaching-research partners. They see me, as they say, 'inside the math' and they want to 'get inside the math' too. In order to ensure that my enthusiasm was not 'colouring' my view of the data, an extensive quantity of data was gathered for analysis. Triangulation of data was constant with the inclusion of multiple perspectives of teacher intervention and student activity along with researcher classroom observations.
Chapter 4. Results

The Results chapter of this thesis describes the findings of this collaborative action research study. The findings were organized using a grounded theory process. To further illustrate this process an example will be used from the study data. To begin, individual words and phrases were highlighted by frequency and emphasis imported on the words. The sources for this open coding system were teacher interviews, teacher-researcher journal entries, and records of meetings (see Appendix C for groupings of data sources). Each data source was analysed discreetly so that key words could emerge without distortion and to achieve saturation of the categories. For example, the words “I need to / I want to” were used 23 times by Donna and Steven during teacher interviews. References to ‘self as a learner’ occurred 6 times in triad meetings. All three teacher-researcher journals described ‘reflection leading to growth and understanding’ on at least three dated occasions for each of the three teacher-researchers. Axial coding allowed the discreet categories to be joined and related in order to find larger themes. In the case of the open coding example above, the three data sources were grouped to create a theme of self observation/reflection. Through axial coding, a total of 16 themes emerged from the data, and were organized into the following chart (see figure 1.2).
### Figure 1.2 Axial Coding Summary: For Data Sets 1, 2, and 3 of Teacher-Researcher Community of Practice

<table>
<thead>
<tr>
<th>Reflection → Professional Growth</th>
<th>Communities of Practice</th>
<th>Sources of Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self Observation/Reflection:</strong></td>
<td>Building a Community:</td>
<td>Power Shift:</td>
</tr>
<tr>
<td>1. Teacher interviews</td>
<td>A. General</td>
<td>1. Donna’s journal (April 21 x2)</td>
</tr>
<tr>
<td>“I need to/want to” (23x)</td>
<td>2. Steven’s Journal (Oct 20, Oct 25, Mar 24, Apr x2)</td>
<td></td>
</tr>
<tr>
<td>2. Triad Mtgs</td>
<td>B. Trust, Caring and Support in the community:</td>
<td></td>
</tr>
<tr>
<td>“self as learner” (6x)</td>
<td>1. Triad Mtgs (“Support” 6x)</td>
<td></td>
</tr>
<tr>
<td>3. Cathy’s Journal (Oct. 13, 14, 17, Nov 6 x2, Oct. 10 chart)</td>
<td>2. Cathy’s Journal (Nov 3 x2, 8 x3, 28, Dec 4 x3)</td>
<td></td>
</tr>
<tr>
<td>4. Donna’s Journal (Sept 29, Nov. 3, 10)</td>
<td>3. Donna’s Journal (Nov. 3, Dec 4, April 21 x2)</td>
<td></td>
</tr>
<tr>
<td>5. Steven’s Journal (Nov 8 x2, Mar. 30)</td>
<td>4. Steven’s Journal (Sept 29, Oct 3, Nov 28 x2, Apr.)</td>
<td></td>
</tr>
<tr>
<td><strong>Professional Learning:</strong></td>
<td>C. Risk Taking / Fear:</td>
<td>Presence and Silence:</td>
</tr>
<tr>
<td>1. Teacher interviews (9 examples)</td>
<td>1. Triad Mtgs. (“Risk” 7 x)</td>
<td>1. Triad Mtg (1 case)</td>
</tr>
<tr>
<td><strong>Questioning Stance:</strong></td>
<td>3. Donna’s Journal (Ap 21 x 2)</td>
<td>3. Cathy’s Journal (Nov 22)</td>
</tr>
<tr>
<td>2. Cathy’s Journal (note to Donna re: questionor)</td>
<td><strong>D. Identities / Shifting Roles / Layers of Roles</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Triad Mtgs (“layers, complexity, parallel” 11 x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Cathy’s Journal (Sept 29, Oct 10, 13, 14)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Steven’s Journal (Oct 20)</td>
<td></td>
</tr>
</tbody>
</table>

**Images**

- **Water / Rivers:** (illustrates Power Shifts) 1. Cathy’s Journal (Nov 15 x3, Dec 4) 2. Steven’s Journal (Nov 18 x3, Dec 4)
- **Math as a Building:** (Illustrates Prof. Growth) 1. Donna’s Journal (Dec 4 x3) 2. Steven’s Journal (Oct 3 x2)
- **Cliff Image:** (illustrates Risk and Fear) 1. Triad Mtg (1 case) 2. Unshared image by Cathy (Sept. 1999)
- **Wheels/Circles:** (illusrates Professional Growth) 1. Triad Mtgs (2 cases)
- **Bridgework:** (Illustrates Identity of Self and self related to other) 1. Cathy’s Journal (Oct. 13, 14, Nov 6, 22) 2. Steven’s Journal (Nov 8 x2)
In order to generate an overall structure for the data, selective coding was used. Themes were grouped together in order to create larger categories such as “Reflection Leading to Professional Growth”. Once the larger categories were organized, three broad themes were identified: Reflection leading to professional growth, building a community and sources of tension. Several images presented themselves and reflected aspects of the various themes. The result was the generation of a model for collaborative action research among teacher-researchers, found on page 53 of this section.

Donna:

Donna is a Grade 4 teacher in an Ontario school of over 300 students. She has been teaching for eight years. Her areas of expertise include Special Education and classroom management. Her on-going focus on establishing a respecting and respectful environment promotes a safe place for students to take risks in their learning. Donna is a practical person. She is able to take ideas and structures and apply them to the classroom with ease. In the Spring of 2000, for example, Donna and I sat down together to plan a round of problem-based, manipulative-based mathematics centres. Once we prepared the materials, Donna was able to use that framework as a model for future centre tasks. Donna expressed interest in this research study because she wanted to improve her math program:

I was new to grade four. Everything was new, and so was math, so I reverted back to how I was taught, the textbook. It was there, and easy and friendly, and the kids liked it, because they know the pattern – we did page 12 yesterday and we’ll do page 13 today. But I wasn’t feeling good about what I was doing. I just wasn’t feeling good about the whole math thing, the students weren’t being challenged and I wasn’t being challenged. And then this came along. It was a perfect opportunity for me. When I first got involved, I went ‘oh great I can get some new math ideas.’ I didn’t know that there was going to be more of a commitment on my part. There wasn’t any giving of math ideas, there was the developing of math ideas. So it was wonderful for me to be involved in that... That’s why I’m doing this – to feel better about myself, and hopefully to have my kids feel better about math.

Donna – October 5, 2000
Donna focused on using the Learning Logs in Mathematics in order to encourage students to reflect on their learning. The emphasis on communication in mathematics through the learning logs, as well as through centre tasks, and student discourse, allowed Donna to expand her view of mathematics. In so doing, Donna’s professional learning and development of a questioning stance as a teacher was expanded. These themes will be further explored in this chapter.

Steven:

Steven is a Grade 6 teacher in the same Ontario school. He has been teaching for eleven years. He has expertise in language learning. He weaves language throughout his program as a common thread. Steven regularly uses rich, meaningful tasks with his students and sees these tasks as little beginnings for larger life learning. Steven is an intellectual, broad thinker who enjoys the complexities of the classroom dynamics and all that it offers as a site for personal and professional growth. Steven’s interest in this research project stemmed from his desire to have students communicate their mathematical understanding more thoroughly. He believed that Mathematics programming was the weakest aspect of the student program overall. The use of student learning logs to encourage student written communication and representation of ideas was the beginning of a much larger review of his entire math program.

In a presentation to colleagues, Steven described his interest in the study:

One of the pieces for me was that I wanted to have my children thinking out loud and creating the math, and now to expressing that thinking in their learning logs. So last year the learning logs were sort of like, just answers and I wasn’t satisfied with them. Then Cathy came in and I had this golden opportunity to learn about how to run a learning log program, from that we cracked the whole thing open, the whole kettle of fish about my program: what text I’m using, whole group, small group work, where they are able to make the math. That’s part of what I hoped for to get out of it. Originally, I just wanted to create learning logs, to have them write in their logs period. But through the course of this presentation you’ll see how much broader this is now.          Steven – October 5, 2000
Steven maintained a focus on the use of student learning logs, but expanded his program shifts in order to establish a community of learners in the classroom. He encouraged robust discourse and defense of opinions. He examined the flow of lessons to solicit student thinking, dialogue and then writing and representing of mathematical ideas in the student learning logs. In so doing, Steven embarked on a journey of re-forming his identity as a teacher of mathematics.

Broad Study: Action-Research and the Teacher-Researcher Community
How do teachers and researchers go about working together collaboratively and negotiating relationships in order to conduct action research?

Results:
Based on processes of open coding, axial coding (see summary of axial coding activity in Appendices C and D) and then selective coding, a grounded theory model for establishing an action research teacher-researcher community has been developed (see Figure 2). This model reflects the data collected during this research study and proposes how a community of practice for teacher-researchers can be established through focused, professional learning during action research. It also identifies some of the opposing forces that work against collaborative action research. The model will be used as the framework for describing the results of the study in this chapter. Also identified are images that emerged during the action research that further illustrate phenomena identified in the model. These images were not developed during data analysis stages, they were explicitly generated by the teachers and/or myself during the activity of the study and served as ways of explaining, to ourselves and others, what our work ‘felt like’. Significant use of citations from teacher-researcher journal entries, transcripts from triad meetings, and interviews are included in order to provide a thick and detailed description of the results.
Creating a Teacher-Researcher Community

A. Reflection Leading to Professional Growth

Three Characteristics of Ongoing Activity for All Participants:

1. Self Observation and Articulation of Analysis
2. Recognition of Professional Learning and Change
3. Development of a Questioning Stance

B. Establishing a Community Of Practice

Three Stages:
Stage 1. Building a small community through trust, risk taking, and finding new identities
Stage 2. Establishing the new community within an existing community
Stage 3. Expanding the teacher-researcher community towards inclusion of others in the school

C. Sources of Tension and Opposing Forces

Inner Fear
- math anxiety
- being observed
- making changes
- inadequacies as a researcher

Negotiation of Power
- initiators and followers
- heightened awareness (presence & silence)
- decision making roles

Pressure of Larger Community
- reactions of others
- sense of aloneness
A. Reflection Leading to Professional Growth

I was aware as I was teaching, of observing myself, not critically, or analytically, but objectively. There was Steven. This stepping out of my self and observing the lesson unfold was a key step in my understanding of how my being inside the role of teacher is inextricably linked to the perception of myself as teacher, my perception of myself in relation to the students, and my perception of myself in relation to others.

(Steven, April 3, 2000)

I’m feeling better about what I’m doing. I’m not feeling lazy. I have kids in and going whoohoo! And you know how if it’s not your best effort you feel lazy with yourself. We talked about how we could never go back to doing math the same way again.

(Donna, Nov. 10, 2000)

Five sources of data found that a critical component to professional growth was the ability to observe oneself and reflect. In the teacher interviews the words “I need to / I want to” were used twenty-three times by Donna and Steven when describing their math programs. Further, during triad meetings (those meetings when Donna and Steven and I met to discuss the progress of the study), the notion of self as learner was referred to on six occasions. All of our journal entries also strongly indicate that the three of us were involved in a process of self-reflection.

Based on grounded theory analysis, three key characteristics of professional growth emerged from this study. They are: self-observation and analysis; professional learning and change; and development of a questioning stance.

1. Self-observation and Analysis

Although observation of one another was a tangible state of the study (through site visits and classroom observations, for example) Steven, Donna and I also engaged in more reflective practice with an emphasis on self-observation and analysis. At times, for me, I felt as though I had stepped outside of myself to observe the triad in action. This was an important process that prompted me to question my own role within the teacher-researcher triad.
I sort of jumped out of my body for a minute and looked at the three of us standing by the filing cabinet. I was thinking about how we each bring a completely different package to the group. Donna brings an up-front style of direct thinking, feeling, and reflecting. She has a clarity about her that I envy. Steven brings a complex style of reflection-based action. He reviews everything thoroughly in his mind and takes steps from there. He’s not afraid to be fuzzy and let things unfold because they always start from a well thought out base. For a few frightening minutes, I decided that I don’t really bring anything to the group. Then I put myself down by thinking that the only thing I bring is technical math competence. Now I am thinking a little harder, and less harshly. I bring a form to the group. I bring ways to frame our work so that we can make more explicit sense of it. I am attempting to bring bigger pictures to the contexts of the mathematics classrooms, teaching, and the students. I bring a hinged mirror that lets us look at ourselves and at one another in different ways.

(Cathy, Oct. 17, 2000)

After sharing my journal entry with Donna and Steven, this incident became known as “The filing cabinet incident” and symbolized that process of being present in the activity and being removed from activity simultaneously.

Steven described his understanding of self-reflection as a teacher when he stated “work is an opportunity to examine yourself in relation to the world” (Steven, April 3, 2000). Specifically related to the way that he teaches (encouraging exploration of ideas), Steven wrote:

I hope that one day I can establish once and for all for myself why the accidental, the scattered, the random, the unplanned, the collage, the abstract, the improvised, the discovery, the shifting of the peripheral to the centre, the letting go at the edge, the formless, the hidden, the mystical, the unknown, the discarded, the obscure is so much more appealing to me than their counterparts.

In my teaching I look for opportunities to bring these pieces in so that I can see them and see the students see them. It amazes me that through being a professional with a reasonable imagination and massive expectations of this very human experience that I have been blessed with the opportunity to legitimately explore in a very simple way the presence of these pieces in my daily life. (Steven, Nov. 8 2000)

One of the explanations as to why this observation of self became heightened was my presence as an observer in the classrooms. This role of external
observer amplified our abilities to observe more critically in the classroom environment and observe the dynamics of ourselves within that environment:

As far as the whole observer/teacher/student dynamic: I think of it as being a continuum that comes to life when somebody opens the door and sits in the room...This 'project' is a sort of matrix for you to build meanings or feelings around and about. (Steven, Oct. 20, 2000)

In her journal, Donna described a specific moment when she realized that she had taught a concept to students in a way that was confusing:

Reflecting, I realize that I jumped around too much in teaching the concepts of perimeter and area. I quickly introduced perimeter and area as formulas (i.e. perimeter as measuring and adding all sides and area as l x w). I should have just used manipulatives in various ways to strengthen a conceptual understanding and through this understanding demonstrated to students why area is l x w and perimeter is adding all sides. My own math education was largely operation and textbook driven. I need to become more aware of how manipulatives are used in demonstrating concepts, as well as, and in addition to, operations. (Donna, Sept. 29, 2000)

These examples of self-observation and reflection illustrate an on-going self-learning dimension to the study that became the foundation for further learning about ourselves as people, teachers and researchers.

2. Professional Learning and Change

Steven described the teachers' desires for change when reflecting on the study in April 2001:

Donna and I had to "do something" to change things. I can see very clearly in retrospect that the need was more displacement (of current practice and current relationships with self, children, each other, the Division, and probably the job itself), than superimposition. (Steven, Apr. 27, 2001)

During the teacher interviews, there were nine examples where the teachers indicated that they were learning and subsequently changing their practice as teachers. In the initial interviews, Donna and Steven identified specific areas of program weakness. Steven explained how he began teaching math in Grade 6 with a strong emphasis on textbook learning:
It's very simple, I had no understanding of the terms I was teaching when I started this grade level. I didn't understand the math, I couldn't see the connections between the strands, my kids had no opportunity to describe their understanding of the terms to each other or to me. There was no interaction between the kids. It was all text driven and so their experience of it might have been shared but it was shared in terms of their understanding of what they were to do in the text...And that was my darkest time, honestly, teaching math.  (Steven, March 20, 2000)

Donna described some of the areas that she wanted to focus on in her math program during her initial interview, including a more student-directed approach:

I want to see a lot more rich tasks. I want to see them not just learning the skills but applying them in a lot of different settings. And understanding how they’re applying, why they’re applying, and justifying. I want to see a lot more center use, manipulatives, the computers will come into play there. I need to balance the different strategies I’m using, not just rely on teacher directed approach. I want to see less of me directing the lessons and more of them working together to help each other.

(Donna, March 7, 2000)

Steven and Donna worked hard to meet their goals through interventions spurred by the action research process. In February of the following year, during the teacher interviews, Donna and Steven both made specific reference to their own professional learning due to the activity of this study.

Donna states:

I have gone through a whole evolution. Basically for me, math was just numbers. And that made sense. I have been re-learning math in a whole new way, just getting inside concepts and seeing why these equations work. Now I’m on more of an even plane with the kids, because I think they might have been on an even higher plane than me, because they need to understand it conceptually before they understand the equations. So now I am starting to see through their eyes more, which is interesting to them: Admitting to the kids that I don’t know everything. Some of the resources I’ve been using to develop these centres, I’ve been going through a lot more [professional] resources instead of going through my handy folder. It’s been a lot of hard work. Next time I can polish from what I have done. I can see this as a continual growth thing. There is no way next year that I will be sitting here and saying 'oh I don’t have to do any work in math. It’s doing it all by itself. Which is exciting too.

(Donna, Feb. 1, 2001)
It is interesting to note that Donna’s initial desire to shift her practice to be more student-centered, actualized itself beyond her initial intention in that she later saw students as having been on an ‘even higher plane’ than herself. Donna found herself admitting to the students that she didn’t ‘know everything’. This acknowledgement allowed her to learn along with her students.

When I asked Steven to describe the professional learning he experienced during the study, he began laughing. His laughter was interpreted by me and later confirmed by Steven as a response to the enormity of the question. Nonetheless, he did respond in the following manner:

I could sit down and write you reams and I already have. [pause] There are simple ones like the process has been more important to me than the product. It’s taught me the importance of accountability to yourself personally and professionally in the way you relate to other people, in the way you see students as other people. There’s been a change there. I can’t live with my conscience to use power as a weapon. I want them to see themselves growing as human beings. My practice has been elevated dramatically this year. Perhaps this experience, more than anything else, including EQAO development team work, has really opened my eyes to my responsibility to myself and my colleagues. Not to change my colleagues ways of thinking or teaching – they’ll do that when they’re ready, but to serve by example. My example is one of ‘personal process’ who happens to be a teacher. And so my practice is where my craft is. My craft is where I develop discipline. And discipline is where I develop responsibility which loops into how I develop the program and work toward everything that is possible. It is an act of kindness: The whole thing of learning logs, running the classroom is an act of kindness, to show kids what is possible. (Steven, Feb. 1, 2001)

Steven’s initial desire to move away from the textbook grew to a much larger scope of professional discipline in developing a program and continuously refining it to help students reach their potential and to provide a model for colleagues.

Both Donna and Steven continued to identify areas for growth in their math programs throughout the study. Donna has indicated recently that she is frustrated with the physical structure of the math learning logs because a similar
type of prompt is being used within the centre task student packages (see Appendix E). She wants to somehow combine these items for more meaningful log entries. Steven has recently indicated a desire to use manipulatives more often in his math program. He sees himself and his students as comfortable with the manipulatives for geometry concept development but less comfortable with other mathematics strands.

3. A Questioning Stance:
The stance of the teacher and researcher as one of questioner or inquirer has been well documented (see Newman, 1991; Hubbard and Power, 1999, as examples). For Donna, the stance of questioner was a shift from previous practice:

As my teachers before and those before them, taught this way, so too have I. But I am not blaming of judging them, so much of what we see and know we accept without questioning, accept without understanding, accept without relating, accept without thinking. But I now question... You broaden your horizon (the first time that saying has ever actually meant something for me) because you take the time to think, to consider, to question, to relate, to apply, to question.

(Donna, Dec. 4, 2000)

This shift in Donna's stance posed a threat to some of her colleagues. Donna was no longer taking her already functioning program for granted. She began to continually search for ways to improve student learning through program shifts. In one case, after having several colleagues criticize her, I wrote a letter to Donna to support her in her efforts as a questioner. The following excerpt describes some of the difficulties of living with a questioning stance:

Hi Donna,

A friend of mine told me once that I was a questor and that questors often choose difficult paths. She used the word questor to mean a person who is after something - always going after something better, aiming for self improvement, self questioning. There are very few questors in the world...especially in the teaching world (of non-riskers who never left school - literally!). So it is from me to you that I pass on this same message. Donna you are a questor too. You want to know more, do it
better, change it, shape it, refine it! It is almost like a part of the personality that just won't shut up. - things nag at you until you address them. You aim high - you get there (of course it's never good enough when you get there - so you aim higher).

...Over time, a questor develops thicker skin - it doesn't mean that we don't feel every single jab, but we can start to put it aside - in its rightful place - after the hurt... Stay strong - reply with honest but revealing questions and explanations. Know that what you are doing is VERY important work - for you, for your kids. (Cathy, Nov. 8, 2000)

A questioning stance allows, indeed encourages, the teacher-researcher to take on a learning role. In embracing oneself as a learner one opens the door to professional growth in a continuous cycle of improved practice. My own learning stance was encouraged by Donna and Steven as well:

Steven also said that he and Donna wanted to know what was happening with my thesis work. They are curious but also want to try to help me with where it is going and to problem solve through some of the tensions. I was absolutely stunned – happy stunned that is. I DO need their help, and want their help. This was really a critical moment for me. I am a learner too and I need help in my risk taking. All three of us are risk taking, and we need to support one another in that challenge, in whatever ways that takes form. (Cathy, Nov. 3, 2000)

The three characteristics of reflection leading to professional growth that were clearly experienced during this study create the foundation for collaborative action research. They represent a stance, a way of behaving, an attitude, or perhaps even the criteria for which the possibility for the development of a community of practice exists. Although professional growth acts as a foundation, it was a constant component throughout the stages of the building of a community of practice among the triad of teacher-researchers.
B. Establishing a Community of Practice

Collective learning results in practices that reflect both the pursuit of our enterprises and the attendant social relations. These practices are thus the property of a kind of community created over time by the sustained pursuit of a shared enterprise. It makes sense, therefore, to call these kinds of communities communities of practice. (Wenger, 1998, pl 45)

When Steven, Donna and I embarked on this study, our primary enterprise was to enhance student communication in mathematics through the use of learning logs. As our work began to take shape and progress, we quickly discovered that because of our common goals and our sustained efforts, we were indeed creating a community amongst ourselves, replete with the development of a common language about our work and our discoveries, shared jokes, and mutual support.

In detailed data analysis through a grounded theory approach, three stages of relationship building were identified as occurring during the action research. Stage 1 involved building the community for the three teacher-researchers through taking risks, developing trust, and re-defining our identities with one another and for ourselves. Stage 2 focused on establishing our small community of practice within the larger and existing community of teachers at the school. Stage 3 involved explicit attempts to expand the small community of teacher-researchers within the larger teacher community at the school. Each of these stages is described in detail.

Stage 1. Building a Community of Practice
In building a small teacher-researcher community of practice there were a number of themes that were repeatedly referred to, or observed by members of the teacher-researcher triad. The three key themes were those of:

a. Trust, Caring and Support
b. Risk Taking
c. Identifying and Shifting Roles and Identities.
Each of these sub-categories for building a community of practice illustrate the
dynamics of activity for the teacher-researchers of this study.

a. Trust, Care and Support
In a caring relationship, people learn to trust and support one another. In the
early stages of my site visits at the school, Donna and Steven both indicated that
my very presence was stressful. This was an honest beginning point. In order to
gain their trust, I tried to be as open as possible about data collection. Each visit
was followed with verbal discussion and then I shared the written text of what I
had observed for further clarification and input. We met regularly in order to
discuss progress of the study and what each of us was thinking and feeling. An
openness of spirit grew as we shared more time together. Steven and Donna
frequently met together for short periods of time to discuss the successes and
the difficulties they were experiencing while making changes to their math
programs. The teachers soon grew comfortable with this exchanging of ideas
and with my interaction in supporting their desired changes. This instilled a sense
of privilege in having the opportunity to work with one another and support one
another:

Hey Cathy, briefly, thank you for the wonderful journal entry. I've read it
through twice and find myself again feeling that deep sense of privilege of
having you work with myself and my class. (Steven, Sept. 29, 2000)

This establishment of a caring relationship allowed us to develop trust in one
another and provided the necessary groundwork for taking risks. Steven
demonstrates his level of trust in the following journal entry excerpt:

I have an anxiety about being seen to be weak. I am placing considerable
trust in her [Cathy's] discretion as well as faith that in revealing myself
there will be reciprocal confirmation and validation of my efforts. I think I've
chosen well. (Steven, Oct. 3, 2000)

A critical factor in developing trust within the triad was a sharing of journal entries
by all three members of the group. These entries were personal and honest and
allowed us to view one another in a significantly different way than the face-to-face contact of site visits. My own level of trust and caring for Donna and Steven grew tremendously, as documented in the following journal excerpt:

Long haul. Punctuated with moments of surprise and light and bliss. The kind of journey that requires constant, consistent, energy and focus. The kind that actually turns out to be a way of life. Questioning, refining, revisiting, reshaping, risking, stepping in, stepping out, observing, feeling, thinking, knowing, finding, learning. Over time, time and again.

Holding one another up like pillars, jammed in swift river water, keeping the bridge up. The three of us have some kind of unshakable strength together in our understanding of the quest for better. What’s better for students? What makes it right for them? How do we do that? And keep at it? Is it possible to do this alone?

I am so honoured to be part of this support system – to be part of the strength that makes this little big project tick – and to be admitted to the naked truth teaching that Donna and Steven are living. I want to give them my sleep so that they are rested, my wee hours of the morning so that they can finish their work for the day, my eyes to observe, my privilege of time so that they can breath fully. They have given so much to me, I sometimes gasp when I look at the collection of notes and journals and observations. I gasp at my own learning. (Cathy, Nov. 28, 2000)

Donna used the image of a cliff and jumping off the cliff to describe her efforts to make shifts in her math program and in the process, she received the support of Steven and I:

Many months ago I had envisioned myself at the edge of a cliff. I felt strong enough to fly, I could imagine soaring across the clear blue sky to horizons unknown. But I had fear in my heart when I looked below me. I knew that if I fell I would be seriously hurt if not crushed….Lastly I remembered Steve and Cathy, I knew then that I could leap off the cliff and it would be my own strength buoyed by the support of others that would take me to new and exciting horizons. ..I have leapt, spread my wings and soared to far off lands.” (Donna, Apr. 21. 2001)

Steven described the value of our trusting relationships further as a catalyst for his own redefining of himself as a teacher:

The net result of the dialogue was to establish a link of faith and trust through which we acknowledged, questioned, celebrated, and contextualized actions within the work. It was in this creation -
paralleling and defining and acknowledging the work - that my own personal Waterloo of redefining myself as a teacher took place. This could only have occurred in a safe place. (Steven, Apr. 27, 2001)

b. Risk-Taking

Embarking on this project scared me in so many ways. It is not easy to critically look at oneself and bare our life’s inspiration (teaching practice) to others. (Donna, Apr. 21, 2001)

In developing a strong sense of trust and caring, risk taking became more manageable and desirable. The word ‘risk’ appeared on seven occasions in transcripts of the triad meetings. In addition, all three teacher-researcher journals acknowledged personal and professional risk-taking anxiety. Nonetheless, we carried on with shifts in our practices because of the safety we felt as a triad; as a small community of practice. Donna described her fear of reading the field notes of classroom observations in a triad meeting:

I almost didn’t want to read it [classroom observation notes]. And so then I actually sat down and read it. I want to know - what do I have to do to have a kick ass math program? (Donna, Oct. 13, 2000)

Steven described his growing confidence with risk-taking and in why he believed it was important:

We’re not good. Period. We’re risk-taking. There’s a whole helluva lot of difference there. We’re good risk-takers. We’re going to be good Math teachers. Donna and I get what we want ‘cause we make it happen
a) it gives us an opportunity to doubt ourselves.
b) it gives us an opportunity to say I’m not this person I’m that person - yeah that one over there.
c) it allows us to feel dissatisfaction.
d) it places us apart from the accepting herd.
e) it lets us feel change.
f) it opens the door to possibility. (Steven, Oct. 25, 2000)
Item 'd' on Steven's list highlights how the risk-taking approach to program shifts set Donna and Steven apart from those colleagues who were willing to accept a current level of practice without question. This theme re-emerges as the small teacher-researcher community begins to define itself within a larger school community.

For me, a recurring image that illustrated the theme of risk was a river image. This image was used mostly by me but also by Steven. My journal entries which use the river image described my deep sense of risk-taking as the ‘researcher’ of the study:

The image of the river with its inherent flow of thought is recurring. The water itself is penetrable but slips away and around, ever elusive. It is a deep source of risk, of self-doubt, of courage, of digging deep, of finding pattern and then of the water shape-shifting before our eyes. Just when I've fixed a gaze on the surface ripple of the water, the wind blows it out of that shape and into something new. We know there are things that feel right, that work for the kids. We are after those things. Sometimes when we get there, they look different. Perhaps some of that is based on our own expectations that when we arrive we will no longer need to paddle upstream. Actually what happens is that the arrival is fantastic! But it isn’t good enough. We want to travel further upstream. Always just a little harder, just a little farther. Like stepping into a fast flowing river and trying to get grounded on the slippery rocks, trying not to get swept away too quickly, trying to build a stepping stone path, a path that just keeps going...
Enjoying the water is maybe the essence of this research/inquiry/wet stuff we are doing. (Cathy, Nov. 15, 2000)

All three teacher-researchers took risks and supported one another in those risks. This became a form of bonding which solidified our small community of practice. Working in a supportive, caring community which acknowledged and encouraged risk-taking made it possible to begin exploring our own identities and shifting roles within the study.

c. Identifying and Shifting Roles and Identities
Issues of self-identity, and roles played by the teacher-researchers became a complex layer of developing a community of practice. On eleven occasions, the
words “layers, complexity and parallel” appeared in transcripts of the triad meetings. Further, journal excerpts revealed significant complexity of the parallel roles we each played and shifts in those roles over time. Donna’s initial thinking was that her involvement in the study would mean that she would be able to gather some quick math tasks to work on with students:

I wanted to improve my math program with as little effort as possible. I quickly found out that that would not be the case. I was welcome to do this but in turn I would be challenged to grow and experience math in new ways personally. You cannot learn solely through others, you cannot learn without expending effort. In some cases, large amounts of effort. 

(Donna, Apr. 21, 2001)

Donna quickly assumed the role of team player, and began to shape a new identity as that of a risk taker and learner:

I took my role as part of the ‘team’ seriously and I was taking risks for Cathy and Steven to help support them through their own risks so that we might learn from the same / parallel / opposite experiences of each other.

(Donna, Apr. 21, 2001)

Steven also connected our abilities to ‘share a risk’ with trying on new roles within the school environment:

The ‘project’ has broadened considerably as its focus has narrowed. Donna is now much more a piece of it from my perspective as she offers commentary or shows me how her Math centres are working. Learning for me has always been a feature of my own efforts but here is someone wanting to share a risk they are taking replete with its mess and glory! In the personal exchanges that Donna, Cathy and I are now able to undertake we wrestle with the intricacies of being humans engaged in something that should provide a specific focus but has recognizably many of the features of something quite larger. It would be easy to ignore those other features - maintain an arms-length relationship and focus entirely on the goal but there is in the development of better practice or in taking public risks something inextricably greater that is about who we are, what we believe, and what we expect of the world.

(Steven, Oct. 20, 2000)

For myself, the layers of roles seemed overwhelming. Steven suggested that I represent the layers visually in order to make better sense of them. The following journal entry excerpt is a record of my attempt to create that chart:
As I See Myself | As I See Donna and Steven
--- | ---
Myself as researcher (observing) | Teachers as researchers (trying new things)
Myself as teacher (bridging in) | Teachers as teachers (with an observer)
Myself as colleague (teacher to teacher) | Teachers as colleagues (in same school)
Myself as learner (of the students) | Teachers as learners (of the students)
Myself as learner (of the teachers) | Teachers as learners (of me)
Myself as ‘expert’ (math teacher) | Teachers as experts (in teaching)
Myself as 36 year old woman doing Masters Thesis field work, on leave from the local board of education as a consultant in assessment and research | Donna as 30 year old woman – Grade 4 teacher (second year in this grade) Steven as 43 year old man – Grade 6 teacher (four years in this grade)
Myself as a friend with Donna and Steven | Steven and Donna as friends with one another and with me
Myself as a resource to others in the same school who are not involved in the research project | Steven and Donna as a resource to other teachers in the school who are not involved in the research project

When I finished the chart I blew out a long slow breath of air. Partly because I was relieved to have actually identified what was going on in my head! And partly because I was overwhelmed – nine layers with nine parallel layers, making 18 all together. Some of the categories overlap so much that it would be almost impossible to separate them. What now?” (Cathy, Oct. 10, 2000)

The creation of the chart to identify the multiple roles and layers I was experiencing was helpful in allowing myself to become aware of which roles were being used most and least, and which roles were changing. One of the challenging identities I was attempting to explore was that of researcher. I took on the role of temporary researcher during this study and found it enormously challenging, because it was new and required a different kind of patience and faith than that of the teacher. The chart also framed some of the roles I perceived Donna and Steven to be playing during the action research study. Donna and Steven were not surprised by the chart and agreed that they were indeed experiencing this multi-layering of identities.

Our roles continued to evolve during the study as our small community of practice became more solidified. As our level of comfort grew in our relationships

Cathy Bruce, MA Thesis - Results
together, we were more comfortable in allowing our roles to shift. An example of how roles shifted is described in Steven's journal entry:

Cathy has several roles, observer, intervention strategist, student, teacher, friend, colleague, parent, qualifier of the qualitative, and many more. The role that is most apparent now is that of co-facilitator - the stepping-in occurs both during the input and during the response, exchanges are occasionally mediated through eye-contact or through sudden flurries of writing that I observe and occasionally remark on. Significant events that might otherwise escape me through my distractibility or through my not recognizing them for what they are become obviated through my sense of her response to them.

(Steven, Oct. 20, 2000)

This experimenting with roles allowed us each to re-shape our sense of self within this new community of teacher-researchers. During one site visit for each class, we physically switched roles so that Donna and Steven were observing the classroom activity while I acted as 'teacher' of the class. The students accepted the shift easily and for Donna and Steven and I, it gave us the opportunity to try on different roles within the same settings. Donna describes the particular activity of my work with students in the following journal entry excerpt:

I enjoyed seeing how Cathy provided the framework for the students, allowing them to fill in the spaces. Through this they were able to demonstrate a good understanding of what criteria belong in each of the levels in a rubric for the chosen category...I can see how this activity empowers the kids while there is still enough input from the teacher to get them started on the right track. (Donna, Oct. 31, 2000)

My own journal entry related to our 'role switching' reveals the importance of seeing the same environment from different angles. In changing roles, we were each afforded a different view of the research site environment. The image of the river recurs in this passage, with the direction of the flow of water illustrating the shift in roles:

In both Steven's class and Donna's class, we changed the direction of the flow of the water in a tangible, physical way. As Steven introduced class, he began by saying “We are in different places today. Cathy is standing at the front of the room. And where is she normally?” The students unanimously pointed to the back table where I usually set up a station during my visits. Then he said, “Well Cathy will be up front, so where do
you think I’m going to be?” The students unanimously pointed to the back of the room a second time. Our physical locations shifted. This was true in Donna’s class too. In Donna’s room, I worked through negotiating the beginnings of a rubric with students for math learning logs from the front of the room while Donna observed from the side of the room.

So we changed the flow of the river, and in its course, we saw the rocks from different angles. We watched the riverbanks exposing the undersides of plants normally brushed in the opposite/different direction. For Donna and Steven, they had the rare opportunity to watch their students working on tasks without having to do the directing, overseeing, managing. It freed them up, to look, to observe in an indulgent way—they could choose who they spoke to, what kinds of questions they asked, what notes they made about the students, about my teaching, about their own thinking. They also got to watch their students with another teacher. I wasn’t there to teach an exemplary lesson. I was there as a foil—changing the dynamics for a fresh view.

(Cathy, Nov. 15, 2000)

This shift in roles was very helpful for me as the researcher. It allowed me to view the students as a group entity, which up until that point had not occurred. Previously I related to students as individuals or small groups only. When faced with the role of teacher (a more familiar role for me), I was given the opportunity to see how the students functioned as a whole.

Building a community of practice in this study involved three main themes or activities: developing caring and trusting relationships; taking risks; and experimenting with shifts in roles in order to find new identities and perspectives as teachers and researchers. These themes proved to be fundamental to building a strong community of teacher-researchers.

**Stage 2. Establishing the New Community Within the Existing Community**

Once the triad had established ourselves as a strong teacher-researcher community, it became apparent to other staff within the same school environment that we were engaged in activity that was very important to us and was having significant positive impact on student attitudes toward mathematics. This led to some positive and some negative reactions from other staff members. The negative influence of the larger community of staff in the school on the smaller
community of teacher-researchers will be explored in the 'Sources of Tension and Opposing Forces' section of this chapter. Whether the reactions of the larger community were positive or negative, they impacted on the triad's desire to clarify what we were doing and ensure that our work would continue without disruption. This then forced us to establish our teacher-researcher community within the existing larger community explicitly. Steven reflected on his perceptions of how others viewed our sense of belonging in the teacher-researcher community and the nature of our work during in the following note:

I am compelled by your reference to Wenger (ref. "belonging"), particularly as I feel a burden of guilt towards my colleagues who have watched with a mixture of jealousy, bafflement, and curiosity as we have unfolded what I feel certain is of interest to them but which I also sense is (in their eyes at times) suspect because of its apparent one or two step removal from what can functionally be termed "A Program". In other words, a) "why mess with something if it ain't broke"? b) "what's wrong with teaching from a 'well-organized' text?" c) "how can anyone afford the time or energy to step back into meta-analysis of their program?" (Steven, Apr. 3, 2001)

It was determined during a triad meeting in November 2000, to request time on a staff meeting agenda to discuss the research study with staff at the school. Our goals were to de-mystify our work and describe the action research cycle we were using as a framework (see Appendix F – McNiff’s research cycle), and to share some of the early data collection with staff to solicit feedback. We wrote a proposal to the principal (see Appendix G – Proposal for Staff Presentation on Action Research) and he agreed enthusiastically, providing us with a full hour of time on the agenda. During the presentation, I specifically requested permission from staff to audio-tape the meeting for later transcription. It was one way that we modeled our research activity within the staff meeting. Another strategy we used to model the three-way ownership of the study was to have Donna, Steven and I all speak during the presentation using three simple questions as our framework:

1. Why are we doing this?
2. What are we doing?
3. What are we finding out?
The last part of the presentation involved sharing student learning log samples with the staff and having them discuss what they saw in small groups. Samples represented a very early learning log entry and a later entry for high, middle and low achieving male and female students. Staff were then asked for feedback about their observations related to student communication in the math logs. The presentation was accompanied by a four-poster presentation that was displayed on the staff room wall for further review by staff over the following two weeks. The principal and staff members were quite supportive at this meeting. Four individual staff members also approached us to talk further about the meeting over several weeks. As a guest in the school I personally noticed more friendly greetings from many staff that had, up to that point, not made contact with me. It also allowed Donna and Steven to talk about their work with a more common context of understanding in larger group settings, such as divisional meetings and lunch-time discussions.

The teacher-researcher triad remained as a contained community of inquirers for the four month period of intensive intervention. Donna described her comfort with her belonging to the smaller community whilst being part of the larger community as follows:

Thank you friends for the realization of this, for the courage to put this into words and share it, to have thought about, and puzzled over: I am not looking for agreement, not anymore. I am looking for understanding from those who take risks, those who are on their own journey of meaning.  
(Donna, Dec. 4, 2000)

Stage 3. Expanding the Small Community into the Larger Community

Over time, and particularly as the research project came to a close, Donna and Steven made efforts to expand the teacher-researcher community to include other staff members. They needed to find support systems within the school in order to sustain their inquiries. The notion of expanding the community began to take hold after the presentation to staff in December 2000. As chair of the junior
division at the school, Steven began to imagine how to support whole division action research when he wrote: "I would like to take some features of your work in my room with me and with Donna and push it into the bigger picture of my Division" (Steven, Dec. 21, 2000). The junior division teachers met in late December and spent forty-five minutes discussing areas of strength and areas for improvement both individually and as a division. By February, the division members had agreed to a portfolio project for the 2001/2002 school year. The student math portfolios would begin in Grade 4 and would follow the student through Grades 5 and 6. The teachers discussed what would be important to include in these portfolios and how they would be managed. Steven described the process of building ownership and commitment for a portfolio project in the following e-mail text:

I know what I could do but I think that we need to arrive at something that bears all our marks, that will demand something of us that we are all willing to give to. Having a broad base of options as to how this is implemented, its discrete features, as well as how we assess its success is probably key to the others really buying in.  

(Steven, Feb. 15, 2001)

This was the beginning of a series of divisional meetings focusing on the portfolio project and ending in the spring with a sense of direction for the group. Steven began to believe that a portfolio project may indeed occur. He indicated that the influence of the small teacher-researcher triad may have impacted on the larger teacher community:

It's very gratifying to see that what you and Donna and I achieved has finally started to spread and is going to affect a larger group of teachers and students.  

(Steven, Apr. 11, 2001)

The three stages of establishing a community of practice can be related to circular ripples formed on water by a thrown stone, expanding from a center point outward. The impact of the stone acts as an initiator for ripples of expanded activity. Initiating this study acted as the stone disturbing the surface of the water. The first circular ripple was that of building a strong teacher-researcher community. In the second stage, the small community became surrounded by
another ripple, that of the larger community at the school. The teacher-researcher community openly shared experiences and findings with the larger community. In the third stage, the community of inquiry began to expand into the larger community of teachers through the initiation of the portfolio project. At this point, it is difficult to estimate the value of expanding the community of teacher-researchers to a larger community. The focus on portfolios in math is promising.

C. Sources of Tension and Opposing Forces:

Three main opposing forces were identified by the teacher-researchers during this action research study. These particular forces reflect the environment and the individuals involved in this study. Nonetheless, some of these same opposing forces have been documented as a phenomenon of collaborative action research work (e.g. Hayes and Kelly, 2000; Ross, 1999). We felt it was very important to clarify sources of tension in order to find ways to manage them.

The three main forces in opposition to the development of a collaborative community of practice in our study were inner fear amongst the teacher-researchers themselves, the negotiation of power within the teacher-researcher relationship, and unconscious pressure from the larger community of the school.

Inner Fear

Each of the teacher-researchers in this study experienced significant moments of fear. For Steven, his fear stemmed from an anxiety about teaching mathematics. When describing his own math learning as a student he wrote: “I tried to fake it. I came up with a hundred clever ways of solving [problems using] formulas I knew nothing about… I didn’t really know anything. Nothing that had gone before really counted” (Steven, Oct. 3, 2000). In having a researcher in the room during math, that anxiety was brought forward again:

In choosing to work with Cathy on this there is the first confrontation – the issue of placing my self and my abilities squarely in the spotlight of someone for whom the issue of Math competence is a non-issue. (Steven, Oct. 3, 2000)

In coming to terms with these fears, Steven wrote:
Letting go in front of someone who I knew (let alone perceived) to be able to see the emperor's clothes, to know what functions and what doesn't, what is sustainable and what is mere rhetoric, was a daunting and yet embraceable task. That was only possible because I had [developed] a personal relationship with Cathy that allowed me to consider the possibility that even if things were not especially brilliant or formidable in substance, she would be able to tweak them carefully enough to propel my thinking and my actions through my classroom into something looser and more creative long enough to bring about real change. I knew that was a real possibility, which is what eventually won me over.

(Steven, Apr. 27, 2001)

Steven learned to manage his fear through the support of the triad, and through his own great desire to bring about meaningful and sustainable change in his program. As Steven so concisely put it: "The fear never left, but it was manageable" (Apr. 27, 2001).

Donna used the image of a cliff to describe her fears (see section on 'Risk-Taking' in this chapter). She was fearful as she saw herself jumping off the cliff to try new approaches to teaching. As a student, Donna learned mathematics from a textbook based program. As a teacher, she in turn taught using a textbook based program. When she committed to participating in this study, Donna wanted to move away from that type of math program to one that encouraged the use of manipulatives, exploring math concepts from a variety of different angles, fostering student communication about their learning. These goals were quite large and can be interpreted as reflecting Donna's fear of stagnating in her chosen profession. Donna saw complacency as troubling:

It is very easy in one's profession to become complacent. It is very easy and very dangerous to do this. As teachers are essentially motivators and inspirators, it is impossible to fill these roles effectively when one has lost all joy/meaning/challenge/love/growth for what they are undertaking each and every day. (Donna, Apr. 21, 2001)

This fear of herself becoming stagnant and of losing self-motivation led Donna to set high personal and professional goals in her mathematics program and also in her approach to life:
I remember a comment that Cathy made last spring when I told her the students enjoyed using the textbooks each day. She said that was because the students had become apathetic to learning and being challenged. A short while after that I read that hate was not the opposite of love, apathy was! That scared me. A personal goal I have had since then is removing apathy from my spirit. Thanks to this project for helping me recognize an enemy that I never knew I had. I will not forget this enemy, I will always be on guard against apathy. (Donna, Apr. 21, 2001)

My own fears largely circled around issues of the study taking on a life of its own, as the work was emerging in ways I had not anticipated:

This research is unsure. It's messy. It scares me. The overt work in math is not a problem. It will glean good information and it will be a practical, exciting learning experience. It's the covert that scares me. I am watching myself as the researcher making decisions, watching, feeling, thinking, in a parallel self-study. Some air seeps out between my lips, a tiny leak of my subconscious has escaped – which is very painful because now I have to acknowledge it and at the same time, my headache is easing. Now is the time to pay attention to the covert. I am not in a well lit space. I'm fumbling. This is not a freefall – it's a roll down a dirty hill!

(Cathy, Sept. 29, 2000)

I decided to approach Donna and Steven about including our explorations of identity in the study. This was a risk for me because I was not sure how they would react:

I suppose the first step is to meet with Steven and Donna and talk about it. I need to see if they want to talk about how they see themselves. I am very nervous about doing this – not because I don't want to talk about it with Donna and Steven, but because it means acknowledging in a very public way – that there is a lot more to this research than mathematics. It's about the relationship of the researcher and teacher in this particular context. It's a self-study for each of us as much as a group-study. Mathematics is the vehicle. What we are learning goes far beyond mathematics teaching and learning. Where will this go?"

(Cathy, Oct. 13, 2000)

My fears about changing the focus of the study were largely based on my sense of inadequacy as a researcher.

I was asking myself whether it mattered if the two teachers had the same vision to begin with. And what if it wasn't the same as my own? How would I reconcile the issue that their ideas did not always match my own?
This acknowledgement that my own beliefs and ways to proceed might be different was difficult. I was confronted with my own sense of inadequacy, my lack of confidence as a researcher. I did not know what "a good researcher would do". I have read so many studies that have an impartial, empirical stance. They give the message that the role of the researcher is to observe and document, but not to 'get involved' or offer opinions.

(Cathy, Jan. 15, 2001)

In sharing my fears with Donna and Steven and in the discussions related to the surprises of our research, I was relieved and given new found confidence.

Steven wrote the following note of support:

Blast the protocol! Tell about the unfolding of your work and how the real people you worked with really messed it up and reformed it. How you reacted to that. Why it worked so very well. Make it a duplicable process for the lucky readers.

Do you remember the little sentence where you opened the door to the possibility that things might not evolve in the way they were "supposed to". There is your keystone. Right there is where the future becoming present presented itself. It is from that that Donna and Steven (and then the whole OVPS Junior Division flailing down the path - and there's more on that coming soon....) took their leaps and started the dance that keeps on unraveling.

(Steven, Jan. 27, 2001)

With the support and encouragement of Donna and Steven, I was able to make the shift to this new dimension of our work. In describing my sense of building confidence, I connect my growing skills as a researcher to the anxieties of writing an exam:

The sense of accomplishment for me was immense. I'm not sure if, even now, Donna and Steven know how challenging it was for me. It was like I was cramming for an exam. And then when I got to the exam room, it wasn't the multiple-choice exam I had been expecting. It was an interpretive, creative essay that emerged from the knowledge and skills we shared as a team. I gained trust in myself and in my colleagues.

(Cathy, Feb. 15, 2001)

In confronting our fears, we each gained internal strength and confidence. We acknowledged their presence, made them public to one another, and supported each other through the process of facing those fears. In so doing, our reward was a deep level of personal and professional learning, and belonging.
Negotiation of Power

Three specific questions of inequality presented themselves in the relationships of the teacher-researchers during the study: Who were the initiators and who were the followers? Who were the observers? How were decisions made?

To begin, although Donna and Steven had identified their math programs as areas for improvement, it was the researcher (me) who presented the idea of conducting this study. In addition, I was known from previous experience within the district as a consultant with particular strength in mathematics. Thus, I entered the relationship with Donna and Steven as the initiator of the research study and the expert in mathematics. Donna and Steven entered the relationship as experienced teachers who were attempting to shift their practice. They agreed to the study in the hopes of gaining support for making those shifts. One interpretation of this situation would be that Donna and Steven were in a position of deference, as the learners. A kinder interpretation might be that although we all agreed that we were learners from the outset, our positions were not equal. Initially, I was the ‘bell ringer’ (Wiesenfield, 2000). Over time, Donna and Steven saw me more as a learner, and I saw myself more as a learner during the study. The study took on a life of its own and we allowed that to occur with gentle prodding to maintain a focus on action research related to student communication in mathematics and the exploration of teacher-researcher relationships.

A second inequality occurred because of the environment in which the study occurred. Donna and Steven were teachers and members of the large community of the school in which they taught. They established themselves within that community over several years of teaching at the school. I entered the building as a guest. I was not a member of the school community. I was welcomed into the school very kindly by the principal and the two teachers, and thus can describe myself as a ‘welcomed guest’. There were times when I was unable to observe or participate in activities because I was not there every day.
There were other times when being a guest was very awkward, as plans would change in the classroom and my observations were not possible or were postponed. For example, on November 3, 2000, when I went to visit in Steven's room, the class was at the gym for physical education. When the class returned from the gym, Steven was surprised to see me. I sensed his discomfort and considered leaving, but ultimately stayed:

Steven looked a little taken aback when he saw me. It was an awkward moment where I really felt like I was invading on the rhythm of things and invading Steven's space. The tension was in my mind, because Steven hadn't indicated that I was invading his space at all, and so I was reading into the situation, and I wasn't sure if I was being over-sensitive or not sensitive enough. (Cathy, Nov. 3, 2000)

This incident reminded me that although our relationships as teacher-researchers were strong and trusting, I continued to be a guest at the school and a guest in the classrooms. The issue of the teachers needing to reclaim their 'space' became more explicit in the month of November. In his journal, Steven wrote:

I had an overwhelming - sort of an adolescent - craving for space and independence. Not a negative thing, not an exclusive thing, not a personal thing, not a mixed-up perception - a need to grow without someone else pointing out the stages. I really wanted to experience myself for myself. I needed my own space. I wanted to move to the next stage and I honestly didn't feel that having Cathy there would allow me to try it on my own, become more responsive in my own right to the changes in my students and more importantly to the comments, interactions, and flow of their dialogue. All too often I was relying on her to point out these things.

(Steven, Nov. 8, 2000)

In a further meeting with Donna and Steven, the following conversation was recorded:

Donna:
I feel like I need to see what the kids are doing. I'm spending all my time making sure that it's going okay. I feel that I'm not in there enough. And that's going to be my next focus - to try and get inside their heads; so what are you learning, what are you doing? Cathy's been doing that for me when she comes in the room - that's what she's been doing right?

Steven:
Yes, I know. I complain about it to myself.

Donna:
And that’s what I need to take on here.

Steven:

It doesn’t bother me that she does it, it bothers me that I’m not doing it myself. It’s wanting to be able to step back and have that chance to look. And it’s not easy to do.

(Triad Meeting, Nov. 10, 2000)

My own reaction and thinking about the tension of my presence is captured in the following journal entry:

Donna and Steven are watching me. They see me observing – looking for the detail, the critical moments, listening to the words attentively. By my very presence in the room, I become the observer, I become the eyes, the video camera. Presence, even in silence, impacts on the dynamics of interaction. This measuring of river flow, velocity, volume, depth is one of the key pieces that I have offered to my partners in this project. Donna and Steven are stretching, they need the room to reach out in any and all directions, extending their finger tips to the very edges of the river and beyond.

(Cathy Nov 22, 2000)

From this experience, the theme of silence and presence emerged.

Silence – my voice is getting quieter, Steven and Donna are listening to their own voices. At the same time, we share a collective voice that is shouting from the rooftops, not silent, even when there are no words.

Presence – being in the moment, watching that moment unfold. We are watching leaves dance and shift at this moment, and the next. Our presence working with the students is the informer of our practice and of our re-shaping.

(Cathy, Nov 22, 2000)

In recognizing the need for the teachers to become their own observers, the number of classroom visits decreased, while the contact with the teachers to discuss progress of students and their program shifts increased. The forms of our increased contact included frequent email, phone conversations and meetings.

The third inequality that presented itself during the study was that of the decision-making process and who was making the decisions. In the early weeks of the study in September (as well as during prior meetings and discussions), I initiated
the activities of the study (when I would interview the teachers, the questions for those interviews, and interviews with students to gather baseline data, for example). As the study unfolded and we gained trust in one another, the decisions and discussions were collaboratively initiated by both the teachers and myself. We determined what should be done next, when we would meet, and what would be the topics of discussion. This sharing of the power for decision-making was essential in establishing a collaborative partnership.

The key to the success of our project was simple. The power had to be shared and eventually let go in order for the communication to work at the level it so obviously wanted to. We had to get out of the way.

(Steven, Mar. 19, 2001)

Some of the things that the teacher-researchers of this study agreed on (in April 2000) which allowed us to share decision-making and made our relationship more collaborative included the following:
1. Regular meetings during which all three members of the team proposed and spoke to items on the agenda.
2. An understanding of a continuum implicated in our work, which defined us all as learners and as 'works in progress'.
3. Open discussion of how we perceived ourselves, and one another, including an obviation of the personal-professional dynamic.
4. Sharing journal entries regularly.

The inequalities of power, which appeared as inherent in the initial stages of the project, could not be ignored if we wanted to establish a collaborative relationship. Power and who had it, or needed it, required attention and negotiation throughout the study. Part of our roles as teacher-researchers was to negotiate that power openly and respectfully.

Pressure of the Larger Community
As the teacher-researcher group gained strength, the larger school community began to pay more attention to the smaller community. In many cases, this took
the form of positive feedback from the administrators of the school (as noted in the transcript of the staff presentation, for example). In other cases, this took the form of negative reactions toward the teacher-researcher activity. Donna, in particular, experienced a number of negative comments related to work in the study.

On one particular occasion, Donna and I discussed the situation in detail:

Donna was upset, and rightly so. She described how it made her angry, because she is trying so hard to get these centers running, and meeting the expectations and her goals, and meeting student needs. She felt frustrated because once again, as the risk taker, she’s the one up for critiquing by other staff members. (Cathy, Nov. 8, 2000)

Donna was very happy to share materials and self-created strategies with others — that was not a problem. The problem was that the relationships were not reciprocal. My observations included the following comment: "There is not a spirit of sharing in this case. It is a more tenuous one-sided taking type of relationship.” (Cathy, Nov. 8, 2000)

On one occasion when the teacher-researchers were meeting at the school (Oct. 14, 2000), a staff member passed by and said jokingly to Donna, “Oh so you’re meeting with the Math Gurus this morning”. Donna was not feeling like a 'math guru' and found the comment strange. I believe this comment was meant as harmless, but upon further reflection I believe it was not about the fact that we were doing math research, it was about the fact that Donna and Steven were taking risks to make changes. In addition, Donna and Steven’s association with me included them in the category of ‘Math Gurus’. This was perhaps subconsciously threatening to some others. Donna and Steven were willing to live with this tension. They were strong in their convictions that they wanted to continue improving their programs, and hoped that others would be working toward shifting their programs as well.

The mixed reactions to the study led to a sense of aloneness at times for Donna and Steven as they continued to spend their time in the school environment:
It disheartened me when I realized many people were waiting to see me fall. They, if not consciously, unconsciously hoped that I would, as my fall would legitimize their own reasons for not attempting flight. ...My ambitions were a threat to their own feelings of success. In some twisted way, they saw my successes as their failures.” (Donna, Apr. 21, 2001)

Steven and Donna have made significant attempts to eliminate the sense of aloneness as action researchers by encouraging other teachers in the school community to participate in an extended study with a focus on the use of student portfolios in mathematics. In working to expand the community of teacher-researchers, Steven and Donna are also hoping to remove some of the self-perceived isolation they have felt during and after this study. The three main sources of tension in building a collaborative action research relationship experienced during this study were inner fear, issues of power, and pressure from the larger community. Each opposing force was discussed amongst the teacher-researchers in efforts to recognize the problems and to develop ways of coping with them.
Enhancing Student Communication in Mathematics

Question: How can student written communication in mathematics be improved by the collaborative action research between teachers and researchers?

This section provides evidence that student writing in mathematics improved through the interventions that the teachers used as part of the collaborative action research study. Site observations and learning logs were analysed in order to determine whether teacher-researcher interventions led students to shift their mathematical writing from simple, short responses to the communication of more complex and in-depth mathematical thinking.

The teacher-researchers shared a common goal in our collaborative action research study. Our main focus was the implementation of student learning logs in mathematics. We used the logs to measure student growth in communication with a rubric (see Appendix H) as the constant assessment tool. In both classes, evidence of student enhanced communication is strong and most evident in the student learning logs.

Observations and Interventions

For Donna, interventions included developing centre tasks for students through the use of a model we developed in the spring of 2000. The following site observations, recorded on October 20 provide indicators of the success of this initiative:

The students were very eager to participate in the centers and stayed on task throughout the class. It was interesting to see how the students used mental math calculations while doing the grocery activity and rounding. It was clear in observing students, which students had sense of number in their minds and which students were struggling with every addition and rounding aspect of the task.

Students had one tracking sheet on the top of their work booklets. Then there was an activity sheet for each center. They used the center sheets to record their work, and the top sheet to indicate which centers were
complete. There were a few writing prompts on the top tracking sheet as well. (see samples for details).

Donna was pleased with how the centers were operating, with the skills students were learning and using and with their enthusiasm for the tasks. Several staff members have come in to see what is happening. The principal came in and was very enthusiastic about student involvement and Donna's shifts in her program. A teacher came in to observe students to inform her own practice as she would like to start centers in math too.

(Cathy, Field notes, October 20, 2000)

In addition, Donna encouraged rich entries in the student learning logs through promoting student discussion about their mathematical ideas and opinions. In September, Donna wrote:

I need to address with students how the learning log discussions need to be more informal. Hands do not need to go up. It should be less teacher-directed. Perhaps small group discussions would benefit students. They might be more relaxed and share information more freely.

(Donna, Sept. 29, 2000)

Donna continued to work with students in encouraging robust discussion. She was observed grouping the students and having them share in small groups and then with the whole group. This strategy was very effective in helping students become more comfortable with informal discussions. Further, Donna gave the students an analogy. She described the discussion of math ideas to her students as a 'dinner table discussion':

To have a meaningful discussion we need to share what we are thinking at the moment. We need to talk to each other about math. All statements do not have to go through me or even be directed at me. Just like a discussion around the dinner table. When you and family or friends are discussing something you don't put up your hand and wait for permission to speak. These discussions need to be informal. As long as we are respectful of each other and listening to each other, it's okay to speak out.

(Donna, Oct. 3, 2000)

On November 17th, the following observations, which illustrate the progress of students in both their written learning log entries and in their verbal communication during discussions, were recorded during a site visit:
Students will be working in their math learning logs today. The math learning log rubric that students and the teacher negotiated is on the board. All students have a copy of the learning log rubric with their logs. (Donna is thinking about shrinking the rubric so that is can be pasted into the logs from time to time when used for scoring.) Donna began by reviewing the rubric.

Teacher moves on to discuss the center activities that students have just finished.

T: Think about what you have learned. So our topic today is Geometry. Include information about the centers. Did you learn some new skills? Were they previously learned? Make some connections to how you can use it.

Teacher records on the board:
- Topic: Geometry
  - Include information about centers
  - Skills - new?
    - previously learned?
  - Connections “you using it”

Donna then gave students 20 minutes to write in their learning logs. Donna came over to the table where I was sitting. We talked about listing some other key words on the board which Donna then did.
- Using: charts, diagrams
- Support: ideas, opinions

For the first ten minutes of writing, most students were using prose type entries. Then nine students shifted to drawings and diagrams. These students were careful to label their drawings. Once the first nine began illustrating concepts, their neighbours also tended to move out of prose and into other styles of communication.

11:07 Small Group Sharing

Donna asked students to share their learning log entries in their small groups. As I listened to the sharing I noticed that students had written a significant amount (all students that I observed had at least 2 pages of entry – small book - while some had 4 or 5).

11:16 Whole Group Sharing

Donna asked for volunteers to share their learning logs with the whole class. Many students were eager to participate and added on to what one another were saying.

Comments are just highlighted here:
Earl – geometry with rolling dice that are cubes, garbage can that can be a prism or a cylinder, “we sleep in a shape – my room”.
Katie – measuring angles was her favourite center. “I had never heard of it before.” Also used the word “fulcrum” to describe the area for measurement using a protractor.
Brendan – favourite part was eating the marshmallows, “We made shapes” (meaning nets)
Stacey – 3D nets, made out of “just rectangles. It was new to me, I’ve never traced a box. I had to fold it into the shape I traced.”

11:22 end of class

Donna and I talked briefly after class. She is pleased with the eagerness of students to share their log entries and sees progress in the quality of the entries.

I was struck today by the way Donna moves the conversation so that key ideas are constantly reviewed and revisited. She is working hard to get these students to work co-operatively and respectfully. Donna models good listening for the students and expects them to be attentive to others. These skills carry through math and into all areas of classroom dynamics. It is wonderful to see how enthusiastic the students are. These kids love math – they love the center activities, and writing in, and sharing, their learning logs.

(Cathy, Field notes, Nov. 17, 2000)

For Steven, interventions related to changing the structure of math lessons from that of a teacher-centered program to a student-centered program where students were encouraged to discuss and defend their ideas, and explore new ideas within a mathematical community. This included promoting student discussion through concept mapping, exploration of ideas in small groups, and reflection in the student learning logs.

On September 26th (the first site visit in Grade 6) the following observations were recorded:

As a summary, the teacher asked students to record, in their learning logs, any new things that they had learned about measurement during the math period. After a quick glance through the journals, I have seen mostly one-sentence responses, which are literal. For example: ‘I learned that you
can measure everything in the world." I also read attitudinal responses, such as, 'measuring and building is hard'.

(Cathy, Field notes, Sept. 26, 2000)

On October 17, Steven moved the students into groups and began to include group tasks regularly in the math periods. At this point, the flow of student-directed discussion began to take hold. Steven describes this shift in the program in the following journal entry excerpt:

The pieces I am teaching are fully prepared but always incorporate a loose unfocused / unprepared element to allow the possibility of the unexpected to enter the room...some features flow and others are frozen...Those features that flow have the greatest potential for a level playing field [student directed]. I can be quieter, I can listen to the students, they can hear themselves, roles become less important.

(Steven, Oct. 20, 2000)

Student discussion and Steven's facilitation of discussions began to take shape and became more effective. At the same time, student learning logs became more useful tools for the teacher and the students. The following observations were made on November 3, 2000:

Beginning of Class:
The teacher asked students to record in their learning logs, what they understood to be the meaning of the word 'net'. He suggested that they might want to include an illustration "because that's part of telling about your understanding."

After giving students time to do their log entries, Steven asked students to talk in their groups about: "When you're drawing a net, what do you need to do to make sure that it will make an accurate 3D object?"
Students worked in their groups and generated lists of criteria. In most groups, one person recorded the list into hi/her learning log.

Then students were asked to talk about what they understand about nets as a whole group. The teacher recorded student comments on the board:

Net
It's a closed object.
An unfolded object
An unfolded 3D object
Not closed
Has shapes in it
A flat, unfolded 3D object
Steven stopped here and asked the students what they noticed about the list. After several suggestions, one student stated: “There are different opinions.” Another student said: “The ideas are changing as they go.” Teacher: “Okay in a good group discussion we’ve gone from some detail to more and more detail.” Steven underlined the words as follows to illustrate the adding on of ideas from one contribution to others as the ideas built on one another:

It’s a closed object.
An unfolded object
An unfolded 3D object
Not closed
Has shapes in it
A flat, unfolded 3D object

Then he asked: “Is that enough, if we were going to talk to a younger student down the hall?” The students decided to add: - we need measurement, instructions (How to) and “maybe” where it’s from. On chart paper, Steven wrote the last description of a net onto chart paper.

The teacher then moved onto a new word. “Okay what do you know about objects? You have two minutes in your group to discuss it.” (I noticed the teacher’s attention to time on the clock, keeping the pace strong and focused – he has made specific efforts, I believe, to “tighten up” the timing on student activities in math.) Steven told groups that one person would be reporting for the group. The following list was generated and recorded on the board:

Object
Can’t always hold it.
Closed object
It has weight (it weighs at least something)
Holds up space
Can’t always see it
Something you CAN hold
A 3D shape
Different colours
Everything is an object

With this last comment the teacher opened a dictionary and talked to students about the definition of THING and how it connected to object. (There were several contradictory statements on the board and some students had great difficulty keeping their opinions to themselves. Steven reminded students of the expectations they had established for discussions the previous week.)
Nicky described what her group was discussing about nets, in that you need different shapes to make different 3D objects. She gave three examples: squares for cubes, triangles for triangle based pyramids, rectangles for rectangular based prisms.

All during this discussion, Joe was working in his learning log. One might imagine that he was off-task and doodling. In fact he was working out the definition of a net. He finally put up his hand. The teacher said: “Joe you’ve been working on something there. Tell me what you’re thinking.” Joe: “I said for net that you’ve gotta have a top and bottom. But then a square based pyramid just has triangles that join at the top – so some objects don’t actually need tops.”

Joe had approximately 10-12 drawings in his learning log. The teacher asked Joe what happened to his thinking. Joe said that he had changed his mind. Steven thanked Joe for his contribution and then suggested that students needed to go home and decide over the weekend what an object is. “On Monday, we’re going to do a ‘How To’ for working from an object to a net. You need to be able to go over to students in Mr. Fisher’s class and be sure about what you are saying. You can’t say, well it’s sorta like this and it’s sorta like that.”

The students in this class are engaging in tasks where they take a mathematical position and defend it appropriately. This is powerful mathematics! Steven is asking the students to use more sophisticated thinking and to demonstrate their conceptual understandings thoroughly in discussion and in their logs. End of class.

After class Steven and I talked about the positive flow of the math period and the ease that the kids were beginning to demonstrate in working through ideas to come up with their own understandings. I do think that Steven’s attention to timing is very important and helps the flow tremendously. He also seemed very relaxed with the kind of wrestling students were doing and moved them along from idea to idea artfully. There was a significant shift in flow and sophistication of thinking from the previous visit a week and a half ago. (Cathy, Field notes, Nov. 3, 2000)

In addition to site observations and teacher-researcher journal entries, student learning log entries have been assessed by the teacher-researchers and have been examined for evidence of improvement based on the rubric generated by the teacher-researchers. This rubric was designed using grounded theory approach (see Appendix H).
Rubric Generation and Use
In the goal setting meetings of the fall (September 2000), Donna and Steven articulated some general ideas about what they thought they would see in the student learning logs. The first rubric was drafted in September to clarify our thinking and to reflect initial ideas of what we might see in the logs. Then students and teachers tried experimenting with the use of learning logs. The students wrote about their feelings about mathematics, past experiences, and how they used math outside of ‘math time’. They were encouraged to use examples, and to describe how they learned certain concepts in math. In mid-October, Donna, Steven and I met together to review the student learning logs to identify common themes and observations. We used an approach based on Grounded Theory: We generated a second rubric grounded in what was observed in the student learning logs. This was a phase of consolidation of ideas and vision building for the teacher-researchers. The ‘grounded rubric‘ was used from this point forward to assess student communication in their learning log entries. In November, the teachers negotiated a parallel rubric with the students that reflected key elements of the grounded rubric. The teacher-researchers wanted to develop a shared vision with the students of what the learning logs would/could include. Thus, the third rubric was negotiated, this time, with students in the respective classrooms. These two new student negotiated rubrics were not the same for Grade 4 and Grade 6. They were specific to the students involved with their respective teachers and reflected the negotiation process that occurred in those classrooms. The students used the student negotiated rubric for further self assessment. The teacher-researchers used the grounded rubric to score sample log entries and to measure the quality of student communication in mathematics for this study.

The chart on the following four pages summarizes the teacher-researcher interventions through action research in the classrooms, and the resulting evidence of improved student communication in the learning logs. The data sources for this chart are site observations and field notes (for data on teacher-
researcher Intervention) and the student learning logs (for data on student written communication). The logs were sorted by grade into three piles: Higher level achievement, middle level achievement and lower level achievement. From each of these six piles (three for Grade 4 and three for Grade 6), logs were randomly selected, reviewed, and photographed. The log entries were examined by month for length of entries and against criteria found in the grounded rubric.
### Summary of Teacher-Researcher Intervention During Key Months of Action Research and Resulting Evidence of Student Improvement

<table>
<thead>
<tr>
<th>Month</th>
<th>Teacher Researcher Intervention Based on Collaborative Action Research</th>
<th>Characteristics of Student Written Communication in Learning Logs</th>
</tr>
</thead>
</table>
| **September 2000** | 1. Goal setting for math programs with Donna (designing rich math centre tasks and using learning logs – Sept. 19) and Steven (building a community of learners and using learning logs – Aug. 31) to foster student communication in mathematics | Description:  
- General descriptions with some use of math terms  
Connections:  
- Limited connections to past experiences (such as references to playing a sport or getting gas, but no explanations as to how the experiences connected specifically to math concepts)  
- No connections to other math concepts  
Style/Representation:  
- All cases: prose used  
- No other forms of representation found  
Feelings and Attitudes:  
- Limited descriptions of liking and/or hating math (e.g. "I dislike math because it is not fun." – Student B Sample 1 – Grade 6)  
Typical length:  
Grade 4: 1-4 sentences (1/4 page)  
Grade 6: 1-6 sentences (1/4 page – ½ page) |
<p>|            | 2. Introduction of learning logs to students. A listing of beginning log entry prompts was shared with the teachers from which they selected some for use with students. |
|            | 3. Classroom observations by researcher (baseline data about the classroom and its early activity)                                    |
|            | 4. Draft rubric generated based on criteria discussed in goal setting meetings. Rubric reviewed by teacher-researchers             |</p>
<table>
<thead>
<tr>
<th>Month</th>
<th>Teacher Researcher Intervention Based on Collaborative Action Research</th>
<th>Characteristics of Student Written Communication in Learning Logs</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2000</td>
<td>1. Teacher-researcher rubric generation using grounded theory (grounded in student log samples and categories being drawn from the data) for scoring the student learning logs (Oct. 13)</td>
<td>Description:</td>
</tr>
<tr>
<td></td>
<td>2. Half day meeting of the teacher-researchers to examine student learning logs and discuss progress of the study (Oct. 13)</td>
<td>• Descriptions use math terms such as perimeter, area, length, width, 3D object in context</td>
</tr>
<tr>
<td></td>
<td>3. Classroom visits (6 site visits) with follow-up discussions and notes</td>
<td>• Use of notation such as cm, units, m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Limited procedures described (Student C – Sample 2 – Grade 6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connections:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Some connections to past experiences (such as how the student might use perimeter when shingling a roof on a house – Student F – Sample 1 – Grade 4 or making sure the sides of a house were equal in size – Student E – Sample 1 – Grade 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Some connections to other math concepts (such as the relationship between perimeter and area – Student F – Sample 2 – Grade 6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Style/Representation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Combination of prose and point form notes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Limited use of charts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Displays of calculations and simple diagrams (such as a rectangle with measurements along each side)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feelings and Attitudes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Some descriptions of liking and/or not like math with explanations (e.g. “I enjoyed it because I am good at it. I learned a lot about perimeter and area and measuring with different symbols.” (Student F Sample 1 – Grade 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use of terms such as “my understanding” (Student B – Sample 2 – Grade 6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typical Length:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade 4: ¼ page – 1 page</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade 6: ½ page – 2 pages</td>
</tr>
<tr>
<td>Month</td>
<td>Teacher Researcher Intervention Based on Collaborative Action Research</td>
<td>Characteristics of Student Written Communication in Learning Logs</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| November 2000       | 1. Teacher-researcher meeting to discuss possible presentation to staff and progress of the study (full day – Nov. 10) | **Description:**  
- Descriptions use math terms such as net, geoboards, polygons, angles, geometry, square based pyramid, triangular based pyramid, etc. in context  
- Procedures described with some detail (St B – Sample 2 – Gr 4 “Then we made shapes out of toothpicks and marshmelos”)  

2. Teacher-student negotiated rubrics generated in classes (Donna – Oct. 31 & Nov. 3, Steven – November 28) | **Connections:**  
- Specific connections to personal experiences (“My room is a square…my lamp is a cilender” – St C – Sample 2, Gr 4; – St E – Sample 1, Gr 4)  
- Some connections to other math concepts (such as the relationship between shapes and solids – Student E – Sample 2 – Grade 4)  

3. Use of the student-teacher negotiated rubric for student and teacher assessment of student learning log entries | **Style/Representation:**  
- Combination of prose and point form notes  
- Purposeful use of diagrams to further illustrate mathematical ideas (e.g. St F – Sample 2, Gr. 4: illustrates types of angles using image of a protractor)  

4. Classroom visits (8 site visits) with follow-up discussions and notes. Subtle shifts in teacher foci to class discussions, group work and flow/order of lessons | **Feelings and Attitudes:**  
- Some descriptions of liking math with explanations (e.g. “It was real fun to be a leader.” (St C - Sample 2, Gr. 4)  
- Clear descriptions of learning (e.g. “…This year I have learned a whole lot more, such as circle graphs, and folding and unfolding a net into a 3D object” -St C - Sample 3 – Gr. 6, and St. F- 3, Gr. 6)  

**Typical Length:**  
Grade 4: 1 page – 2 pages  
Grade 6: ½ page – 2 pages |
<table>
<thead>
<tr>
<th>Month</th>
<th>Teacher Researcher Intervention Based on Collaborative Action Research</th>
<th>Characteristics of Student Written Communication in Learning Logs</th>
</tr>
</thead>
</table>
| Late November and early December 2000 | 1. Whole staff meeting presentation (Dec. 5) about the study (as well as preparation and debriefing)  
2. Continued use of the student-teacher negotiated rubric for student and teacher assessment of student learning log entries  
3. Classroom visits (2 site visits) with follow-up discussions and notes. Continued refinement of group work and discussions in classrooms | Description:  
- Descriptions use appropriate math terms and explanations (e.g. "The wax paper will not fit on the table because 12 025 cm² is the area of the table and the wax paper is only 9600 cm².")  
- Procedures described with significant detail including steps used to solve problems (e.g. St - A Sample 4, Gr 6)  
Connections:  
- Specific and detailed connections to personal experiences (e.g. St A – Sample 3, Gr 4; St B – Sample 3, Gr 4)  
- Consistent connections to other math concepts (such as the relationship between multiplication and division) with examples and full explanations  
Style/Representation:  
- Combination of prose, point form notes, drawings, charts  
- Purposeful use of diagrams to further illustrate mathematical ideas (e.g. Image of scale to illustrate weight – Gr. 4; dimensions of a solid and calculations of surface area – St D - Sample 4, Gr. 6)  
Feelings and Attitudes:  
- Positive attitudes toward math: "I think I am getting better at Patterning" – St. B – Sample 3, Gr. 4)  
- Self assessments of ways to improve included in summaries (e.g. "...If I could do something differently, I would probably work more with my group Something the same that I might do is inspect the sheet thoroughly" -St E - Sample 4, Gr. 6)  
Typical Length:  
Grade 4: 1 - 1½ pages  
Grade 6: 1 ½ - 2 pages |
Further Analysis

The student learning log entries, as analyzed, indicate that the students communicated in simple terms, without detail in the initial stages of the study. As the teacher-researcher interventions began to be implemented, the learning log entries grew more complex and more detailed amongst lower, middle and higher level achieving students. Rather than providing a simple statement such as "I like math when we did the activities." (Grade 4, lower achieving level, Oct. 11, 2000), more elaborate explanations were provided such as "My favorite center was solid models because we got to learn about udges and we got to pick a partner. Then we made shapes out of tooth picks and masmelos. There is so many shapes that we don't relize...." (Grade 4, same student, Nov. 17, 2000). The length of entries began to stabilize to approximately 1 – 2 pages on average by the third month of action research intervention. Samples of log entries are included in Appendix J of this thesis as evidence of student communication in their logs between September and December. These samples represent typical entries for the four months with indications of levels (high, middle or low achieving students) for each sample.

As students negotiated the learning log rubric with their teachers and used it as a self-assessment tool, the log entries became more refined and focused on those items described in the rubrics (such as the inclusion of charts, diagrams and drawings, as well as supported opinions). In negotiating the criteria explicitly with students, the students were then able to meet the criteria of a quality log entry. The following discussion, recorded by Donna in Grade 4, highlights the importance of making the assessment open and honest for best student results:

I think students have a much clearer understanding of what our expectations are for the learning log entries. Suzie had an interesting comment. She said 'I never knew you wanted us to use more than words!' Now she knows!! Some students seemed surprised that it was okay to draw diagrams and pictures.

(Donna, Nov. 3, 2000)
Students began to include diagrams and charts to illustrate their mathematical ideas in the months of October and November. Students added drawings that, in some cases, did not further their communication of ideas. In many cases, however, diagrams were extremely effective in illustrating concepts and furthering ideas, particularly for students of middle and higher achieving levels. For example, in determining the surface area of a rectangular prism (to determine how much wrapping paper will be needed to cover a box), an average level achieving student in Grade 6 drew a diagram with measurements first, and then performed calculations and explained the steps used. This same student stated in an excerpt from an entry on November 28, 2000: "Math is a tool I use to help me find things out, like the size of my room."

Students regularly remarked on their enjoyment of the math programs. One Grade 6 student described his perceptions of mathematics class: "So far math in Grade 6 is great! I though it would be hard and boring but no way! I love how Mr. L teaches math. Because he uses lots of examples. And lets us students explain our ideas." (male, middle achieving level, October 4, 2000). This excerpt was similar in tone and attitude to most entries in both the Grade 4 and 6 learning logs. For example another Grade 6 student wrote: "This year its fun, exciting and interesting. Were always working in groups, whether it's working in a group of six or a group of twenty-six. WE each get to say what are our understandings or what we would like to do to improve in math." (female, lower achieving level, November 28, 2000). Site observations match the student declarations of enjoying math. During site visits, students were consistently eager to participate in math activities in both classrooms.
Chapter 5. Conclusion and Implications

Although the collaborative action research literature is rich with descriptions of outcomes of teacher-researcher activity, this study is distinct in four ways. First, the use of mathematics as the vehicle for collaborative action research is an area with very limited documentation. This study provides additional volume to that body of research. Second, this study does not follow the typical case study methodology but instead applies a grounded theory approach which is not regularly associated with action research studies. Third, although I was acting as the research initiator of the study, I am not a university researcher, I am a teacher who had the opportunity to learn how to conduct action research. Fourth, the development of a model based on the collaborative action research of this study demonstrates how the experiential and concrete practicalities of conducting collaborative action research in a school setting occurred and identifies key characteristics of creating a teacher-researcher community. Contrary to most published studies, this model also identifies problematic areas beyond logistics and financial support that were experienced in creating a teacher-researcher community of practice.

The theoretical model of creating a teacher-researcher community was constructed through qualitative data analysis, and grounded in the classroom activities of the teacher-researchers. The lived experiences of the triad in this study forms the basis for the theory. In this sense, the findings may not be generalizable to other teacher-researcher groups. Nonetheless, the categories found in this study are common to a small number of other studies that were similar in nature. For example, Edwards and Hensien (1999) found three main variables that were critical in promoting successful mathematics instructional change: collaboration and support; a non-threatening context within which to examine beliefs; and, regular opportunities to reflect on practice. These same themes were identified in this study and proved critical in promoting successful change for all three teacher-researchers.
The findings in this study go beyond descriptions of professional knowledge landscape as developed by Connelly and Clandinin (1995). The results match more closely to the socio-cultural model that Wenger (1998) proposes for learning, making meaning, and finding identity in a community of practice.

There are several key insights that can be gathered from this study which require further elaboration. In addition, some discussion of the possible implications for practitioners will be addressed.

**Key Insights**

Three key insights have presented themselves in connection to this study.

1. The powerful level of learning and professional growth experienced by the teacher-researchers was unanticipated but welcomed.
2. The re-defining of self and one's identity within a small community of practice was a complex and challenging process.
3. There were a number of hurdles, or opposing forces, which threatened the caliber of the relationships and the learning among the teacher-researchers themselves, and between the small community of teacher-researchers and members of the larger school community.

It occurs to me that these three insights also overlap onto the model that emerged from the study, reflecting the three main sections of that model.

1. Unanticipated depth of reflection leading to professional growth:

The present study is congruent with findings by Newman (1998), Hubbard and Power (1999), and Wiesenfeld (2000). During collaborative action research, the activity of sharing knowledge, reflecting and acting, and deriving learning from it becomes a transformational experience of powerful learning and professional growth. Consistently, the teacher-researcher journal entries, interviews, and triad meetings highlight this reflective questioning stance that then led to:
- the learning of new strategies to enhance student communication in mathematics,
- the use of new instructional practices which approach reformist principles,
- the learning about action research and its cycles, surprises and rhythms
- the learning about ourselves as teachers and researchers both separately and together as a team

The professional learning was a constant for all three teacher-researchers. Wenger’s diagram (Figure 1), which places learning at the centre of the model, frames the activity of professional growth within four dimensions: learning as doing (through practice), learning as experience (in making meaning through the experiences), learning as becoming (finding and re-defining one’s identity) and learning as belonging (finding a sense of one's place in the community). These dimensions were all components of the learning and professional growth of this study and support a socio-cultural perspective as defined by Wenger.

2. Identity within a community of practice:
For Donna, Steven and I, the process of redefining ourselves within the context of the study and subsequently identifying multiple roles and layers of selves was a complex and revealing process. In order to begin to establish a community of practice as teacher-researchers, we first had to build trusting and caring relationships. We built that trust and caring through sharing journal entries with one another, through sharing our fears with one another and through being supportive of one another. In building trust, we established ourselves within the study as learners who were taking risks to try new things such as conducting action research, using centres in math, and moving to student-directed programs. Through our risk-taking, the multiple roles and layers of our identities became more obvious. We could have chosen to ignore this multi-layered dimension of our work together, but instead we chose to pay attention to the complexities of redefining ourselves as teachers, researchers, friends, colleagues, people. In re-shaping our selves, we were able to learn about one another and established a small caring community of teacher-researchers.
3. Facing the problems that presented themselves to the teacher-researchers:
Of surprise to us all, were the opposing forces that we faced during the study. The three main problems were inner fear, issues of presupposed power and negotiating power, and reactions from the larger school community. These problems were discussed and recorded by the teacher-researchers throughout the period of the study, but were not grouped into headings as such until the data analysis stage. One explanation for the fact that these sources of tension took us by surprise may be that they are not well documented in the literature. Boostrom (et. al., 1993) addressed sources of tension within a particular collaborative research project. The findings of that three year study highlight the problems of whether “researchers and practitioners can first admit and then see beyond their insecurity [facing inner fears], their self-satisfaction [issues of power and letting go of personal agendas], and their mutual mistrust [the need to create caring relationships].” (p. 42)

One study addressed issues of power in detail (Hayes and Kelley, 2000) and matched the findings of my study in regards to the initial presupposed power structure that was inadvertently established based on assumed expertise of the researcher. In that study, however, the researchers continued to face tensions related to assumed positions of power throughout the period of activity. In this study, the power shifted and became a negotiated, shared commodity.

Several studies have addressed the sense of aloneness that teachers can experience when working in isolation. However, our own surprise to the reactions of other colleagues in the larger school community could have been anticipated by recalling the literature on school change. In articulating the sources of tension that surfaced during the study, I am acknowledging some of the ‘messier’ aspects of teacher-researcher relationships: Were we not focused on learning how to be more effective, we would not have had to articulate our own fears nor attempt to overcome those fears; Were we not attempting to work collaboratively, we would not have had to negotiate power in our relationships; Had our small
teacher-researcher community not been strong and effective, we would not have received both positive and negative reactions from members of the larger school community. Paradoxically, the success of our triad required overcoming, or at least managing, the difficult sources of tension in order to fully mature into a collaborative action research partnership of learners, teachers, and researchers.

Implications for practitioners
This study confirms findings from previous studies highlighting the value of collaborative action research as a positive strategy for improving student communication in mathematics and teacher professional learning. The effects of participating in this collaborative action research study enhanced reflective decision-making and action by the teachers resulting in instructional practices that better match reform principles for teaching mathematics. Over the period of the study, the relationships of the teacher-researchers strengthened and allowed us all to take risks and try new strategies in a supportive and trusting environment. Thus, this study also supports a process of establishing small communities of practice among teacher-researchers in order to promote effective change.

As is often the case in qualitative research studies, the results of this analysis are unique to this particular researcher, the teachers and the context of our work. The specific circumstances of this collaborative action research study that led to the established model may not be replicated in other situations. However, the body of literature that concurs with the findings of this study make the Model for Collaborative Action Research Among Teacher-Researchers (Figure 2) worthy of consideration as a comparative tool to other studies. The three broad dimensions of the model: Reflection leading to professional growth; Establishing a community of practice; and, Problematics of membership in a teacher-researcher community, are consistent with the literature and are general enough that they can provide a framework for analyzing other collaborative action research partnerships in the future.
As a practicing teacher and former consultant at a district level, this study has provided me with a framework for further work in continuing my own professional growth. In addition, I believe this model of collaborative action research could be facilitated at a district level, where partnerships are organized between University-based researchers, trained consultants and teachers. Large-scale, short-term professional development workshops are questionable in terms of sustainable shifts in practice, and in terms of meeting the specific needs of teachers. When teachers engage in collaborative action research, their specific needs can be addressed directly, and they receive the support of other trained researchers in reflection-on-action and making shifts in practice over extended periods of time. It would be enormously beneficial to establish this type of a program at the district level in order to meet the ever-changing demands of the teaching profession. It may be a more costly model, but I believe it would be highly effective and over time, more cost efficient as teachers begin to become practiced teacher-researchers on an on-going sustained basis.

Some of the recommendations that I believe would make collaborative action research partnerships more effective in the school and district setting are:

1. Seek partnerships within the immediate setting of the teacher-researchers. That is, bring the research dynamic directly into the school.

2. Be prepared to ‘dig deep’ and face personal fears. If the partners can do this, they will reap the rewards of redefining themselves, gaining confidence in their abilities, and truly addressing issues that may impede exemplary practice.

3. Find ways to address sources of tension and opposition. In identifying and addressing problems faced during the research, the full potential of the work and dynamics may be more attainable.

4. Start small. Choose one small area of focus and allow it to unfold on its own.

5. Be prepared for surprises and challenges, and feelings of being overwhelmed. This is when the research truly begins!
In closing I am drawn back to a journal entry from November 2000. I believe it summarizes the essence of this study and its powerful impact for both myself and my teacher-researcher partners:

What is beauty?
When you move beyond the obvious thing of beauty that is occupying most of the space in the foreground, and then look further beyond to find something unbelievably more beautiful, incredibly precious.

That's what this is about. The obvious thing of beauty is the incredible, subtle and not-so-subtle shifts in math programming for Donna and Steven. Further in the landscape, beyond the obvious, across a bridge, is a precious learning about ourselves as professionals and as people. This is difficult to even see through the fog, but it's there. It is thick and beautiful. (Cathy, Nov. 6, 2000)
References


Cathy Bruce, MA Thesis - References 5
Appendices

A. Chart of Data Sources and Chronicle of Events

B. Teacher Interview Questions (Feb. 2000, Feb. 2001)

C. Grouping of Data Sources

D. Axial Coding Summary

E. Flow – Lesson Structure Generated by Steven Centres Booklet – Sample Tasks and Tracker by Donna

F. McNiff’s Action Research Cycle

G. Proposal for Staff Presentation

H. Grounded Rubric for Student Learning Logs

I. Student Learning Log Samples
### Appendix A. Chronicle of Events and Data Collection

<table>
<thead>
<tr>
<th>Type of Contact and Date</th>
<th>Nature of Activity</th>
<th>Data Collection</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Junior Division Staff:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 17, 2000</td>
<td>Discussion on &quot;what makes a rich task?&quot;</td>
<td>Field notes</td>
<td>* To develop a common understanding amongst teachers of what constitutes a rich task</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* To introduce myself to staff</td>
</tr>
<tr>
<td>February 4, 2000</td>
<td>Discussion on &quot;key components of a quality math program&quot;</td>
<td>Field notes</td>
<td>* To develop a common understanding amongst teachers of what constitutes a rich math program</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* Staff development opportunity</td>
</tr>
<tr>
<td>December 5, 2000</td>
<td>Whole staff (primary and junior) to explain the progress of the project to staff members</td>
<td>Audio tape and transcription</td>
<td>* To de-mystify the project</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* To inform staff of the progress of the project and the action research cycle involved</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* Transcription provided additional opportunity to look for common themes where the teachers were describing their work</td>
</tr>
<tr>
<td>Type of Contact and Date</td>
<td>Nature of Activity</td>
<td>Data Collection</td>
<td>Purpose</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Teacher Interviews:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 7, 2000</td>
<td>Interview with Donna</td>
<td>Audio tape and transcription in all contacts of this nature</td>
<td><em>To gather data from the teachers about their perceptions of their programs and their goals</em></td>
</tr>
<tr>
<td>March 20, 2000</td>
<td>Interview with Steven</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 31, 2000</td>
<td>Goal setting with Steven</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 19, 2000</td>
<td>Goal setting with Donna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 1, 2001</td>
<td>Final interview with Donna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 1, 2001</td>
<td>Final interview with Steven</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Student Interviews:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 18, 2000</td>
<td>Focused group interviews with four groups of students (two groups from Grade 4, two groups from Grade 6)</td>
<td>Audio tape and transcription in all contacts of this nature</td>
<td><em>To gather data from the students about their perceptions of their programs and communication in mathematics</em></td>
</tr>
<tr>
<td>December 14, 2000</td>
<td>Focused group interviews with Grade 4 students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December 15, 2000</td>
<td>Focused group interviews with Grade 6 students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Contact and Date</td>
<td>Nature of Activity</td>
<td>Data Collection</td>
<td>Purpose</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Classroom Observations:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept. 26 – Dec. 15, 2000</td>
<td>Grade 6: 10 visits</td>
<td>Recorded as field notes in Microsoft Word.</td>
<td>* To gather data as a third party about student activity and about teacher activity in the mathematics programs with a focus on communication in mathematics, scope and nature of student tasks, discourse related to developing a mathematical community</td>
</tr>
<tr>
<td>Sept. 29 – Dec. 14, 2000</td>
<td>Grade 4: 7 visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Log Samples:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September November January April</td>
<td>All logs available for review (excluding those of students did not have permission to participate in the project).</td>
<td>Sample of logs photographed and annotated (selected random sample – one above average male and female, average male and female, below average male and female for each of the two grades)</td>
<td>* To measure student improvement or lack thereof in mathematical communication from September through to December and then informally from January through April</td>
</tr>
<tr>
<td>Type of Contact and Date</td>
<td>Nature of Activity</td>
<td>Data Collection</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Additional Meetings:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 5, 2000</td>
<td>Donna and Cathy: how to plan center tasks</td>
<td>Notes and copies of</td>
<td>* To develop a model of how to develop tasks using a centers approach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tasks developed</td>
<td>* To establish a collaborative working relationship with Donna</td>
</tr>
<tr>
<td>October 13, 2000</td>
<td>Donna, Steven and Cathy: review action research cycle, look at student learning logs, revise rubric, talk about personal professional learning</td>
<td>Taped and transcribed</td>
<td>* To gather data about student communication in mathematics over the first short period of the project (baseline data of student learning logs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* To address issues of roles in the triad, issues of multiple levels of involvement with one another and in the project</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* To construct a rubric grounded in student work (Strauss &amp; Corbin, 1990)</td>
</tr>
<tr>
<td>November 10, 2000</td>
<td>Donna, Steven, Cathy: lunch meeting to discuss progress of project and plan forward</td>
<td>Field notes</td>
<td>* To plan forward into the following months through to end of December</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 9, 2001</td>
<td>Donna, Steven, Cathy: score student learning logs with grounded rubric</td>
<td>Field notes</td>
<td>* To score independently, then share scores (inter-rater reliability) and examine progress in the student learning logs using the grounded rubric</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 27, 2001</td>
<td>Donna, Steven, Cathy: discuss perceptions of self and other during the study, plan forward for next year regarding implementation of math portfolios across the division</td>
<td>Written comments about perceptions of self and other from each member brought</td>
<td>* To explore perceptions of self and other throughout the study in a reflective manner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* To plan ahead for future interventions in mathematics programs throughout the junior division</td>
</tr>
<tr>
<td>Type of Contact and Date</td>
<td>Nature of Activity</td>
<td>Data Collection</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Teacher-Researcher Journals:  | Teachers and researcher all kept journals about their own learning and discoveries and difficulties. The journals were shared electronically and in paper | All 3 sets of journals on Microsoft Word - dated    | * To record the personal professional learning of the three teacher-researchers.  
* To analyse texts for common emerging themes (Grounded Theory – Strauss and Corbin, 1990; Creswell, 1998) |
Appendix B. Teacher Interview Questions – February 2000

Teacher Interview Guide

The purpose of the interview is for us to understand your math program, how you fostering communication in mathematics, as well as incorporate math software in your classroom. You have been chosen (through a voluntary process combined with recommendations from superiors and colleagues) as someone who is using progressive teaching strategies in your program. This information is being collected to support a graduate studies masters research project. The conversation will be tape recorded as a backup to the interviewer’s notes. If you want to turn the tape off at any point during the interview, feel free to do so. The interview is confidential. No individuals will be identified in any reports.

Section A Questions About Teaching Math

1. Let me begin by asking you about your math program:

   a) How do you use student tasks that are complex, open-ended and embedded in real-life contexts? (Please provide examples)

   b) How do you structure your lessons to promote student discovery of mathematical ideas?

   c) How do you foster the creation of a mathematical community in your class?

   d) How do you encourage your students to use manipulatives to aid in solving math problems? What kind of manipulatives do you provide, and for what types of tasks?

   e) How do you encourage student-student interaction during math time?

   f) Describe the assessment strategies you use in math. Provide examples.

   g) How do you attempt to raise student self-confidence in mathematics?

2. Of the five strands (number sense and numeration, measurement, geometry and spatial sense, patterning and algebra, and data management and probability), which two do you find the most challenging? Provide specific examples of how you dealt with these challenges.

   a) Example(s) for first strand
b) Example(s) for second strand

3. Do you find it difficult to address all five strands in each report card period? How do you accomplish this?

Section B  Communication in Mathematics

4. The district has identified communication and geometry and spatial sense as the priorities for math during this school year.

   a) How do you encourage students to communicate in mathematics?

   b) Could you please describe an instance when you felt that your use of communication in your math program was successful? Why was it successful?

      Do you think you could repeat this in the future? How?

   c) Could you please describe an instance when you felt your use of communication in your math program was not particularly successful? Why was it unsuccessful? What would you do differently if you were to try it again?

   d) How do you encourage group work and why?

   e) How have you addressed the strand of Geometry and Spatial Sense?

   f) What kinds of real life connections did you and your students make in terms of Geometry and Spatial Sense?

   g) What do you find difficult to teach in the area of Geometry and Spatial Sense? Why?
Section C Questions About Teaching Math Using Computers

5. I would now like to ask you about your use of computer software in your mathematics program.
   a) How do you usually use computers in your mathematics program? (Provide examples)
   b) What software do you use most in your math program?

6. I want you to think of a specific time when you felt that your use of computers in your math program was very successful.
   a) Describe what you did.
   b) How did you define success? (What evidence of success did you see?)
   c) Why was this activity successful? What factors contributed to the success of this activity?
   d) Do you think you could repeat this success in the future?

7. I want you to think of a specific time when you felt that your use of computers in your math program was not particularly successful.
   a) Describe what you did.
   b) How did you define lack of success? (What evidence of lack of success did you see?)
   c) Why was this activity unsuccessful? What factors contributed to the lack of success?
   d) What would you do differently if you tried a similar activity in the future?

Section D Further Comments about Mathematics

8. Is there anything else that you would like to share that was not addressed during the interview?
Appendix B. Teacher Interview Questions – February 2001

Teacher Interview Guide

The purpose of the interview is for us to understand your math program, how you fostering communication in mathematics, as well as incorporate math software in your classroom. You have been chosen (through a voluntary process combined with recommendations from superiors and colleagues) as someone who is using progressive teaching strategies in your program. This information is being collected to support a graduate studies masters research project. The conversation will be tape recorded as a backup to the interviewer’s notes. If you want to turn the tape off at any point during the interview, feel free to do so. The interview is confidential. No individuals will be identified in any reports.

Section A Questions About Teaching Math

1. Let me begin by asking you about your math program:

   a) How do you use student tasks that are complex, open-ended and embedded in real-life contexts? (Please provide examples)

   b) How do you structure your lessons to promote student discovery of mathematical ideas?

   c) How do you foster the creation of a mathematical community in your class?

   d) How do you encourage your students to use manipulatives to aid in solving math problems? What kind of manipulatives do you provide, and for what types of tasks?

   e) How do you encourage student-student interaction during math time?

   f) Describe the assessment strategies you use in math? Provide examples.

   g) How do you attempt to raise student self-confidence in mathematics?

2. Of the five strands (number sense and numeration, measurement, geometry and spatial sense, patterning and algebra, and data management and probability), which two do you find the most challenging? Provide specific examples of how you dealt with these challenges.

   a) Example(s) for first strand

   b) Example(s) for second strand
3. Do you find it difficult to cover all five strands in each report card period? How do you accomplish this?

Section B Communication in Mathematics

4. 
   a) How do you encourage students to communicate in mathematics?

   b) Could you please describe an instance when you felt that your use of communication in your math program was successful? Why was it successful?

   c) Do you think you could repeat this in the future? How?

   d) Could you please describe an instance when you felt your use of communication in your math program was not particularly successful? Why was it unsuccessful? What would you do differently if you were to try it again?

   e) How do you encourage group work and why?

   f) Describe how you feel your use of learning logs in the classroom has helped students.

   g) Tell me about the professional learning that you have experienced since September of this school year.

Section C Further Comments about Mathematics

5. Is there anything else that you would like to share that was not covered during the interview?
Appendix C: Grouping of Data Sources and Process of Analysis

Teacher-Researcher Community of Practice:

Open Coding Data Sources:

Source 1. Teacher Interviews (two interviews for each teacher)
Source 2. Teacher-Researcher Journal Entries (each analyzed discreetly as sub-sources)
Source 3. Staff Presentation and Group 'Triad' Meetings

Axial Coding Data Sets (by category):

Set 1: Across Sources 1, 2, 3 (to determine common themes and anomalies)

Selective Coding Data Sets (matrix of overarching themes and categories)

Set 1: Sources 1, 2, 3 (viewed together as a body of data)

Student Communication in Mathematics:

Source 4. Site visits (for corroboration of the impact of teacher-researcher interventions impacting on teacher practice and student learning)

Source 5. Student learning log entries (viewed by month over the four critical months of September through December)
- Grade 4 and Grade 6 logs viewed discreetly
- Logs sorted into three groups (higher level achieving students, middle level achieving students, lower level achieving students)
- Student learning logs were then randomly selected from each pile for further analysis, photographing and photocopying
- Log entries analyzed by month against the ground rubric generated by the teacher-researchers
Appendix D. Axial Coding Summary: For Data Sets 1, 2, and 3 of Teacher-Researcher Community of Practice

### Reflection → Professional Growth

**Self Observation/Reflection:**
1. Teacher interviews
   - “I need to/want to” (23x)
2. Triad Mtgs
   - “self as learner” (6x)
3. Cathy’s Journal (Oct. 13, 14, 17, Nov. 6 x2, Oct. 10 chart)
4. Donna’s Journal (Sept 29, Nov. 3, 10)
5. Steven’s Journal (Nov. 8 x2, Mar. 24, Apr. 3, Apr. 25 x 2)

**Professional Learning:**
1. Teacher interviews (9 examples)
2. Cathy’s Journal (Oct. 14)

**Questioning Stance:**
1. Donna’s Journal (Dec. 4, Apr. 21)
2. Cathy’s Journal (note to Donna re: questor)

### Communities of Practice

#### Building a Community:

**A. General**
1. Donna’s Journal (April 21 x2)
2. Steven’s Journal (Oct. 20, Oct. 25, Mar. 24, Apr. x2)

**B. Trust, Caring, and Support in the community:**
1. Triad Mtgs (“Support” 6x)
2. Cathy’s Journal (Nov. 3 x2, 8 x3, 28, Dec. 4 x3)
3. Donna’s Journal (Nov. 3, Dec. 4, April 21 x2)

**C. Risk Taking / Fear:**
1. Triad Mtgs. (“Risk” 7x)
2. Cathy’s Journal (Sept. 2x, Oct. x2, Nov. 2, 8)
3. Donna’s Journal (Ap. 21 x 2)

**D. Identities / Shifting Roles / Layers of Roles**
1. Triad Mtgs (“layers, complexity, parallel” 11x)
2. Cathy’s Journal (Sept 29, Oct. 10, 13, 14)
3. Steven’s Journal (Oct. 20)

#### Community within a Community:

1. Donna’s Journal (Nov. 3)
2. Cathy’s Journal (Nov. 3)

#### Expanding the Community:

1. Donna’s Journal (Nov. 3)
2. Cathy’s Journal (Nov. 3)

### Images

**Water / Rivers:** (illustrates Power Shifts)
1. Cathy’s Journal (Nov. 15 x3, Dec. 4)
2. Steven’s Journal (Nov. 18 x3, Dec. 4)

**Math as a Building:** (Illustrates Prof. Growth)
1. Donna’s Journal (Dec. 4 x3)
2. Steven’s Journal (Oct. 3 x2)

**Cliff Image:** (illustrates Risk and Fear)
1. Triad Mtg (1 case)
2. Unshared image by Cathy (Sept. 1999)

**Wheels/Circles:** (Illustrates Professional Growth)
1. Triad Mtgs (2 cases)

**Bridgework:** (Illustrates Identity of Self and self related to other)
1. Cathy’s Journal (Oct. 13, 14, Nov. 6, 22)
2. Steven’s Journal (Nov. 8 x2)

### Sources of Tension

**Power Shift:**
1. Donna’s Journal (Oct. 31)
2. Steven’s Journal (Mar. 29)
3. Cathy’s Journal (Nov. 22)

**Presence and Silence:**
1. Triad Mtg (1 case)
2. Steven’s Journal (Nov. 8)
3. Cathy’s Journal (Nov. 22)
Appendix E.

“Flow” – generated by Steven to illustrate the flow of a lesson

Task Booklet – generated by Donna for a series of centre tasks
The concept is introduced and elaborated through a whole-group discussion or improvisation initiated with a key-word or phrase.

The phrase:
- represents a bridge between previous and current learning.
- is ambiguous enough to prompt a range of responses but specific enough to 'open up' the topic. e.g., when introducing transformational geometry I used the phrase "shapes move".
- is central to the learning and utilizes language that is grounded in the vernacular of the classroom.
- represents both a point of departure and a place to return to.

The knowledge web is a graphic representation of the collective knowledge of the students prior to any formal instruction or application. It can be arrived at through either a whole-group discussion, or through simultaneous small-group discussions from which a collective understanding can be assembled by gathering together each group’s knowledge on chart-paper and then bringing together common and uncommon points on the board or in a similarly prominent location.

The context is arrived at through the amplification of relevant features of the knowledge web or through prompting. This can include an example present in the room, an occupation in which the knowledge might be applied, an experience that a student may have had, or a link to other learning.

Context:
- bridges the real-world of the students experience with the abstracted world of their learning.
- places their present knowledge and the learning that is about to take place in a real-world context.
- grounds their experiencing of abstracted, conjectural, and applied information in something relevant.
- serves as a referent point to contextualize future learning.

The skill-insert is the point at which the collective knowledge is addressed both as a whole and in its component parts. Text-based, this offers the opportunity to focus the student’s emerging understanding of the concept in a math-based standardized framework.

Skill includes:
- the use and application of Math terminology.
- the selection, and application of procedures, formulae, and strategies.
- the use of leveled, directed and assessable tasks.
- the opportunity to integrate manipulatives to 'open-out' the text.
**KEEPING TRACK!**

1. The Place Value Game
2. Grocery Shopping
3. Nearest

4. Expanding Numbers
5. Mystery Numbers

My favourite centre was ____________________ because ____________________


My least favourite centre was ________________ because ____________________


Are you proud of your participation and effort in these math centres? Why?


The Place Value Game

Read the game directions and play the place value game. Be sure to complete the following chart after each game.

(Whole group activity.)

<table>
<thead>
<tr>
<th>Your Number</th>
<th>&lt;</th>
<th>&gt;</th>
<th>=</th>
<th>Winning Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explain the strategy you used to try to win this game.
**Grocery Shopping**

You have $20 to spend on groceries this week. As you are shopping you want to make sure that you don't overspend. To keep track of what you are spending you will need to round your items to the nearest dollar and add these together in your head. Stop shopping when you have reached your limit. When you are finished shopping have your partner add up your purchases for you on the calculator to make sure that you didn't go over your $20 limit. Complete the chart below when finished.

(Pairs activity within your group.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Actual Cost</th>
<th>Rounded to Nearest Dollar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Spent:  
(Actual and Rounded)
**Nearest**

Read the game directions and play the game ‘Nearest’. Be sure to complete the following chart after each game.

(Whole group activity.)

<table>
<thead>
<tr>
<th>Your Number</th>
<th>Rounded to Nearest Hundred</th>
<th>Give yourself a point if you got it correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Points:

Explain when you might need to round numbers.


**Expanding Numbers**

One at a time each group member prepares a number using the place value cards. Show your group the number and read the number to them. Each member of the group completes the place value chart below for each number. When everyone is finished expand the number for your group so they can check to see if they were correct.

(Whole group activity.)

<table>
<thead>
<tr>
<th>Standard Form</th>
<th>Thousands</th>
<th>Hundreds</th>
<th>Tens</th>
<th>Ones</th>
<th>A point if correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How would you use your understanding of place value to order or compare numbers according to size?
**Mystery Numbers**

Read the game directions and play the mystery numbers game. Be sure to complete the following chart after each game.

(Whole group activity.)

<table>
<thead>
<tr>
<th>Your Number</th>
<th>Guess (Highest, Middle, Lowest)</th>
<th>Give yourself a point if you got it correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Points:

Describe how you determine that one number is larger than another number. You may use diagrams to help you explain your ideas.
Appendix F. The Action Research Cycle

1) We review our current practice.

2) We identify an aspect we want to improve.

3) We imagine a way forward.

4) We try it out.

5) We take stock of what happens.

6) We modify our plan in light of what we find out.

7) We monitor what we do.

8) We evaluate the modified action.

Framing Our Work

Adapted from:

Topic 15: Your Action Research – Background Information 15.1
Appendix G. Proposal for Staff Presentation on Action Research

For: Jim Manley, Otonabee Valley PS
Date: November 14, 2000
From: Dana Geen, Steven Leak, Cathy Bruce

As we have been conducting research together over the past six months or so, we recognize that other staff members are curious about what we are doing, and how the work is progressing. The three of us would like to offer a short presentation/update at a staff meeting in the near future.

The presentation would focus on:

- Our work **IN PROGRESS** – we have not met any final goals, but we have a plan and are working away at making small shifts in practice over time.

- The action **RESEARCH CYCLE** that we are following – something that we consider as an on-going part of a professional development plan.

- The use of **STUDENT LEARNING LOGS** as a central tenant of the work. This includes journal prompts, negotiating a rubric with the three research partners and then in turn negotiating a rubric with students. Looking at improvement in the quality of the log entries.

- Specific areas of attention for each teacher:
  - Dana - math centers
  - Steven - timing and groupings
  - Cathy - teacher support

- A clear message about the **LEARNING** stance of the group, as opposed to an **EXPERT** stance.

- Our own use of **JOURNAL ENTRIES** to document the events, our feelings about the work, and the roles we play in the research group.

We would welcome questions in an open dialogue. We would also like to support others in their efforts (using this kind of a learning/research cycle) toward continuous professional development. The presentation may provide another way for teachers to share what they are doing in their classrooms at future meetings and/or informally.
# Appendix H. Ground Rubric Generated by Teacher-Researchers

Name: __________________________  Date: __________________________

<table>
<thead>
<tr>
<th>Rubric for Learning Logs: Mathematics</th>
<th>1- Level 1</th>
<th>2- Level 2</th>
<th>3- Level 3</th>
<th>4- Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- of process and procedures</td>
<td>-Partially describes problem solving processes or lists some of the steps used.</td>
<td>-Generally describes problem solving processes to arrive at solutions and / or lists the procedures used.</td>
<td>-Clearly describes problem solving processes to arrive at solutions and / or provides details of the procedures used.</td>
<td>-Thoroughly describes problem solving processes to arrive at solutions and provides details of the procedures used with precision.</td>
</tr>
<tr>
<td>- of concepts, rules, formulas</td>
<td>-Describes concepts, rules and formulas with unclear and imprecise terms.</td>
<td>-Describes concepts, rules and formulas in simple terms.</td>
<td>-Describes concepts, rules and formulas with examples and / or convincing arguments.</td>
<td>-Effectively describes concepts, rules and formulas with examples and convincing arguments.</td>
</tr>
<tr>
<td><strong>CONNECTIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to personal relevance and other experiences</td>
<td>-Makes limited connections by reviewing past experiences and / or projecting into future experiences beyond school.</td>
<td>-Makes simple connections by reviewing past experiences and / or projecting into future experiences beyond school.</td>
<td>-Makes personal connections by reviewing past experiences and / or projecting into future experiences beyond school with detail.</td>
<td>-Makes personal detailed connections by reviewing past experiences and / or projecting into future experiences beyond school about math, learning strategies and problem solving.</td>
</tr>
<tr>
<td>- to other math</td>
<td>-Makes little or no reference to other math concepts and strands.</td>
<td>-Makes general connections between current math concepts and other math concepts and strands.</td>
<td>-Makes solid connections between current math concepts and other math concepts and strands with justification.</td>
<td>-Makes specific connections between current math concepts and other math concepts and strands with justification in order to make further meaning.</td>
</tr>
<tr>
<td><strong>STYLE / REPRESENTATION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Uses one single mode of representation (such as prose, drawings, lists, charts, point form notes or diagrams) to represent ideas incompletely.</td>
<td>-Uses a limited combination of prose, drawings, lists, charts, point form notes, diagrams to represent simple ideas with some clarity.</td>
<td>-Uses a combination of prose, drawings, lists, charts, point form notes, diagrams to effectively represent a range of ideas.</td>
<td>-Explicitly selects a combination of prose, drawings, lists, charts, point form notes, diagrams to thoroughly and precisely represent a range of complex ideas.</td>
<td></td>
</tr>
<tr>
<td><strong>FEELINGS and ATTITUDES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- about Math &amp; learning</td>
<td>-Rarely describes feelings about math and learning.</td>
<td>-Uses limited and / or general terms to express feelings about math and learning.</td>
<td>-Clearly expresses feelings about math and learning and explains enjoyment/ success or frustrations/ problems.</td>
<td>-Extensively describes feelings about math and learning where explanations show shifts over time about learning.</td>
</tr>
</tbody>
</table>

Additional Comments:
Appendix I. Samples of Typical Student Learning Log Entries

Grade 4 – Sample 1
Male, lower level achieving, September
Prompt: When do you use math outside of school?

September 27, 2000

Wen I am playing hockey and Lackrose. I aso yose math wen I am out side of the school.
I understand math by adding the Ones colons, and when I finish adding the ones collon. I add the tens collon. That’s what makes me understand math.
Grade 4 – Sample 3
Female, Higher level achieving, October
Prompt: Did you like the math centres?
October 11, 2000

I enjoyed it because I am good at it. I learned a lot about perimeter, area and measuring with different math symbols. I might use perimeter when I older and get a job. I might use area for see putting shingles on a house and see how many shingles on a house.
Grade 4 – Sample 4
Male, Lower level achieving, November
Prompt: Did you like the math centres?
November 17, 2000
The 3-D seter was
The neatest seter
I have did. It was
my faveret seter.
On 3-D nets you
would haveto pick
a box and then
labul the box like so
(see image)

My seckend favet
seter was sold sapes
some were hared to mack. Here
is an insmple done below. I
learned how to mack 3-D saps.
(see image)
Grade 4 – Sample 5
Female, Higher level achieving, November
Prompt: What was your favourite math centres?
November 17, 2000

My favourite centre was the

math because it taught me

how to measure things. I

loved it because it was fun

and exciting. I also liked the

number game because it was

very educational. I enjoyed

the fact that I could do it

by myself or with a friend.

It was a great way to

master the math concepts.

November 17, 2000
My favourite center was Measuring angles. I liked that center the best because I learned a lot more in this group than any other group because I have not heard of it. I learned that you line up the bottom of the angle at 0 degrees and the vertex at center. Where ever the tall point is that is how many degrees it is.

(see image and labels)

My least favourite center was Polygons because it was sort of like cut and paste but this was a little boring I was fun when I figured out the heptagon but the rest was way to easy. Here are some shapes.

(as per drawing)

Triangle  square  rectangle  pentagon  hexagon  heptagon  octagon

Appendix I – Sample Learning Log Entries 7
Grade 4 – Sample 6
Female, middle level achieving, December
Prompt: Open
December 7, 2000

I need think it. It’s going better
not eating when we patitions
get in get the baking
right was, "I want to
for my phone that has
yellow much blue in it.
Hidden one up air

Letters got born from the sun
now. When it was beautiful get
after school, then I had
have to know how to do.
I became that new
teaching in the. It became
person that. We teacher /
It would hence to cccce
I think I am getting better at patterning. We can use patterning if we get a job like making floors they might say "I want a pattern for my floor that has green and yellow and blue in it.

I am excited to go in groups when we helped the cat Chitters get down from the chimney. When I am older I have to now how to do math because most jobs have math in them. If I was a person that did cashier I would have to count money like this… (see image)
This is what I think Math is all about –

I like math because it's part of my life! I use it everyday. When I go to the store. Or even when I go to the cookie jar, I pulled out five cookies but I'm only allowed three. I need to know the “math”.
My understanding of a 3-D object is you can hold it. Another is if that object takes up room and one other reason is it can't take the space another object is in. So my understanding is that a 3-D object doesn't have to have a certain amount of sides.
Grade 6 – Sample 3
Male, Middle level achieving, November
Prompt: Describe what you did to solve the problem.
November 29, 2000

The problem I have to solve is how much wax paper we would need to cover the work area. Here is how I will solve this problem. I will do length times width.

Part A. The calculated area of the work Table is 12,025 cm².

1.85m

65 cm

65 cm

1.85 m

Part B. The calculated area of the wax Paper is 9,600 cm².
Answer. It will not cover the work table because the area of the work table is 12,025 cm² and the wax paper is 9,600 cm² so you would need two boxes of wax paper. I can improve my work by being neater on my drawings.

Grade 6 – Sample 4
Male, Middle level achieving, December
Prompt: Open
December 13, 2000

The relationship between lines and shapes is that a shape has at least one line to form a shape. Line can be short, long, endless, zigzagging, etc. Shapes can have from one to eight or more lines to form a shape.
A line is a straight path that continues without end.

A line segment is part of a line. It has two end points.