Children's problem-solving language: A study of grade 5 students solving mathematical problems.

by
© Ana Maria Klein
Department of Educational Studies
McGill University

A Thesis submitted to the
Faculty of Graduate Studies and Research
In Partial Fulfillment of the Requirements for the
Degree of Doctor of Philosophy in Education

August 1999

0-612-64590-8

Abstract

Children's problem-solving language: A study of grade five students solving mathematical problems

This dissertation describes the *personal problem-solving language* used by grade five students as they solve mathematical problems. Student classroom interactions were audio-taped and filmed during the course of the 1997/1998 school year. Ethnographic methods and a qualitative research approach were used for gathering, analyzing and interpreting the data. The questions that guided the study were: (1) how children solve problems and (2) what tools and symbols systems do they use. The purpose was to understand the problem-solving process better. The underlying assumptions were that: (1) most students can generate their own strategies and problem-solving theories (2) many students can solve complex mathematical problems. The findings revealed that students generate problem-solving strategies and symbol systems that resemble the tools that they chose to use and their individual learning styles. Most students needed to talk about their proceedings and often used a personalized language form and nomenclatures that were uniquely creative as place holders for the more exact terminology, which replaced the invented language. The data also captured highly creative moments when the students experienced a heightened sense of awareness and sensibility while they explored their problem spaces. It was also evident that there is a transfer from the child's personal problem-solving style, choice of tools and creative symbol systems into his unique representation of the problem's solution. This transfer supports Vygotskian notions that language mediates thought and that social interaction mediates language.

Résumé

Le langage de la résolution des problèmes: Un étude dans une classe en mathématiques au niveau d'une cinquième année de l'école primaire

Cette dissertation décrit le langage personnel de la résolution des problèmes développé par les élèves d'une cinquième année de l'école primaire lorsqu'ils travaillent dans des leçons en mathématiques. Les interactions des élèves ont étés enregistrés et filmés pendant l'année scolaire 1997/1998. Les méthodes ethnographiques et un approche qualitatif ont étés utilisés pour prendre les données et pour les analyser et interpréter. Les questions principales étaient: (1) comment font les élèves pour atteindre leur solution des problèmes et (2) quels sont les outils qu'ils utilisent pour le faire. Le propos de l'étude était de mieux comprendre se processus. Les notions principales étaient que (1) presque tous les élèves peuvent développer leurs stratégies et leurs théories et (2) beaucoup d'entre eux peuvent trouver des solutions aux problèmes complexes en mathématiques. Cet étude a aussi trouvé que les élèves créent des stratégies en utilisant des outils et des systèmes symboliques qui leurs rassemblent et qui évoquent leur style personnel d'apprendre. La plupart des élèves ont eu besoin de parler à quelqu'un au sujet de leurs stratégies et utilisaient une terminologie créative au début qui était remplacée plus tard par la terminologie plus exacte. Les donnés trouvent aussi que les élèves expriment leur créativité avec des réactions très sensibles et qu'ils explorent leurs espaces de résolution des problèmes pendant ces moments de sensibilité élevé. Il y a eu aussi l'évidence d'un transfert du style, des symboles et de la représentation très spéciale du problème sur chaque étudiant. Ce transfert met en évidence les notions de Vygotsky qui a dit que le langage et les situations sociaux influencent les actions.

Table of Contents

Prologue			1 - 9
Chapter 1	-	An Introduction	10 - 40
Chapter 2	-	A Conceptual Framework	41 - 61
Chapter 3	-	The Research Site	62 - 89
Chapter 4	-	Methodology	90 - 123
Chapter 5	-	Classroom Episodes	124 - 157
Chapter 6	-	Analysis & Interpretation	158 - 176
Chapter 7	-	Conclusion	177 - 187
Epilogue	-	A Confirmation	188 - 190
References			191 - 200
Appendices			

Acknowledgments and Dedication

To life, a most precious gift.

I wish to thank,

my family: my husband, Tito Graffe for accompanying me on this journey, my daughters, Nicole and Natasha for inspiring me, my grand-daughter Clarissa for motivating me and my son Andrés for being there for me and encouraging me, assisting me with the technology, and for teaching me so much about giftedness. Mother, thank you for bringing me to Montreal.

A very special thank you to Dr. Ann Beer, my thesis supervisor who taught me how to generate readable texts, to keep a sense of focus, and to rise again, over and over. An inspiration and a supportive role model, she and I shared countless hours discussing our thoughts, engaging in intelligent conversation, and problem-solving life's intricacies.

My elementary school director, Dr. George Takacs, who encouraged me to pursue graduate studies in Gifted Education. My hosts at St. John's School, Miss Z, grade five students, Miss B, the principal and all the members of that wonderful educational community. The members of my thesis committee: Dr. Vicki Zack, for allowing me to visit her classroom during her absence, Dr. Lynn Butler Kisber for guiding me through the entry process, Dr. Howard Riggs for his insightful advice on hands-on instruction, Dr. Mary Maguire for her caring guidance and support in devising the form and the ethnographic components of this study, Dr. Gill Rejskind for introducing me to the process of incubation and the "eureka moment" and Dr. John Gradwell for encouraging me to pursue my study, for being receptive to my thoughts and ideas and for his genuine interest in creativity and love of education.

This thesis is dedicated to all those women who dared to step out of a comfort zone to adopt new roles in their lives.

Prologue

This dissertation describes the manner in which a *problem-solving language* evolves and develops in a grade five classroom as the students solve problems in mathematics. The study is informed by my personal inquiries and concerns harbored during the past ten years of professional life. These concerns began when I was commissioned in 1989 to create an enrichment program for gifted and talented students at Escuela Campo Alegre, an international North-American school located in Caracas, Venezuela. At the time, I did not know where to begin and whether giftedness or talent were measurable. I also had serious doubts about labeling children as better or more capable than their peers.

Since I had both studied and worked at this international elementary middle school, I was very familiar with its structure. We had a very particular school culture and language-specific problems to address. My mandate was to create an auxiliary, more challenging program for capable students who were not motivated in class. I explored as many enrichment program options as I had available, and traveled to other overseas schools to observe how they, in turn, addressed theirs.

After much observation and reflection, I decided to design a program tailored to our school culture with a strong focus on student needs and interests. Critical thinking and creative problem-solving tasks would slowly be integrated into the classroom program, fostering curiosity and inquisitiveness in the children. I encouraged a "let's find out" disposition, factoring in a sense of wonder and awe. Unknowingly, I was already addressing problem number one, how to improve our existing curriculum.

Projecting a positive attitude towards problem solving was also an effective tactic because it helped portray it as a human coping mechanism, common and natural to everybody, and not to a select few gifted or talented individuals. This distinction helped me work closely with colleagues who might have otherwise resented a change in their teaching practice.

I used simple problem-solving activities in public sessions where I was asked to demonstrate the program. At the time, I staged the lighter, more entertaining aspects of my program including audience-friendly, puzzle-like games and activities. In this way, I could involve everybody, students, parents and teachers. Guided by intuition, I made decisions that I would still make today, ten years later. However, I have become more knowledgeable and continue to pursue this interest in problem-solving in mathematics even more deeply.

My 1989 mandate was not an easy task because I had to design a program that would transfer easily from different school settings, since I worked with a highly mobile school population plagued with frequent teacher and student turnovers. My first step was to focus on the learners, to find out how to motivate them, and to help them develop their problem-solving capabilities. I have always believed that every child is unique and also capable of solving many types of mathematical problems. My dilemma was how to provide these opportunities for all the students and how to assist them in uncovering their individual problem-solving potential.

What seemed simple options then were twofold: (1) providing classroom enrichment or (2) creating a resource-room program. These two options were not appealing to me because they meant more busy-work for both the teacher or the students. I preferred to build something more lasting and to create a culture open to critical thinking and creative problem solving.

My next concern was how to measure a child's gift or talent. I never used performance objectives or tests to include or exclude children from my program, preferring instead to foster their self-esteem and well-being. A focus on individual children and how to develop their problem-solving potential was at the core of my program. Because my real intentions in devising this enrichment program were to motivate students and to generate a spirit of life-long enjoyment of learning, I dealt with the mandate, the placement dilemma, and the different kinds of problems as I went along. The following is an anecdotal account of this experience.

Towards the fourth year of my program, I piloted a small lunch-hour mathematics problem-solving event, called the Mathematics Olympiads. This was a program developed at New York University (SUNY) by Dr. George Lenchner. It created a network of mathematics problem-solvers who competed at a monthly world-wide school-based Olympiad. Its competitive nature attracted a wide number of students and support staff. We adhered to Olympiad rules, which were defined within the contract, and allowed only committed young problem solvers to enrol in the program. They would join a team for the monthly competition and present their results to a particular set of problems mailed to us by courier. At the end of each month, the Olympiad results were announced publicly and individual students as well as teams of students received trophies or medals as public recognition for their efforts. The after-school enrichment program, which also included mathematical problem-solving exercises that prepared students for the Olympiad, soon extended into some classrooms.

My next goal was to integrate a classroom-based, school-wide, mathematics problem-solving program. However, this was not an easy task because most of my colleagues resisted additional duties. However, my team of after-school Olympiad facilitators started replacing text-book problems with Olympiad problems in their classrooms. This had a domino effect on other teachers who soon began to request our materials. It was invigorating to watch them and the children during these problem-solving sessions, because both the teachers and the students enjoyed solving these problems so much. The children became more vocal, assertive and even argumentative. The game-like nature of the problems encouraged them to become more critical. I share one of these experiences:

Personal Anecdote

Hin Kin (a fictitious name) was a newcomer to our school. He had recently arrived from China and spoke very little English. He was struggling in grade four not only because of the language, but also because of his overweight. He requested to join the lunch-hour Olympiads—perhaps avoiding ridicule on the playground. One day, a week after the second Olympiad, he brought me a frayed piece of paper requesting that I read it. He told me he'd spotted a mistake in one of the Olympiad problems and showed me his interpretation of it. I looked at the paper and told him I'd write to the Olympiad director on his behalf. I later shared Hin Kin's solution with the school director who suggested I call Olympiad headquarters in New York City. I hesitantly made the long-distance call knowing that it wouldn't be a brief one. I soon found myself talking to a well known authority in mathematics who wanted to speak to Hin Kin directly. We set up the international call later on that day. Evidently, the child had spotted an important mistake that had gone unnoticed. I'll never forget the gleaming smile on Hin Kin's face when he walked out of the director's office. Later on that month, his name and photograph were published in a school-wide newsletter.(ECA/Enr/89)

Although I experienced, first-hand, the constraints involved in adding an extra program into a school—let alone a mathematical problem solving program into the regular classroom—I valued its impact on young learners like Hin Kin, who would probably never have spoken out or shared this critical observation otherwise.

I strongly feel that problem-solving activities should be integrated in the mathematical program along with computational/procedural arithmetic skills. However, certain conditions have to be in place for this inclusion to operate effectively. Critical thinking and mathematical problem-solving activities in the classroom are time-consuming and demanding operations requiring a different time-frame for tasks to be completed. Students engaged in these activities need different kinds of time factored into the program. They need time to reflect on the problems, time to explore the symbol systems, and time to manipulate the tools to assist them in solving problems. Young problem solvers also need supportive adults around them to assist and direct them while validating their problem-solving efforts. Children involved in problem-solving processes experience high levels of concentration that put them in highly vulnerable and sensitive mind-sets. Having a personal vested interest in this area of heightened sensibility, I decided to explore it in more depth in this inquiry into problem-solving in mathematics.

The following excerpts from my teacher's journal reflect my 1989 concerns, pursuits and interests. The first, my dreams of an ideal classroom, describe the painful way in which I conformed to the curricular constraints that were handed down to me and my colleagues in the 1970's.

I still squirm when I remember how intimidated I felt when the school principal would walk into my classroom unannounced. Clip-board in hand, and a stern look on his face, he was not interested in finding out what the students were learning. The reason for his periodic visits was to oversee that the educational process was enforced properly and that it could be accounted for in the school roster. He was interested in seeing to it that students sat in straight rows and had their text-books opened to the right page. He was not interested in noticing whether I stretched my students' imaginations or embellished the rigid curriculum with innovative ideas. His main concern was whether I was following my plan-book and the designated curriculum properly, and whether I kept accurate records.

My Dream

> My lifelong dream was to teach in a classroom where I wouldn't have to stand in front of the blackboard imparting instructions. I no longer wanted to teach in settings where learners sat in straight rows, at impeccably-organized desks with basal readers open to the exact page while passively and obediently receiving instructions. When I could finally break away from this teaching-style, my lesson-plan book stopped reflecting instructional outcomes. My students' grades stopped forming a perfect bell-shaped curve. I moved away from the black-board and shelved the dreaded basal readers and text-books. I became an advocate for innovative teaching and concentrated on learners, offering them an opportunity to explore on their own.
> (Researcher's Personal Journal, September 1987.)

Today, as I work in another capacity, supervising pre-service teachers at their schools, or assisting them in creating portable educational materials and projects, I envy school settings of the 1990's, which are ideal to me:

My Ideal

> Elementary school classrooms today look and feel very different from ones that I taught in during the mid-seventies. Learning centers, computer stations, reading corners, and science activity centers appear here and there. Student art-work hangs from ceilings. Classroom pets strive for survival. Plants travel along walls. Student writing is published and displayed. Teachers bring a visiting library collection along with children's publications to the "author's corner". The designated "author of the day" reads from the official author's chair. Classroom furniture is designed for group work and group activity. Students move around freely from a work station to a learning center to the reading corner. Children are sprawled on the carpet, propped-up on a window-sill, under a desk—reading.
> (Pilot Study. Nov.96)

When I embarked on my doctoral studies, I wanted to carry out my research in an ideal classroom setting where there was a healthy balance between a loose sense of structure and an inquiry-based approach. I found my ideal research site and an ideal reflective practitioner in Montreal, Quebec:

An Ideal Research Site

> I found an exemplary classroom like the one I had envisioned and met an exemplary teacher in Montreal, in the fall of 1996. Her fifth-grade classroom promotes student-centered learning using an inquiry-based approach. She is also a well-known reflective practitioner (Schon, 1983) who publishes widely, participates in conferences throughout Canada, teaches at the university level and manages this grade five classroom. She invited me to visit her classroom and to familiarize myself with her approach and with the concept of reflective practice. The following year (1997) I carried out an informal pilot-study in her class, and proceeded to carry out the formal research study the following year (1998). (Researcher's Personal Journal, 1998)

During my pilot study year, I became familiar with the program, the classroom routines and the literature that supports this type of instruction. I worked closely with the exemplary teacher who, although on a sabbatical leave of absence during the two years of my study, provided me with the guidance and support needed to gain entry into the school as a research site and access to up-dated information on innovative classroom practice.

While visiting this classroom, I shared these personal observations with my research supervisor, who encouraged me to explore reflective practice in more depth and to keep a researcher's journal. She also encouraged me to value my past teaching experience as a form of "lived experience". In this way, I the researcher was now vested with a tool for interpretation, that of my own experience. I decided to use ethnographic tools and a qualitative research approach (Miles & Huberman, 1994) because they fit my study best. I quote Miles & Huberman's (1994) comments on the usefulness of a qualitative approach in settings like my research site, where events occurred within an extended time-frame, and where the interactions and dynamics of the children could elicit un-predictable and unexpected outcomes:

> *With qualitative data one can preserve chronological flow, see precisely which events led to which consequences, and derived fruitful explanations. Then too, qualitative data are more likely to lead to serendipitous findings and new integrations (p. 1)*

The flexibility within this approach also allowed me to factor in and record those day-by-day incidents, events and moments that make each classroom and teaching/learning experience so different from one another, and so unique. I decided, early on into my study, that I needed to branch out and to observe both within and outside the classroom, because there was a wealth of important information to account for. The method and approach gave me that needed amplitude where I could (1) interview students probing more deeply to find out what incidents, ideas or events led to their solutions or affected their way of thinking, (2) talk to their other teachers and find out what they were doing in other classes, hence making room for these important outside influences, (3) include environmental incidents (natural disasters, extended holidays, school events) that affected the school year and the children's life-styles, (4) record curricular and social processes affecting school-life, and (5) keep an open eye for serendipity, which in classroom life, is short-lived and extremely important. Classroom research offers a rich arena for observation of events and processes, however, some of the most enlightening findings occur unexpectedly, and disappear in seconds, and sadly, are usually unaccounted for.

Chapter 1

An Introduction

In this chapter, I highlight classroom activities and events that led me to uncover the importance of children's personal problem-solving language. I also illustrate how the children's tools and symbol systems as well as the influence of their individual learning styles assist them in deriving unique representations and solutions to complex mathematical problems. I begin my account by sharing what Dianne, a fifth-grade student said and did on a memorable day in class when she found the solution to a mathematical problem.

> *"**Partner dots!**" She yelled out, "**Partner dots!**" and chanted "This one tells this one, this one tells that one...each partner tells another partner and they all become **partner dots**..."*

This event illustrates one of the principal questions that I address in this study, namely, what do children do while they problem solve. The following excerpt from my field notes substantiates what I witnessed that day, November 23,1997.

Dianne solved the "Problem of the Week" by devising a unique representation of the problem. Her solution consisted of rows of circles facing each other resembling people's heads. She bounced back and forth from circle to circle, calculating and counting how many probable combinations she could come up with. When done, she put her pencil down, celebrated joyfully, and walked around the room chanting. She then returned and modified her original set of partner dots, improved her strategy, and uncovered a successive pattern of numbers. Her partner dots served not only as an abacus, or symbolic representation, but as a life-like context and a language to work in.   *(F.N. 11/23/97)*

She had been struggling with the problem The Sale at The Frozen Yogurt Shop for a while, not realizing that her problem-solving strategy offered her a window to the solution. The problem (see appendix # 1) required the student to calculate how many people could tell other people about this sale within a particular time-frame. Dianne had started solving the problem by drawing little dots on the corner of her page (see figure 1). Her work looked somewhat like this:

this partner	**this partner**	**this partner**	**this partner**
to this dot	**to this dot**	**to this dot**	**to this dot**

Figure 1

She used dots and "partner dots" to keep track of the numbers that she was working with. By aligning each dot to a partner, she realized that there was a one-to-one correspondence between each dot and its partner, and that she had to carry out a mathematical operation that required grouping. She hence assigned a number to each set of dots and to its corresponding partner, and began to view her solution as a progression of groups of numbers. This hopping back and forth from the dots to the numbers, her sing-song, dancing, and all of the other activities that she was engaged in during the task, allowed her to see this connection. On the top of her page was the figure presented above and in the middle of her page she created yet another chart to tabulate her numbers (see Figure 2):

dot + partner dot	**dot + partner dot**	**dot + partner dot**
corresponding digit	**corresponding digit**	**corresponding digit**

Figure 2

Refining the process even further, her re-drawing of the dots allowed her to notice this successive pattern of numbers that followed a predictable sequence. Her genuine problem-solving strategy surfaced from her need to do four things: (1) to jot down what her preliminary intuitions were, (2) to check again by enlarging her original drawing (3) to physically represent this recursive action, and (4) to say it out loud. This redefinition of intuition and physical engagement, along with movement and language, enabled her to work towards a successful solution of the problem. Her engagement allowed her to come up with the meaning of the problem and its implications. Building upon her intuitive notions and her particular planning style helped her generate her own "little" theory which was a result of her reaction to the problem. She had read the problem over and over and realized that one person "tells" another person about the sale. This "telling" action that went back and forth between people resulted in the series of dots on the top of her page, which in actual fact represented her problem-solving theory. When she realized that her solution was accurate, and that her calculations worked every time she redid them, she celebrated loudly by yelling and clapping. She felt happy, good about herself, and proud that she could teach herself something about number patterns. The following excerpt from my field-notes marks this as a memorable event for my research:

Dianne laboriously worked on the problem, erasing numbers, drawing figures and counting her "partner dots", she began to sing a rhythmic tune related to her counting activity. This rhythmic tune evolved into a rhythmic dance which she performed joyfully after completing the problem. (F.N.11/23/97)

Watching her work, I noticed how concentrated and on-task she was, so engrossed in what she was doing. I also noticed her special sense of joy, as if nothing else mattered during those invaluable moments of heightened sensibility. This special moment was a revelation to me as researcher. It continues to impress me, so many months later. As I look back at personal classroom experiences, I remember marveling at this phenomenon of heightened sensibility before, watching students become totally abstracted, concentrated, on-task and oblivious of everything else happening around them. At the time, I did not know enough about this phenomenon, and unknowingly made the wrong educational choices. In the past, I thought that these were unacceptable classroom behaviors and tried to stop them. I would tell a child to get back on task or to do something "meaningful". As I observe children today, at my research site, I realize what a sensitive and vulnerable state of mind this is, and how easily it can vanish. I notice how some children "snap out" of it quickly to avoid reprimands or ridicule. Some children know how to operate in this state and to prolong it by cleverly masking it. They pretend to be singing or humming, or looking as though they are seriously putting something together.

As this phenomenon continues to intrigue me as a problem solver, I wonder if it is possible to evoke this problem-solving state or to relive these moments of heightened sensibility and awareness? For example, I watch people after they have been asked a difficult question. They will disengage themselves from conversation and start whistling or humming while they search for the answer. It is as if they were saying to themselves, "Wait a minute, please, while I switch on my personal *search engine* and look it up."

I want to unravel what these moments of discovery, these epiphanies, are really like. In so doing, I interviewed some of the children after I had witnessed these moments in the classroom. Mark, for example, told me that he felt very good and that he was so excited about finding a solution to the problem, that he forgot about everything else around him. Zack also told me that, "It felt so, so good."

I define these "epiphanies" as "eureka moments", and they have become the *leitmotifs* of this study. By addressing them now, I answer some of the many questions that I had back in the 1980's. After observing these students for an entire school year, and after examining the data and the artifacts that I collected, I see that:

(1) Children are capable of deriving strategies.
(2) Children can generate theories.
(3) Children are capable of solving complex problems.
(4) Children are aware of number patterns and can use them to learn about mathematics.

Some new questions that have arisen as a result of the above are:

(1) How do children do all of this?
(2) What tools do they use?
(3) When does it all come together meaningfully?
(4) How can teachers encourage this type of learning in classrooms today?

Exploring these questions today, in a modern classroom setting, not only provides a working example of classroom-based problem-solving in action, but also makes an original contribution to child-centered pedagogy. The following are some of my initial observations. Children use a *problem-solving language* while they solve mathematical problems. This informal language has features that reflect the child and the problem-solving task that she is engaged in, as in the instance where *partner dots* became a breakthrough for Dianne. As this personalized language evolves and develops, it becomes a *shared problem-solving* language which the child uses as a tool for interpreting the *language of instruction* (mathematical epistemology, the teacher's instructions, and the text). The language is representative of a problem solver or group of problem solvers, reflecting the features and characteristics of their particular learning style. The language sometimes includes invented, contrived, and unconventional words or accompanying body language like rhythmic chanting, and dancing, depending on a child's expressive preference. This *problem-solving language* operates on a separate and parallel channel to that of the instructional or mathematical *speech registers*[1] (Halliday,1973) that are elicited in class. Language, as such, in Halliday's view, operates as a *social semiotic,* (Halliday, 1978) vested with a "shared meaning potential" (p. i) which in this case is the language of

[1] Halliday (1975) defined *register* as "a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings" (p. 65)

interpretation used as a scaffold to help the learners understand the language of instruction which in this case includes the mathematical register. This language of interpretation helps learners decipher what the problem they are solving is about and it also allows them to explain this to each other. As the young problem-solvers learn from this form of engagement with a mathematical problem, they access and revisit a learning space from which they draw meaning and make connections, and draw conclusions about what these things mean to them. This access area is their *problem space*[2] (Newell & Simon,1972) which operates as a personal data-base from which problem-solvers retrieve information on an on-going basis.

In this dissertation I describe, define and attempt to unravel the manner in which this *problem-solving language,* assisted by the learners' access to their *problem space* evolves and develops in a grade five mathematics classroom. The data gathered in this study are supportive evidence of this *problem-solving language*. The data also capture the phenomenon of attention which results in a heightened sense of awareness where language, symbolic representations and tangible objects become the problem-solving tools that allow learners to retrieve and access information from their problem space. This research study also captures some of these

---

[2] Newell & Simon (1972) suggest this to be a search area where the learner uses strategic knowledge, prior experience and innate problem-solving knowledge to retrieve information. It is lodged in long-term memory; connecting to it is short-lived, (probably ten minutes).The problem solver has little time to retrieve information requiring several attempts or visits until she makes a connection.

moments of access and retrieval in their full effervescence as they happened naturally in a classroom setting.

A hypothetical assumption that guides the study is that a young problem solver naturally seeks opportunities to work within her *problem space,* and creates personal mechanisms to do so. Such mechanisms are a form of *purposeful delay*, a term which I have created to represent various forms of busy classroom activity. Highly active classroom activity, like the one described on page 10 has surfaced frequently from the data as a clear indication that it represents a natural need that young problem solvers have. Students engaged in problem-solving activities like these need to create time for themselves so that they can reflect, experiment with strategies, and engage in doing other things. Some of these *purposeful delayers* are represented by such harmless classroom activities as extended periods of seemingly *busy-work* that sometimes resemble play. The child fashions a tool or spends a lot of time cutting, pasting, coloring, and ornately decorating his materials, or merely arranging personal belongings and moving about the classroom. Adult observers might classify these behaviors as off-task, when in fact they represent a child's hard work. What might wrongly be interpreted by adult observers as distracted or withdrawn behavior is yet another example of the child's natural need to explore her *problem space* and to develop strategies for doing so. Other seemingly *off-task* behaviors are prolonged silences, brooding, sulking, and frequent classroom absences to the library, rest-room, hallway, as well as forms of playful inventiveness or evasion.

Most children are naturally playful, buoyant, happy, and oblivious to everything that is happening around them. If asked, they would probably not know the difference between pretend or real-life behavior (Piaget,1945). This is why they sometimes get carried away, inspired by the context of a story within the problem and start acting it out. Children cultivate a sense of story and can easily get distracted by focusing on the contents of the story rather than the mathematical problem they are solving. Adults unknowingly judge them without realizing that children are still creatively playful at this age (Winner & Gardner,1979).

Representative classroom episodes that illustrate these moments of heightened awareness are described throughout this dissertation. I provide detailed classroom descriptions, close readings, analysis of classroom-artifacts and impromptu interviews with the young problem solvers after they have experienced them. These episodes are described and analyzed further in chapter five. The examples provided bear interesting testimonies of how these young learners in this classroom setting developed unique strategies, explored their learning space, and adapted their unique and particular learning styles to shape and pattern a *personalized problem-solving language.*

The program of instruction at my research site factors in most of the conditions and features that allow for this type of exploration to take place. This classroom, in its atypical nature, allows youngsters to move around freely and provides educational tools (Bruner,1993;Cobb,et al.,1996; Dienes,1960; Pimm & Love,1991;Papert,1980) and a rich problem-solving environment that ignites inquiry (Borasi,1992; Confrey, 1995; Fosnot,1989; Harste, 1993). In this classroom, a question-posing, let's-find-out-and-prove-it learning atmosphere prevails (Lakatos,1977;Pólya, 1954;Resnick & Ford, 1981; Schoenfeld, 1989) and is discussed on page 62, Chapter 3 and in Appendix 6.

Examples from the data illustrate how the instinctive and natural problem-solving mechanisms evolved into the *children's unique representations.* They also show how the different learning styles manifested themselves as the children revealed their unique and *multiple intelligences* (Gardner,1991). This study, in describing these moments of heightened sensibility in children, and in bringing forth each child participant as a unique learner and problem-solver, vested with an innate problem-solving potential, makes an original contribution to classroom practice. It focuses on the child as an individual and portrays those "eureka moments" as they happened naturally during the 1997/1998 school year. Given that classroom conditions allow sufficient time to explore, adequate tools of instruction, nurturing adult presences, and validation of children's unique learning styles, children can work up to their potential. This study attempts to sensitize readers and educational practitioners to continue encouraging and promoting a similar classroom program, tailoring it to the needs and the capabilities of each student.

The excerpt of Dianne's problem-solving solution shows how the wording of the problem transferred onto Dianne's language for solving the problem. It helped her develop a representational symbol system as a tool. Her interpretation of the problem helped her see the relationship between the dots and the "partners" as a numeric progression. The chant and subsequent celebration shows her confidence in the problem-solving strategy and her sense of agency. This event reveals that the process of refinement and that the focus was generated and transferred from the problem, from the child's conceptions of it, and from her learning mechanisms. Her chant-like naming, calling, playing, and relocating of the dots brought these to life. There was a *teller-told* correspondence which engaged her in a conversation between the dots and the numbers. This conversation created an imaginary presence or *interlocutor,* that necessary audience which the learner seeks in an expert/ novice situation, or a discursive presence of an interlocutor with whom to make meaning (Halliday,1973; Lantolf, 1994; Vygotsky, 1962).

This realization indicated to me how an interactive use of language like Dianne's becomes a language of interpretation resembling the way in which young children, learning a second or other language, use their mother-tongue to interpret or to understand this new language (Lambert & Tucker,1972). This language of interpretation provides young learners with yet another tool for exploring their *problem space.* They can now access this "thinking" space with the words that are helpful to them in retrieving tentative answers from their problem space.

The *language of problem-solving* is hence used as a learning tool. An example of this is when I asked Dianne about her "partner dots", and she explained her strategy to me saying, " I needed to **partner** these". The word "partner" stood as a place-holder for what Dianne really meant, but did not know at the time. Her *problem-solving language* helped her create a manageable symbol system which transferred from her mind onto her paper. The "temporary" word **partner** as place-holder was transferred onto paper and developed even further as she processed the problem. Once she had succeeded in explaining this problem to herself, and in attaining the sought-after solution, she bounced up joyfully. She was not reprimanded or discouraged for being loud and cheerful. She then calmly pulled out her library book and began to read.

The nature of this *problem-solving language* as it evolves in this classroom of dynamic and buoyant activity is unique. It corroborates the Vygotskian view that mental functions are governed by the activities themselves, in other words actions govern thoughts (Kozulin, 1990) as opposed to thoughts governing actions. More detailed explanations and descriptions of this as a phenomenon are offered in chapter five, where the language events are broken down into a descriptive narrative. The *conditions* which are necessary for such language events to occur are also a pivotal component of this classroom setting. These conditions are described and explained further in chapter four.

To preview both the above phenomenon and its distinctive features, they are broken down and described in the following twelve strands. These strands also include some detailed descriptions of the school, the program, the children and the classroom.

Strand # 1 Problem-Solving Language

I define *problem solving language* to mean the language of explanation that the children use to interpret the language of instruction. Used playfully and privately, this language form as a code is seldom shared with children who are not members of the group that is processing the problem. While Miss Z, the classroom teacher may judiciously use the *mathematical register* (Halliday, 1973;1977;1978), in class, she does not stop youngsters from using their own code or system to process or to solve a problem. However, once a problem is committed to paper or it is presented to the rest of the class, this simple language form disappears or is refined into a more appropriate or formal language register. To illustrate, while Dianne used the word **partner** as place-holder she also created a temporary language form that had a particular momentary meaning for her. While working, she mumbled to herself "this to this, this to that" assigning a numerical value to each partner and its corresponding dot. Examining her language usage closely, it is clear that usage and appropriate grammar-use were not her priorities at that point. However, her choice of words illustrated this correspondence of numbers and allowed her to continue processing the problem.

In the data gathered for this study, there are several other similar instances where the children used incorrect grammatical terms temporarily. They were not object to ridicule by others, and the teacher seldom reprimanded or corrected them at that early stage of the problem-solving process. The teacher allowed the students to experiment with language. The students themselves, reverted to more accurate language forms once they had refined their problem-solving processes. They did not use this informal language form when presenting their findings to their peers and seldom used it when working in pairs. The young problem-solvers in this classroom seemed to know the difference between talking in a *work-in-process* mode and talking in a *public domain mode.*

Strand # 2 Unique Solutions

The children's problem-solving solutions were usually unique and representative of their problem-solving style. They seemed to bear the child's imprint making their products easily distinguishable, one from the other.

Some of the children enjoyed using tangible objects such as lego blocks, counters, and pocket calculators as "multiple embodiments" (Dienes, 1960;1970) or representational scaffolds to illustrate their thinking. They often transferred these constructions onto paper, using sophisticated color-coding schemes and diagrams. Some children fashioned their own tools or used ready-made ones, such as rulers, counters and building blocks. This again showed how unique each child's representation can be.

Each time the same problem was presented to a new group of students, new and unique solutions surfaced. To illustrate, in subsequent school years (1996;1997 & 1997/1998) when the same problem was presented to a different group of students, there were as many different representations of the solution as there were children. I wondered why there were so many representations of this problem:

> *I attempted to solve the **Burrows Problem** (Fall, 1996) along with the children to understand the process better. I jotted down my calculations and put them in my pocket so that I could work on it later. I had a hard time figuring out the problem myself. The children produced six fascinating solutions to the problem:*
> *1. beads on a necklace, abacus style, "sending one "bead" over" in descending order.*
> *2. 3 rows of groups of three (difficulty connecting lines to each and most commonly abandoned strategy).*
> *3. dots on a line, that when connected look like iron filings around a magnet (This was also abandoned because of proximity of dots and arcs)*
> *4. carefully drawn houses in a one-to-one distribution (9 houses eight lines, 8 houses 7 lines until reaching 1 house 2 lines.)*
> *5. color coded column of squares (represented in two ways)*
> *6. numbered columns (F.N.10/23/96)*

I was intrigued by finding so many different representations for the problem the following year as well, and formulated this as a question to address later on:

Why are there so many interpretations for one problem?

In an Analytic Memo written a few months later, I reflected on this same question:

> *Some students resort to enlarging their original burrows, others to placing them in an orderly way. Still others change processes from using colored markers (which fade into each other when mixed) to using hard-point crayons.*

The results of their endeavors are very distinct and unique representations that look like:

1. *A nerve cell*
2. *A pyramid*
3. *A cube*
4. *A fence*
5. *Color-coded spiders*

I wonder whether these unique representations are a result of the materials that the children work with or are due to other factors? Could it be that students each create their own visual representation? Why is it that they resort to so much "busy" coloring and drawing? The more time they spend doing this the more they refine their final product. Why do so many of these unique representations coincide with the same number patterns?
(An.Mem.23/10/98)

At the time, I wondered whether the students were driven by the materials they used (paper, pencils, and colored markers) adapting their drawings to the limitations of these. While they changed their work instruments to suit the task, they also became very focused and concentrated, almost enjoying this seemingly arduous labor. This again, was a confirmation to me of how their actions governed their thoughts in a Vygotskian sense, and to his introduction of the concept of *semiotic mediation* whereby mental processes are assisted by tools, symbol systems or interactions with others (Kozulin, 1990).

I often shared my questions and concerns about issues like these with Miss Z and her colleagues. A question that continued to intrigue us was why there were so many unique representations each time the problem was presented? This uniqueness and its frequent appearance offered me sufficient evidence to assert this to be a phenomenon worthy of inquiry.

Strand # 3 Tools, Symbols & Scaffolds

Besides using language as a tool to solve mathematical problems, young problem solvers in this classroom created their own symbol systems to assist them in understanding these problems. Tangible objects such as lego blocks, pencils, rulers and other classroom tools shaped the *problem solving language* giving it a physical and a portable form. Tangible objects also functioned as resources and *symbolic interlocutors* providing young learners with an outlet for verbal expression. As they sub-vocalized or chanted, some students talked to these "gadgets" or *symbolic interlocutors* as if these embodied a real "listener". This imaginary listening presence also provided them with another scaffold to build their solutions and strategies from.

Strand # 4 Mobility

Young problem solvers cannot and should not be restrained and confined to their seats for extended periods of time. They need to get up and move around. If they are not allowed this freedom of mobility they will invent ways to leave the classroom or to walk about. The problem-solving process requires a freedom of mobility.

As the children evolved through the different stages and phases of the problem-solving process they needed to get up from their seats, to spread out, to work in a larger area, to find more tools, or to distance themselves from the problem. The children also needed to view their productions from different perspectives and to celebrate and share their success with others. Howard

Gardner (1996) would agree that these are highly-mobile learners who have a kinesthetic learning style. Traditional classroom settings often do not allow this mobility. It is often mis-interpreted as distracting or disruptive behavior and the children are penalized for it.

Strand # 5 Time

Mathematical problem solving requires extended periods of class time. Students need to explore, to write things down, to wait and see, and to talk to each other. This is sometimes not possible in forty or fifty minutes of class time. Sufficient time needs to be provided for productive problem-solving activity to emerge. Sufficient time is also a fundamental component of the problem-solving process because most of the very focused and directed problem-solving activity surfaces after the initial thirty-minutes of exposure.

Strand # 6 Nurturing Adult Presences

A trusting, validating, caring (Noddings, 1996) adult can make a difference in the problem-solving classroom. This knowing presence can embody that needed *interlocutor* who does not judge the quality of the child's work, but supports and validates it. The young learner is still an apprentice who naturally seeks expert assistance. Some young problem-solvers whose efforts are not validated and recognized positively often destroy their work fearing criticism and disapproval. Consequently, they hesitate to share their personal problem-solving strategies publicly unless they have received confirmatory or validating support from their peers or teacher.

Strand # 7 Conditions For Successful Implementation

In order for such a problem-solving program to be implemented, the features and characteristics described in these twelve strands should be enforced. The administrative and teaching staff as well as the school community and the children should work together to build an environment that is conducive to this form of learning. The more basic and necessary conditions that are needed include, of course, a good program design that allows students the opportunity to work with appropriate mathematical problems whose level of difficulty is both manageable and challenging. The other two pivotal conditions are (1) allocating sufficient problem-solving time and, (2) allowing students' learning styles and learning preferences to evolve and flourish. The latter includes allowing students to be mobile, expressive and creative. They should be free to choose the instruments and tools with which they work as well as the vehicle in which they wish to express themselves. Support and validation of these choices should also be inherent in the problem-solving program. Young problem-solvers should work in an environment that reflects a healthy balance between structure and freedom.

Strand # 8 The Problem-Solving Environment

Children learn from their environments. This is very evident when visiting the school site, St. John's School (a fictional name). Youngsters at St. John's pick up non-verbal cues from their environment. To illustrate, the school is a problem-solving experience in and of its own (see appendix # 3).

Objects are placed in certain places and kept there for a purpose. The students know this because they are given many opportunities to display their work, to make photo-copies, or to distribute materials, knowing exactly where everything is located and stored (see appendix 4)

Students value the way space is distributed around the school. For example, those students who prefer to read or to stay indoors during play-time are encouraged to visit hallway displays and art work, or to read the "Visitor's Album" which contains the year's photographic archives.

Certain areas of the school were cleverly transformed into learning spaces as a problem-solving feat. Running and managing such a school in a busy residential area continues to be a daily problem-solving task in and of itself. Yet, the children are aware of this and contribute, through their school governance program, by also participating in space management decisions. Hence, opportunities for planning, management and creative use of space as a problem-solving task is a concern that is given to the children.

On my first visit, several students asked me whether I would inspect their "cubbies". I noticed later on, during the school year, that they were expected to organize and manage their belongings adequately. They were also required to adhere to a list (Appendix 5) which specified which materials they needed to keep in the classroom and which ones they needed to take home or discard. They also had creative models right in front of them, where for example, they could use clip-boards as planners and color-coded bins and boxes for storage of "work-in-progress".

The clever use of hallway and classroom space (Appendix 6) also reveals space-management problem-solving with an eye for aesthetic appeal. Hallways are not problem-areas. Relatively small classrooms are converted into large learning spaces using the high ceilings and bay windows as alcoves and libraries. Small corridors are enhanced by lively color schemes or widened by mirrors. Useless space becomes new space as empty corners, areas behind doors, and areas around window sills become reading hide-outs, art displays and amphitheaters. Children perceive a sense of order and usefulness in this environment.

Seasonal change is also handled in a problem-solving way. Cloak-room-confusion in corridors is solved by a systematic color-coded arrangement of baskets and hooks, avoiding clutter and disarray. Playground supervision is carried out by para-professionals who relieve teachers allowing them to extend planning and rest times. A meals-on-wheels program delivers daily balanced meals to students and staff in a shared summer-camp atmosphere which lasts throughout the winter months. Students study and live in a caring and sharing school environment where there is always a solution to a problem. All of these solutions-in-action rub off on the children, providing them with another problem-solving example to abide by.

Strand # 9 The Role of the School and its Program

The school's mathematical problem-solving program offers students a social forum where they can:

> *...seek out information, organize facts and ideas, communicate effectively both in speech and in writing and work independently or in cooperation with others.(introduction, school brochure)*

This rich environment encourages students to:

> *(1) develop thinking skills*
> *(2) develop mathematical problem-solving ability*
> *(3) assess their own progress*
> *(4) work in groups*
> *(5) share findings and explanations with peers.*

The mathematical program for this fifth grade classroom includes a standard text-book portion along with the weekly problem-solving section. The problem-solving component of the program meets twice a week for ninety-minute sessions which are distributed evenly. Half of the class attends the problem-solving session on one day and the other half on the following day. During the initial ninety-minute problem-solving sessions, students read the problem, attempt to interpret and understand it, and, the teacher explains it over again. Once all of the children have read the problem out loud and clarified its meaning and component parts, they write down a narrative reflecting their initial thoughts and reactions to the problem. They can also draw a symbolic representation of what they have understood. The students are not required to solve the problem right away, but to respond and react to it first, brainstorming ideas and reflections, talking to peers and the teacher and asking questions.

After this initial exploration, the students are given an entire week of extra time to dwell on the problem. This is a period where they are expected to ask questions and to allow things to settle or "incubate". At their next meeting, on the following week, the teacher explains the problem again, clarifying any further questions. She also responds in writing to the student's narratives and shares her written reflections with them in a personal conference.

At the final stage, they gather around her one last time and discuss the problem, making sure that everybody in the class understands it. The teacher then assigns the students group-partners. They then begin to process the problem. After their first deliberations, they present these initial group solutions to the teacher who again, responds to them by conferring with groups or with individual students.

The children are not rushed and their multiple solutions are welcomed. Once the problem is solved and all of the group members agree on a particular strategy or solution, a designated group member presents group findings to the entire class. At this point, the presenters work with a final product and they expect their audience to provide them with feedback and suggestions. The students benefit from this lengthy exposure to the problem and to the opportunity to voice their strategies for different audiences.

Strand # 10 The Classroom Program

The following is an excerpt from early field-notes during an initial visit. It provides an overview of what the entire classroom program is like:

> *Moral Ed -* *This is what I would call home-room period. It's the school's way of inserting what would otherwise be a nondescript time for house-keeping in regular day-schools. It could be used as a time for prayer or silent reflection (ie. a denominational school.)*
> *Language Arts*- *Students are given weekly projects to work on. They are divided into groups so that they can work on these projects or on the mathematical problem solving tasks for the week.*
> *Mathematical problem solving* - *these are strategy-generating activities that get students used to using the procedures and the strategies conducive to problem solving.*
> *Play One* - *this is a recess held between 10:00 and 10:30. Children go out to play. There are a series of rituals involved, kitchen help brings fruit, children grab a fruit, go off to the hallway to put on their winter gear. Miss Z watches them on Mondays, other para-professional staff watch the students during the rest of the week also bringing them a snack or lunch. (F.N.11/25/97)*

I was impressed with what I saw during these initial visits and wrote them as *observations* in my researcher's journal. I also jotted down initial questions as *brackets* when I wanted to explore a particular area later, when more detached. For example, this is one of my early observations of the school:

> ***Observation:*** *The hallways are divided so that each grade has an entire section. Cubbies are carefully color-coded. Children's names are posted next to their hook, basket, and shoe-box. The Principal, Miss B, patrols the halls making sure that all children are properly dressed before they walk out. There are no bells interrupting daily activities. Teachers and students alike are used to having the same predictable schedule for routine activities. They have followed these same routines over time, hence all the children know what to do, where to go, and most importantly, who to ask. (F.N.11/25/97)*

At the time, I had not assigned the environmental component its true value as a problem-solving example. However, it made me reflect about its effect on the children, the staff and the community as a whole. The following *bracket* shows how I handled these questions and how I assigned them a "place-holding" importance:

> ***{BRACKET I}*** *I notice that this shared routine, this familiarity makes children less competitive, less tattlers, less envious. I remarked to Miss B that according to my standards, she's the kind of principal that knows what each child in her school brings in his lunch-box. This is the best compliment you can give a Principal/Vice-principal, however, she responded that children don't bring lunch-boxes here. I got the impression that it's like camp, sharing the same meal, playing together, dressing together brings you closer.*
>
> ***{BRACKET 2}*** *children share lived experiences together each year. They go off to a farm where they spend three to four days together, with each other and with another grade level along with their teachers. This outing brings the entire group closer together. When I visited the school for Open House, I heard that early childhood grades spent the night at the Biôdome, sort of the same experience as spending the night in class or in school. This type of sharing adds to the experience as school being like home nurturing the bonding component. (F.N./brack./11/97)*
>
> ***{BRACKET 3}*** *From what I observed on Monday, play one is gender specific. Boys play soccer, girls stand along the fence edges. They want to join the ball game, however, it's a rough game played in the snow. Girls talk with each other and walk around. The Basket-ball court is also a reduced area where perhaps two to three children can play. Soccer and basket-ball are mostly played by grade 5 boys. There is little integration. Grade 6 girls talk about what they wear, where they went over the week-end and the usual"did you see" kind of talk. Their conversational play is very much about enjoying being together. Few children went down to the play area as there had been an accident the previous week. (F.N./brack/11/97)*

Classroom Particulars

These are my early impressions of classroom details which later helped me understand why the students operate in a certain way and with a particular sense of order. What impressed me as a fascinating management system was how each task is performed efficiently and stored in a specific compartment for easy retrieval. I noticed how this creative use of materials transferred onto the students as they in turn cleverly used their working tools.

Students work steadily throughout the morning, with a brief recess period and at noon. Lunch is brought to their room, caterer style, an efficient, healthy, and expedient problem-solving feat. At dismissal time (15h) students discuss homework assignments and are dismissed.

Strand #11 The Role of The Teacher

Miss Z does not rush students and refrains from making critical judgment. She confers with them in private and responds to their questions in writing. She is a *reflective practitioner* (Schon, 1983) who observes students as they work, plotting their progress, their interactions, and their individual needs in her journal. She monitors student interactions in group work and determines group composition. She addresses the children in a positive tone (Cohen ,1994), turning the language of commands into a language of polite requests. She offers her students a comfortable learning arena where they stop trying to please her and learn by themselves. She inspires the children, modeling her own thought processes, allowing them to *borrow* ideas from her, and provoking frequent dialogue.

Strand # 12 The Role of the Student as Problem Solver

The problem solver is encouraged to be a *problem finder* (Wertheimer, 1959) configuring, fracturing, and rebuilding the problem. The student is given sufficient time, tools, and a forum in which to explore. He is expected to come up with an interpretation of the problem, or a solution. The student needs to focus and to pay close attention to the directives and instructions of the problem. Some students have a harder time doing this than others. There is always a memorable moment for each of them. I share Zack's memorable moment because of the explosive celebration that I observed:

Zack's diagram is progressing well...A possible solution begins to emerge...he starts cheering and moving about rhythmically waving his arms in the air. He gets up from his desk to find more markers...pulling several drawers from the teacher's desk, his search is futile, yet he continues cheering and dancing as he plays with the set of pocket calculators in the drawer...he walks back to his desk yelling "oh, yeah...this is so good...so.. so good!" (F.N.3/21/98)

Zack usually struggled with the "problem of the week". He sought Miss Z out for assistance during most of the sessions. This, his first eureka moment, was eventful, and I, camera in hand, captured it in full effervescence.

The Students

This is a brief description of some of the other students that I encountered. All the names have been altered to preserve their anonymity. Cora was very friendly, (I discovered that she was from a different community than the rest of the children.) She was very proud of her father who played an important role in this community. She wanted me to keep her Earth poem, and she later gave me more pieces of her art work as the year progressed. She shared her stuffed animal (Husky Three) with me on my first visit. She asked me where I was going as I was leaving at the end of the day.

Jules shared his epilepsy bracelet with me. He needed help on his math and I sat next to him watching him work. I also praised him for how well he stacked chairs.

Bernie created a very interesting system for solving a problem; he not only used the *post-it* notes well, but stacked the useful ones below the table and the useless ones above it so he could simplify his task and work more efficiently, thus reducing his options to manageable ones. Bernie also became my special narrator as the year progressed. He usually greeted me when I arrived and told me what projects the class was involved in.

John shared lots of inquisitive, sensitive questions with me. On my first visit, he asked me whether someone would "endorse" my research. He had also mentioned that if I was to look into student "cubbies", that his was not a neat one, and neither was his desktop. John was very concerned about neatness, and as I learned later on that year, resorted to checking using his pocket calculator frequently.

Amalia wanted to find out a lot about anacondas and piranhas. She also asked me what it was like to be both a teacher and a student at the same time. She became very close to me and shared a lot of her work-in progress with me.

Dianne made fun of my name on the first day, pronouncing it with a British accent. She liked me to treat her as a grown-up and often greeted me like an equal.

Alana told me about her skiing classes, her new skiing equipment and her trips to a skiing lodge each week-end. Our conversation was during an outdoor recess. We seldom talked in the classroom later on in the year.

Zack told me he hated dentists and used lots of bodily gestures when he talked. He would rarely engage in a lengthy conversation and bounce around.

Gina shared a special magic square strategy which someone had taught her. I read some of her writing during my first visits. She had an adult vocabulary and enjoyed adult company.

Jordan T. shared some Radarsat information on Antarctica with the class. He described how, through remote sensing scientists have discovered that a certain portion of Antarctica will become an iceberg measuring 300 ft. He shared his knowledge of "Thwaites Glacier" sounding like an expert scientist himself.

Mark had a hard time with the magic squares problem on my first visit. I seldom filmed him because he was very self-conscious and afraid to make mistakes. He became my chief handy-man; such as helping me package equipment each time I left.

Joseph was very friendly and proudly showed me his computer drafts.

Summary

This chapter described how the personal *problem-solving language* used by these young problem solvers involves a language of interpretation along with a problem-solving strategy. The chapter also explored other factors that contribute to the problem-solving process, such as: the usefulness of tangible objects, the benefits of a trusting, highly-mobile problem-solving environment, and the value of built-in time and of opportunities for interactive communication. The presence of nurturing, validating adults is yet another contributing factor as is an appreciation for the problem-solving process in and of itself. Because problem-solving capabilities in children develop over time, it is important to create work settings that are conducive to this growth. Generally speaking, most children can solve mathematical problems because they

(1) are capable of deriving problem-solving strategies,
(2) can generate theory,
(3) are capable of solving complex problems,
(4) have an innate awareness of number concepts, number patterns, and mathematical attributes.

Children hence need to be exposed to situations where they can use this knowledge to develop their problem-solving potential.

The twelve strands have been briefly described in this chapter and are later explained more fully as they form “rules of inclusion” in chapter five. The school setting, the problem-solving program and the children are introduced in this chapter as well. These descriptions are later developed more fully in chapters three and four. However, introducing them at this stage provides a context from which to interpret the early stages of analysis and interpretation of classroom phenomena that occurred.

Structure of the Dissertation

The text of this dissertation is written in narrative form. Gender equity is observed, hence pronoun use may be male or female depending upon the sequence of the narrative. *Chapter one* is an introductory narrative including the rationale for conducting the study, *Chapter Two* provides the conceptual framework as well as a summative review of the literature. *Chapter Three* provides a detailed description of the school, the children and the problem-solving program in mathematics. *Chapter Four* describes the methodology including: the role of the researcher and the way the data were gathered, managed, transcribed and catalogued. *Chapter Five* analyzes the data situating these in an episodic format and converting the twelve strands into *rules of inclusion. Chapter Six* provides an analysis and interpretation of the problem-solving language, the children's tools and symbol systems, and the manner in which their learning styles were reflected in their solutions. The features and conditions for allowing these learning styles to evolve are also explained in detail. *Chapter Seven* concludes the study describing its contribution to educational practice and future implications. The epilogue brings everything together.

Chapter 2

A Conceptual Framework

This chapter draws on (1) Halliday's notions of *register* as domain-specific, contextualized speech acts that govern actions, his views of *language as a social semiotic,* or the value of the social component in a learner's process of understanding the world around him, (2) on Vygotsky's sociocultural theory[3] (John-Steiner & Mahn, 1996) and his notions that higher mental processes are mediated by the activity and the tools used as *semiotic mediators,* and (3) on individual *learning styles* which distinguish and represent each learner. These views form a conceptual framework from which to situate my perspective on educational change. This review of recent literature covers the following areas; (1) innovation (2) an historical perspective of change and innovation in education (3) desirable discursive practices (4) the role of the teacher (5) curricular constraints, and (6) context-rich mathematical problems in student-centered instruction. A more detailed and specific review of the literature that focuses on a particular strand of knowledge or a specific area of interest is woven into the text within each chapter so that it supports the data or the information in that particular area.

---

[3]

They are based on the concept that human activities take place in cultural contexts, are mediated by language and other symbol systems, and can be best understood when investigated in their historical development. (p. 191)

On Innovation

Innovation in mathematics instruction has been a concern since the 1950's, when the launch of the Sputnik reminded the world that the technological race was about to begin. The impact of this launch caused many school systems world-wide to seek to improve mathematics and science instruction to keep abreast of technological innovation.

Prior to the 1950's, mathematics students were ranked as either good or bad problem-solvers in terms of their computational skills in mathematics. They were reinforced for having (1) a meticulous presentation of the problem (2) accurate computations and (3) speed in calculation. In the 1960's more modern instructional trends were promoted. Teachers were encouraged to foster language development by encouraging more lively classroom interaction.

The (1989) National Council of Teachers of Mathematics Report (NCTM) in its *Curriculum and Evaluation Standards for School Mathematics* sought to influence educational reform implying that more student-centered practices were needed. The report also revealed that students were learning the procedural aspects (computation and calculation) well, but were not integrating their skills into life-like contexts. It also reiterated a need for innovation in mathematics instruction recognizing the value of discussion and interaction amongst students in the classroom. To that effect, studies in England found that children sat in base groups and did not participate in group activities at all. Physical seating in these classrooms was not conducive to group work because when desks were permanently attached to the ground this allowed for little or no mobility. Few classroom activities were group-related. Barnes & Todd (1977) had conducted a longitudinal 10-year study on groups of young adolescents as they solved problems through discussion. They analyzed taped recordings of these discussions. The transcriptions in this study attested to the fact that young adolescents, when unsupervised, continued to engage in meaningful activity and to share learning processes stating that:

> *...we are not denying the importance and necessity of the teacher...We do believe, however, that children are often underestimated, and that they possess skills and competences which are rarely called upon in a conventional classroom. (p. ix)*

Fortunately, at the time, Gestalt psychologists' ideas were making headway (Duncker, 1945; Katona, 1940; Kohler, 1925; Wertheimer, 1959) and grouping students was viewed as a way of improving teaching practices. When in groups, the young learner was more of his own agent. The Gestalt School of Psychology also valued group interdependence as a motivational force. Johnson & Johnson (1976) adapted Gestalt theories into their for Cooperative Learning Model, thus contending that when learners become actively engaged in learning and when their actions affect the group, then students are empowered.

From a cognitive perspective, however, and inspired by Piaget and Vygotsky, conflict could set in within this cooperative model causing a healthy unbalance within the group which could generate discussion and argument; also a meaningful form of learning. From a behavioral learning perspective, however, Bandura (1977) viewed the importance of an individual's self-confidence and his perceived *self-efficacy* as a motivating force, hence promoting positive interaction. Bandura's (1986) views pointed out how confidence, a strong belief system, and a rich bank of experiences compelled a learner to repeat previous successes.

In view of these *perceived self-efficacy beliefs,* Pajares & Kranzler (1995) found that experiencing a sense of success like this promotes a desire to pursue problem-solving tasks while also promoting task-adherence enabling the learner to complete the process and not to opt out. Meloth & Deering (1994) carried out a study supporting the notion that student talk and student discussions in the classroom promote and improve metacognitive awareness. If students were given an opportunity to share a common learning language and if they were encouraged to build meaning together, in a visual as well as in a verbal manner, then they could learn how to think by watching each other closely. This is very much in line with Vygotsky's and Halliday's views about self regulation. To illustrate, Vygotsky, while observing how children learned elementary arithmetic concepts, noted that very young children perceive quantity, but do not necessarily operate on it when counting. As the child gets older, he becomes more sophisticated and uses tools and symbol systems as place-holders for counting. Vygotsky also considered that drawing, writing and counting were higher mental functions that were socially meaningful. Halliday pointed out that children formed mathematical concepts at an early age, based on a need to systematically organize the things around them, using language to do so. The child has a need to talk about this process, and if encouraged to, will refine and modify his language use and his understanding of the mathematical concept. Hence, if students are encouraged to explain their learning processes to others and to continue practicing their newly acquired notions, processes and strategies, then their capacity to formulate ideas and solutions in mathematics increases.

To that effect, Bershon, in Hertz-Lazarowitz (1992) traced the kind of speech used by students in cooperative learning environments as a process towards developing their *inner speech* in a Vygotskian sense. In this way, problem-solving speech is generated from the social activity in which the children are engaged in and governed by the goals problem-solvers want to reach. Bershon states that:

> *As individuals verbally exchange ideas during a collaborative task, they create opportunities to use a vocabulary that directs and controls problem-solving behavior. Over time, vocabulary use during problem-solving becomes internalized into what Vygotsky defines as inner speech. (p. 36)*

Promoting such verbal exchanges in group work encourages the use of target vocabulary that helps link the words to the actions that these problems refer to. This offers learners a social context in which to rehearse their problem-solving notions. Ideally, then if the learner has the opportunity to work in a comfortable setting, articulating learning processes, rehearsing domain-specific terms, integrating prior knowledge with new knowledge, then he can learn to solve mathematical problems well. Mulryan (1995), however, stated that recent research findings in small-groups in mathematics point to a need to attend to individual differences when planning and promoting group work.

Recent studies advocate in favor of group work and peer-mediation in contemporary classrooms. Research in classroom applications of Vygotsky's sociocultural theory (John-Steiner & Mahn, 1996) favor interactive classroom practices because students have opportunities to build knowledge and to inform their teachers and peers about their thinking processes.

Recent research studies also point out contemporary issues and problems that arise when children are grouped to solve problems in mathematics. For example, when children are working in collaborative problem-solving situations they need to learn how to adjust to inter-personal learning situations. Learners need to learn how to avoid being dominated and silenced by more capable or more vocal peers (Forman, 1992; Mulryan, 1995). More specific research has to be carried out in cooperative or collaborative small-group instruction in mathematics (Mulryan, 1995; Zambo, 1996). Some studies tend to focus more on the product than on the process (Zambo, 1996). Students also need to learn to focus on the task, not on how they operate within the group's structure (Forman, 1992). As Mulryan (1995) points out, some group members learn to agree and to side with the more dominant member and hence do not carry out the problem-solving task at all.

With respect to classroom interaction, Cohen (1994) poses situated questions that reflect classrooms of the 1990's where teachers are addressing contemporary issues that have not yet been dealt with in recent research studies. To illustrate, some questions that she poses are thought-provoking in a modern context:

> *What should I do when some of the groups are floundering or fighting with each other? How do I prevent students from getting "burned out" in small groups? How can I help the limited English proficient student to participate within the small group? What do I do when good students complain that they are doing all the work? Or, how do I prevent wrap-up from being a boring repetition of reports from each of the groups? (p. xvi)*

Forman (1992) reiterates that children can be taught to interact appropriately in these group settings. She states, however that pre-adolescent children have more difficulty avoiding competition than adolescents do. Hence, when designing opportunities for classroom-based group activities, educators should make age-appropriate decisions and choices.

Sfard et al. (1998) question the NCTM's (1989) recommendations and their validity in today's classrooms where such modern technology as cell-phones, fax machines, computer networks and other rich interpersonal forms of communication already exist. They pose the following question: "How much of this language-based empowerment is really necessary?" Nesher (1998) clarifies that a distinction should be made between talking mathematically and doing mathematical work, because for her, mathematics is a language of symbols and not a natural language. Pimm (1987) would attest to this fact as well, because he points out that learning the language of mathematics is not like learning Arabic or French. Mathematics is a language of symbols. Nesher also voices concerns about contemporary mathematical instruction where awareness of this mathematical language does not promote progress in doing and learning mathematics because this symbolic language is not internalized and rehearsed enough.

Are grouping and promoting group interaction answers to this problem? Contemporary researchers now say that organizing groups into dyads and orchestrating opportunities to make students converse is just not working anymore. Students need room to explore and to develop their ideas in an atmosphere of inventiveness and in the presence of a mediating expert. Forman (1992) suggests that more research be carried out in peer collaboration in schools because children need to learn to adjust the manner in which they work productively with peers and they can be taught to do so given classroom opportunities to rehearse appropriate group behaviors.

These questions offer insights into the concerns of contemporary teachers who would like to innovate and would like to integrate ideal classroom practices into their daily work-spaces, yet have to level the ground before they do so. Graves & Zack (1996), through their work investigating collaborative discourse practices among grade 5 children found that children can learn from each other while solving problems together given that they both share a common interest and that the problem is challenging enough to sustain their interest.

Johnson & Johnson (1994) point out that cooperative learning groups can foster negative forms of interaction and hence not make any progress at all. They alert to such barriers as lack of motivation in groups, prominence of a dominant figure in the group, and even group members that do not contribute to the group's deliberations and hard work. Johnson, Johnson & Holubec (1993), suggest close monitoring of interactive groups promoting the development of rules for group accountability and group coherence. These operate in an almost corporate management style. Some suggestions are, to promote positive interaction, group interdependence and group accountability as top-down structures which, if monitored adequately by the teacher, can promote appropriate group practices.

Cohen (1994) offers suggestions to teachers on how to use discursive practices that are more suitable for group work and group interaction. She suggests, that when teachers mediate among groups they should word their directives in a positive manner, inserting such commands as "I would like you to" replacing the classical "Turn to page 3 and start." responding to students' talk by integrating such positive feedback as "I feel that" instead of the classical "You have to."

Noddings (1996) also suggests that the teacher engage in confirmatory and validating remarks among her students, promoting a natural engagement with the subject being taught and not the short-lived obedience which is not conducive to productive interactive exchanges. On a more practical note, Marshall (1995) suggests using an application of *Schema Theory* as a useful instructional tool in mathematics where learners can make their own inferences, estimate numeric progressions and predict logical outcomes.

With a contemporary perspective in mind, Vygotsky's notion of action mediating thought, Halliday's social implications for language development and the real-world problems affecting students in contemporary classrooms today there are many options to choose from. Students can be encouraged to explore other means of communication to express themselves. A more detailed review of the literature in the historical contexts in which innovation in mathematical instruction has made progress follows.

An Historical Perspective

Historically-speaking, between the 1950's and the 1970's education in the mathematics classroom has usually required a mastery of simple computational tasks performed for the teacher's approval. Students were expected to master the game of producing expected results obediently. Students who completed the course charted by the teacher usually did well in school. The teacher had total control over the program of instruction and over the decisions regarding student progress. J.P. Smith (1996) labels this as "teaching mathematics by telling" as a pedagogical support. This format puts the knowledge in the hands of the teacher, who decides what the students are going to process and when. Hence, if subject-matter becomes too domain-specific and outside her domain, the teacher dismisses it or goes on to other subject matter. In many cases, teachers' selection criteria for material to be taught was governed by how measurable it was and whether it would reflect their teaching. Howard Gardner, in his speech (McGill University, 1999), addresses the role that measurability has in today's contexts by saying that:

> *Does this concept of measuring intelligence define how we control and define the kinds of adults we want to have and the roles they should assume.*

Historically-speaking, the teacher determined what area the student would explore next and qualified the young learner based on such criteria as neatness in presentation, accuracy, and speed in calculation (Chambers, 1995). Students were placed in specific classrooms where they were *streamed* or *tracked* according to performance criteria of this kind. Students who mastered these operations and tasks well were placed in classrooms that worked at a faster pace. Educational reform as a result of the progressive studies mentioned earlier suggested a more learner-centered instructional approach in the teaching of mathematics. As a result of eliminating *streaming* and *tracking,* students were now grouped by ability (Fenstermecher, 1983). Grouping by ability resulted in yet another form of control—group-control. Children sat in base-groups, which were physical seating arrangements based on students' having similar abilities. Studies found that students were not engaged in more talk, rather the teacher out-talked the students. The teacher now had a new role, that of group monitor, the teacher's locus of control did not change and little dynamic interaction between students occurred. John Goodlad (1982, in Brubacher, et al., 1990) states this often forgotten reality:

> *...after studying 1000 classrooms...150 minutes a day of instructional time were devoted to talk, students initiated only seven minutes of that talk and teachers out-talked their students by a ratio of three to one...(p. vi)*

Is this still a matter of concern today? Is it perhaps a question of subject-matter? Some school-subjects may be more compelling for students than others. Some studies may require more verbal engagement and interaction than others. Is it a question of classroom composition?

Stodolsky's (1984) study viewed the social composition of the classroom examining it from a sociological perspective. She also studied the impact of subject matter on the ecology of the classroom. She found that when classroom composition was determined solely by the student's reading ability students were not well represented—only those students who read well thrived. The others were not accounted for. While comparing social studies instruction with mathematics instruction, she found that appeal for the mathematics classroom diminished. Students preferred the interactive environment of the social studies classroom because of the genre itself and the instructional material used in class (manipulatives, globes, maps, measuring devices, etc.) She recommended interdisciplinary instruction in mathematics where the social studies, the sciences, and other dynamic areas of instruction are integrated and combined.

Other studies carried out by Stodolsky (1984) showed that mathematics was taught predominantly through whole-class instruction. Again, these studies showed that the social studies classroom lends itself more to group work. Stodolsky (1984) also found that a few ad hoc mathematics groups sprouted temporarily for specialized, targeted instruction. The teacher would set them up and dissolve them once the task was completed.

More research on group dynamics was carried out by (Johnson & Johnson, 1985; Mulryan, 1995) breaking down the various components of the problem-solving process. These studies focused on student-talk and how it evolved among groups of learners. Argumentation as a learning form was also viewed as a communication tool (Zack, 1994). Sharan & Sharan (1976), for example, envisioned the positive contribution that this form of discussion has on students. Hertz-Lazarowitz (1992) compared this form of argumentation to rabbinical discussions of the Talmud where students are engaged in heated arguments as a form of learning. Lampert (1990) values the promotion of a *community of discourse* through talk and interaction, and student-guided pursuits where the students' interests define their inquiry (Borasi,1992; Harste, 1993).

On Desirable Discursive Practices

Is there a place for this rabbinical-like argumentation and discussion in the mathematics classroom? Can this form of discourse be cultivated? Mathematicians are usually quiet while they are at work, (Nesher, 1998; Sfard et al.,1998). They are busily processing numbers, computing and calculating, not necessarily talking.

What is the language of mathematics like? Is it conducive to argument and discussion? The language of mathematics is not a natural language (Nesher,1998, Pimm,1987). Cultivating domain-specific vocabularies in mathematics or making room for working in mathematics within the different operational *registers* (Halliday, 1978) is not easy for students and teachers to do. Students also have to master the procedural (calculating, computing) components of the problem-solving process because these skills go hand-in hand with the conceptual components. It is a matter of choices between how the problem is taught and explained, and also how the problem-solvers adapt to these different registers. Shared group activities in the mathematics classroom expose learners to the terminology, the different registers and the domain-specific strategies that assist the process. However, the language of problem-solving is not necessarily linear and sequential, but probably "messy" (Halliday, 1978), illustrated by temporary examples of the act of "doing" mathematics. Problem-solvers who think out loud as they problem-solve are not necessarily usage-conscious, but verbalize thoughts that are not quite polished and well thought-out—often their dialogue is intelligible. Ellice Forman (1992) says that:

> *...collaborative problem-solving tasks can provide children with an opportunity to practice academic discourse and learn how to coordinate it with the discourse of everyday life..." (p. 155)*

Students also benefit from watching their teachers model problem-solving procedures (Lampert, 1990; Resnick, 1976;1989) and from interacting with peers (Perkins, et al.,1993; Resnick, 1987; Schoenfeld, 1989).

The Role of the Teacher

The following three teacher-training experts are advocates for a new form of instruction where the teacher works closely with students. Magdalene Lampert (1990), in her pre-service teacher program at Michigan State University, suggests creating a culture of non-judgmental discourse in the classroom. Hence, the teacher phrases her statements promoting interaction in an accepting, tolerant fashion. Lauren Resnick (1976;1987) also offers simple teacher-modeling exercises for teachers to follow so that students can learn from watching them perform these. She suggests that the teacher of mathematics solve problems at the black-board, in front of all of her students, showing them how she processes information and how she solves each step of the problem. Students hence learn from watching. Jerome Harste (1993) is an advocate for the inquiry-based approach where youngsters are encouraged to explore their own interests and to make their own connections.

Some teachers sometimes hesitate to accept and implement these innovative practices that look so exciting when presented to them in work-shops or seminars. Is this perhaps due to the teacher's sense of responsibility towards the young problem solver? Are teachers afraid to leave students on their own? Or do they feel that it is their responsibility to assist students at all times? Are teachers afraid of losing their authority?

Again, a problem of control arises. How many mathematics teachers are willing to relinquish their power and control when they are the sole purveyors of an answer? How many teachers allow their students to question the validity of a problem? Finally, how many classroom teachers know and trust their students' problem-solving capabilities? The problem-solving process hence involves language, skills, reflection and multi-step procedures. Mathematical problems need to be processed systematically and broken down into their component parts (Lakatos ,1977; Pólya, 1954;1957;1973; Schoenfeld ,1989; Resnick 1976;1987) solutions are usually constructed from these fragments. Because many problem-solving processes require a series of steps, problem-solvers should be taught how to decide on the manner in which to approach the problem, how to break it down, how to formulate questions about it, and how to work with strategies to derive solutions. This is the place for that coveted discursive or argumentative moment because the problem solver is required to discuss and defend a strategy thus gaining ownership over it and perhaps understanding it better. Figure # 3 illustrates the four problem-solving formats proposed by Lakatos (1977), Pólya (1945), Resnick (1987) and Schoenfeld (1989),who share at least one process in common, that of questioning. All four theorists ask the problem solver to examine the problem carefully, to ask questions, and not to accept handed-down answers as givens unless they can be proved. They also require that the problem-solver cultivate a sense of self-reliance and confidence as a problem-solving tool.

Lakatos (1977)	Pólya (1945)	Resnick (1987)	Schoenfeld (1989)
prove problem	understand problem	recognize	know resources
point out flaws	make a plan	research	know strategies
create new proof	carry out the plan	represent	adhere to decisions
	check back	relate	
		reduce	
		reflect	
		reason	
		resolve	

Figure 3

As is evident from comparing these four strategies, they all call for reflective and reconstructive activity. The problem-solver breaks down the problem, verifies each component, and begins to know the problem well, interacting with its form and composition. His engagement with the problem creates a need to solve it. This is a key factor in developing the learner's problem-solving capabilities.

Curricular Constraints

A question of depth and form arises, and one of constraint. How many mathematical programs provide challenging, context-rich mathematical problems for students to engage in? Recent research in mathematics reform in the United States (Appelbaum,1995) shows how curricular constraints overpower reform. In the 1980's North American schools were caught between curricular and technological reform. There was too little time to catch up with it all happening at once. However, Appelbaum does suggest a solution to resistance or lack of curricular space for implementation. This translates as taking a classical classroom problem and making it real and life-like imbuing it with a context that students can relate to. One example of a real-life problem is to have students find mathematical implications in, for example, calculating how many glasses of milk are consumed by a family of four during the winter months as opposed to the summer months.

Time is another curricular constraint. Thomas Shuell mentioned Poincaré's (1952) notion of *incubation* as a time for "mulling things over". Shuell also stresses the need for built-in time as part of the problem-solving process in a classroom setting. This is necessary because there is an adjustment period where the problem-solver is just scratching the surface of the problem, getting to know its contents before being able to embark on reflection. As Marshall (1995) also implies, the problem-solver needs time for organizing prior knowledge and for coordinating domain-specific efforts before even beginning to solve it. Shuell also points out a need for scheduling different classroom time-frames so that these problems can be dealt with on several occasions.

What are These Context-Rich Problems Like?

It is obvious that students do master basic computation skills during their elementary schooling years. They continue to build a repertoire of computational capabilities during these early school years. Most fifth-graders can add, subtract, multiply, and divide single to multi-digit numbers. They can also work with more complex problems that require applications of several computational procedures such as adding, subtracting and multiplying numbers in the same problem–a multi-step problem. In most fifth-grade programs, students are also introduced to more demanding tasks such as calculating percentages, working with fractions of numbers, and learning how to work with the numbers to the left of the decimal point. They are introduced to complex word-problems that require multi-step computational tasks such as adding up apple baskets gathered in one week, and predicting a monthly yield of apples. If asked to do so, they can also generate a pricing strategy for apple collection.

The question arises as to whether youngsters are encouraged to take a simple problem one step further. Do teachers take the time to extend problems and to transport them to more life-like situations where students can see the application of their computations and procedures? Some mathematics text books do suggest extensions of problems and some students do them independently or with their teacher. These real-life applications help foster critical thinking and creative problem-solving.

Edward de Bono (1969) suggested that this type of thinking should be encouraged and taught in schools much in the same way that sports and other physical activities are taught and encouraged as productive and conducive to sound educational practices providing positive results in children. According to de Bono, (1979) the more the brain is stimulated, the more its tissues become "physically fit". However, young fifth graders can also be taught to predict, to project figures on a time-line, to analyze previous results and to apply these to mathematical concepts. They can progressively move on from the simple, textual word problems to ones with more complex thinking processes.

Summary

As evident from recent scholarship and research, steps are being taken in many school settings to provide more dynamic, context-based instruction in mathematics. Student interaction is encouraged through group work and through student-engagement in life-like scenarios. Mathematics is being taught in more context rich and interactive formats and students are learning to refer to mathematical operations using the more appropriate and domain-specific nomenclatures.

Current research suggests that students need to work even more on mathematical problems that offer them a challenge and that engage them in solving problems that require multi-step processes. Research and pre-service teacher training programs stress the need for cultivating adequate discursive practices between students and their teachers. Teachers are also encouraged to model problem-solving styles so that their students can learn from these models. Technology and innovation in education continue to offer more specialized tools for teachers and students in mathematics classrooms. However, a computer or a pocket calculator will never replace the value of a meaningful or authentic teacher-student exchange, where the teacher provides the scaffolding that the students need to become independent learners.

Finally, there are new educational currents that tailor educational programs and educational materials to the contemporary needs of today's students. Teaching materials generated by modern publishing companies attempt to integrate modern societal values and cultural beliefs, all in an effort to improve educational practice. Researchers often gather brief samples of classroom interaction because longitudinal studies are not as easily carried out in today's highly mobile societies as they were in the past.

The next chapter presents such a school-based program, describing its structure, mission statement, classroom management and problem-solving culture. Domain specific literature reviews accompany the narratives exploring different aspects of the problem-solving process.

Chapter 3

The Research Site

This chapter contains a more detailed description of the research site as well as the program and educational community to contextualize and substantiate the narrative portion and the examples provided. St. John's Elementary School offers an elementary and secondary private, co-educational day program for students of diverse backgrounds. Its mission, as stated in the school brochure, is to:

> *...Help children become well-informed, thoughtful and innovative...A young adult with the insight and confidence to make an effective contribution to our rapidly changing society. Self-expression, a respect for others, and personal accountability are promoted. (p. lx)*

Its philosophy reflects "Academic rigor taught in an environment that is both flexible and creative". The learning environment of this school promotes collaboration and self-reflection. Students are involved in community outreach programs and are encouraged to participate in a Student Council whose philosophy stresses the importance of assertiveness offering students opportunities to voice their opinions and to become vocal advocates of their beliefs, ideas and convictions. In keeping with the development of self-expression and intellectual risk-taking, all youngsters are encouraged to participate in school governance. Shy and out-going students are encouraged to participate in activities that allow them to develop their voice by assertively learning to govern themselves. Parents are also encouraged to participate in school-wide events. They are well-informed of school activities by a weekly newsletter which is delivered to them. Parent-contributions are also welcome in this publication. An after-school program is also in place to assist students in developing such skills as time-management, and good study habits. A guidance counselor works closely with students and parents assisting them in conflict-resolution. The philosophy that guides these programs is also that of helping the child become a vocal advocate for himself. For example, the way in which the child's report card is shared between the child, teacher and parent encourages the child to stand up for himself. In so doing, he is encouraged to explain his work strategies, his classroom involvement and engagement with the different subjects he has to work with. As the child, the parent, and the teacher discuss the results of the report card together, the child is able to interpret directives and to openly voice personal concerns and doubts.

Staff and educators in the school encourage student-dialogue as early as the pre-school, where creativity and logical reasoning are valued. In grade one, for example, students follow an integrated curriculum delivered through an inquiry-based approach. They work on thematic units that integrate language arts and the sciences as the students study a particular topic. Individualization and group-work are also encouraged. Students in all grades learn in a problem-solving environment. Classroom-based projects assist students not only in becoming advocates for themselves, but also in learning how to express themselves openly. Ultimately, this exercise results in direct, hands-on classroom activity, nurtured by educators and staff that enjoy and value student-centered teaching.

The Elementary School Program

The school is designed for small-group interaction. Each grade level has approximately 25 students. However, for particular classes, large groups are divided into smaller groups of 12 to 13 students. Besides the regular classroom teacher, there are several specialists and teaching assistants. Students are encouraged to discuss and share their knowledge and ideas with others. They choose what they want to read and write about. The four aspects of Language Arts (reading, writing, speaking and listening) are integrated.

The Fifth Grade Program

Fifth-graders are encouraged to:

> *...seek out information, organize facts and ideas, communicate effectively both in speech and in writing, work independently or in cooperation with others, read with comprehension and enjoyment, and listen and think and read and write critically and creatively. (Fifth-grade syllabus)*

Their program (see appendix # 7) is based on reading in content areas where the following skills are encouraged: (1) language arts (2) critical thinking skills (3) map and global skills (4) graphic interpretation skills and, (5) cooperative group work skills. They read several kinds of texts and genres and respond to readings either in a reader's log or by conferring with their teacher or peers.

Children write daily, for diverse purposes and in a variety of formats, (journals, reading logs, creative genres, reports, etc.). They are asked to (1) organize ideas (2) express these with clarity (3) edit and revise (4) use writing conventions correctly (5) produce reader- appropriate texts.

The mathematics program has a problem-solving focus. Students are encouraged to (1) develop their thinking skills, (2) develop their ability to solve mathematical problems, (3) self-assess their needs. There is a clear demarcation between the **conceptual** (understanding of the problem) and the **procedural** (skills and operations). Children work with a text-book that emphasizes procedural skills development. They are held accountable for knowing their tables and facts. However, they are also encouraged to think critically and to explore, use, and understand the mathematical concepts in more depth. They are provided a ninety-minute weekly problem-solving class where they work in small groups applying their skills and their abilities to solve real-life mathematical problems.

A Problem-Solving Environment

The school grounds used to be a curling rink and continue to blend in nicely with this residential sector of Montreal. Perched on top of a hill, it is surrounded by small play areas. Space is well distributed. Environmental projects such as the "Forever Wild Area", a nature trail, are cultivated as school-wide projects. Small play-fields and courts make room for an outdoor amphitheater which blends the arts and sports masterfully.

The main entrance is a problem-solving experience in and of itself. It is enlarged by a creative use of hallway mirrors and a combination of colors that pleases the eye. The principal's office is always open, yet she is seldom there. She is usually walking around the school, helping children into their coats and boots, watching children at work, or sitting on the rug, reading with children, and sharing their daily snack with them.

Wherever I look, I feel that somebody has solved a space problem with care and with a desire to maximize comfort. The teacher's lounge is a small, cozy room with fruit bowls laden with seasonal fresh fruit, a cookie jar with home-made snacks and freshly brewed tea and coffee. This welcoming teacher's lounge promotes a sharing and caring environment among the teachers avoiding inter-personal problems that often exist in schools.

Time-management is also a unique problem-solving feat. A lot of time is usually wasted in cloakrooms and hallways in many schools. Disputes usually arise when so many children are trying to do so much at once. However, this problem is cleverly addressed at the school and you will seldom see a tired teacher nagging at the children to move on to the playground so that she can catch her morning coffee. On the contrary, the meal-monitor takes over this duty for the teacher. There is little argument, pleading or manipulation of youngsters because hallway rules are firmly set and followed.

The School Principal

The string that holds all the beads together—as in a pearl necklace...(conversation with Miss Z , Aug.98)

The principal frequently partakes in classroom activities. She is a welcome presence in the classroom and joins the students while they work. The students perk up when she arrives and enjoy her presence. She knows everybody by name and often delivers messages to students reminding them of after-school appointments. She also reads what students write and watches them at work. She is seldom in her office and is usually dynamically engaged in the school program.

The Fifth-Grade Teacher

The fifth grade teacher, Miss Z creates a very special learning environment for her students. She is very well-liked by her students who often tell her how much they appreciate her. Here is an excerpt from my first day's field notes

> When Group 2 returned from play, Miss Z asked them what they'd say if they'd write a report card for her, here are some comments:
> You have a lot to say
> We like the way you express yourself
> We don't like the way you scratch your nail along the black-board
> You write on the computer without looking
> We like how you help us
> You're fun
> We like your style
> You're cool
> (F.N. 11/23/97)

Her sense of organization is contagious. Youngsters imitate the way she puts things away, and the way in which she organizes materials, events and learning spaces. They address her by first name and she in turn, treats children as important people. On one occasion, I noticed how the children imitated her record-keeping system:

The teacher has introduced "keeping a list" as a concept. The children have internalized this. It was highly evident when two children asked for some "empty" class lists for an un-related activity. They unknowingly internalized her system. (An.Mem.#13/6/98)

She is a systematic time-manager and space creator. Every bit of floor space is wisely used. She also empowers students by assigning them grown-up tasks like being chief researchers or investigators and designating them to be (1) *primary resource* people; in charge of encyclopedic/dictionary facts, or (2) *head researchers*; in charge of compiling and managing fact files. Her proximity to each learner is commendable. She uses student's invented vocabulary and language to reach them, like repeating Dianne's *partner dots.* She then shifts to a conventional language mode to teach them. She celebrates the children's inventiveness with lively encouraging remarks like:

> "Gina's strategy reminds me of somebody who is sewing, wrapping things around corners."

She organizes those groups of children who will work together, sometimes in gendered-pairs, sometimes in mixed triads or groups of four so that she can assist those students in need. She models the mathematical register, repeating words frequently so that children internalize them. This next excerpt from a vignette illustrates this:

I watch the teacher as she breaks down the steps in a problem and repeats the phrase, "... this represents this and this represents that." Whenever she talks to students she has them use the term "represent" incorporating it as part of the mathematical register. Miss Z says, "This figure represents the number of factors this number has and this other figure represents the factors that both numbers have in common. If we substitute what these numbers represent by these figures, we can devise an algebraic equation to represent or substitute all of these numbers." (Vignette # 1:1/98)

She keeps close eye-contact with the students, taking notes while they speak to her and remembers what they wrote down the day before. She often moves around the room and sits with groups of children to "eavesdrop" telling the children that this is her way of witnessing how they think. She circulates from group to group unexpectedly, joining the group as another member. Her interventions are never derogatory or judgmental. Whenever a child is wrong, she'll let him continue working until he realizes his error himself.

Classroom Composition

The class is composed of twenty six students from multiple origins and back-grounds. Cora, for example, comes from a First Nations community, while Dianne is Egyptian. Justin T. is from Japan while Justin W. is from Montreal. Adelso is Italian, Gina is from India, Myra and Wayne's families are from Great Britain, Jules' family is Roumanian. The multi-cultural/multi-lingual aspect of the classroom demographics, as well as the context in which the students work adds life to the already dynamic interaction that prevails. The children come and go freely in this small classroom. They do not bump into each other or get into each other's way. They work well together using appropriate vocabulary and applying appropriate writing skills that allow them to articulate explanations (in both verbal and written form.) They have learned to cultivate writing as an art-form, enjoying reading and writing in different genres during their Language Arts program. They have also learned to speak to each other politely and to respect their differences. For example, most students speak up and speak out if they want to. They are not restrained or constrained by classroom rules that limit their verbal interactions. However, I rarely over-heard children speaking to each other in a derogatory fashion or using rude, loud language. Students are free to come and go without having to sign out or ask permission. Although classroom-space is reduced, students move around without much confusion and noise. The requirements of the problem-solving program in mathematics are such that students must read, write and talk about mathematics in real contexts using real examples and tangible objects.

Focusing on an Individual Child

I enjoyed working closely with the children and often interviewed them separately to capture what it was like for them to solve problems.
The following is an excerpt of an interview with Mark after he had successfully solved a difficult problem. He was explaining his strategy for the next problem and being very creative with language:

> *I am watching Mark celebrate. He is so happy he figured out the problem. I ask him to explain it to me. He says "I put these "here's" over here and then these other "here's"over there. I tell him, "what if these "here's" don't fit..."* (F.N. 5/16/98.)

As I interviewed Mark, he told me that he usually does not understand the problem, let alone solve it. He also told me that he usually seeks the teacher out for assistance and that he does not have much confidence in his problem-solving ability. However, something clicked for him that day and his cheering and shouting were contagious. He added, that while he was making *squiggles* something started coming into shape for him and that he began to see all kinds of patterns emerging. I asked him how he felt, and he told me: " I cannot believe it. All of a sudden I saw these patterns in my head and I solved the problem.". He couldn't believe the fact that he had solved a problem all by himself, and probably before anybody else in his group. I then asked him if he thought he would be able to solve the next problem. He told me that he now "Had the power" and I interpreted this as having a sense of agency. We then talked about the *Burrows Problem* with which he was engaged in next. He had not only created intricate drawings for this problem, but was able to explain his strategy to me as well as invent words about it. The Burrows Problem (see appendix # 2) gave me new insights about all the children. I was already familiar with this problem from the previous year. Because this two-step problem continues to produce such original and unique solutions, I will revisit it in the following section.

The Burrows Problem Revisited

This is an interesting problem that requires the student to work from a plan and to divide the task into several steps, and cannot be solved by performing simple computations. However, some students tend rush the process thinking that it is a simple multiplication problem. When
The teacher realized that several students were not approaching the problem properly, she sent them back to start all over again, asking them to describe each step. She also reminded them that they had an entire hour in which to work. Soon the only perceptible sound in the room was that of pencils and crayons scratching paper. The students were actively engaged in drawing and coloring houses, huts, squares, bubbles or circles and connecting these with intricate webs which soon became tangled meshes. Untangling the meshes was the next problem to solve. Some students resorted to color-coding, others to record-keeping and others to numbering. This fascinating episode revealed how each system resembled the child. I was not surprised to find that some children resorted to merely writing while others sat in quiet contemplation.

The following excerpt from an interview with Gina, Justin and Don is an example of how they talked about the manner in which they refined their particular strategy:

***Researcher**: What did you do?*
***Gina:** I color coded to differentiate and put my burrows in descending order from 8 to 1. I realized that there was one less burrow to connect...I'll show you.*
***Don**: Do you seriously understand?*

Justin T.: *How did you check?*
Gina: *I write down 1 goes to 8, 2 goes to 7, 3 goes to 6 and so on.*
Don: *What if you made a mistake?*
What if you counted one twice?
Justin T.: *That was last time.*
Don: *It might not work.*
Gina: *He's connected 9 tunnels to 8 entrances getting 72 as an answer...burrow 1 = 8 tunnels*
Researcher's notes: *The tunnels are added 8 + 7 = 15 + 6 = 21 + 5 = 26 + 4 = 30 there are 36 tunnels. The clue was in saying every* ***other*** *tunnel, some students figured out immediately that their 9 x 8 = 72 model would have to be halved resulting in 36. Those that drew burrows and distant tunnels not trying to create webs got a better idea from their un-meshed pictures.*(F.N.5/16//98)

These procedural decisions revealed that the students are (1) independent thinkers (2) willing to retrace their steps and (3) ready to take a new risk and start all over again. They have retraced all of the required steps and functioned properly while doing what is expected of them. They have also been validated and appreciated by the teacher, who encouraged them to take the problem a step further, or as in the following excerpt, to realize their mistakes on their own:

Wayne stubbornly stood by his duplication theory until somebody could prove him wrong. The teacher, not wanting to disprove him, helped him reconstruct the problem along with everybody else, engaging the entire class in helping Wayne see where he could have possibly gone wrong. In doing this, the teacher was able to not only model what theoreticians and mathematicians do with the process, but produced excellent outcomes. Wayne is a very different, very creative thinker with a mind of his own. (F.N.5/25/98)

The Manner in Which The Classroom is Managed

From a classroom management perspective, it was interesting for me to see how students understood the problem better as they spent more time on it. Time and exposure were significant factors in the process, resulting in yet another problem-solving technique. Initial reactions to the problem could have resulted in premature, simplistic solutions. However, the teacher ensured that the students understood the importance of taking the problem apart and putting it back together in a mathematical format. Usually, when story problems are presented to students in written form, students do not see the mathematical component unless asked to do so. This thorough explanation of the problem, taking it apart in a literary context and redefining it in a mathematical one is an important portion of the problem-solving process. It allows students to transfer the textual component of the problem into its mathematical component. Children can easily lose interest, and often have difficulty interpreting the mathematical component of a problem. This is perhaps why they sometimes come up with simplistic answers that only touch the surface of the problem.

What I observed in this session, however, was quite different. Because the students had been taught problem-solving strategies and time-management skills already, and because problem-solving is an integral component of their curriculum, this process had an added value for them. Both the teacher and the students cultivate the use of appropriate vocabulary and the necessary writing skills to articulate their interpretations and explanation of the problem. And, the requirements of the program are such that students cannot just brush these problems aside to engage in other, more playful activities. On the contrary, no matter how simple the problem is, students are asked to formulate a hypotheses, to write an equation for the problem and to prove its solution. They are allowed to move about, talk to each other, or to write things down in their planning notebook. However, they have to show their work after the first phase of the session. Hence, their thinking processes, whether verbal or written, are valued as drafts and as work-in-progress. The ultimate goal of the program encourages students to come up with a solution that they can explain to somebody else, and in so doing, to understand it better.

As the students drew lines, color-coded them and counted, the word "count" acquired a new meaning. Because the students had been encouraged to "count" every other burrow, the word "count" had a visual meaning for them. The one that did not count, was really a line that connected every "other" burrow. Realizing this, they were later able to understand that they only needed one and not two entrances to each burrow. As the students drew, erased and colored, they would also yell out whatever they were doing as if the act of drawing lines helped them see patterns of lines.

Another instructional aspect that impressed me as a good management technique in this classroom was the settling down behavior of the children. I noticed that after listening to the problem for the first time, they were relaxed and calm. They either waited for their turn to read the problem out loud, or listened to somebody else reading it. The teacher intervened after each reading to reword what the student had just read using this shared time to build a framework for the children. Their relaxed demeanor assisted this creative interpretation process because the children were very attentive to what the teacher was explaining. After each student read the problem, she addressed the entire group, reminding them to "count every other burrow", stressing the word **other** each time. Sometimes, she would point at children to illustrate what she meant by the word other. In so doing, she created a context-rich scenario to represent the problem for the children, allowing them to visualize it. This stretched, context-rich explanation time where key words are massaged frequently until they become relevant is an excellent teaching strategy often under-used and over-looked by teachers who are rushed by curricular constraints or a time-bound program.

This *stretched* time spent on the problem transferred to the solution-building strategies of the children. For example, some children, at an early stage of the process, realized that the problem was not such a simple multiplication task after all, merely because their calculations did not fit into even slots. They then proceeded to divide and multiply more carefully as Miss Z had modeled for them. Her request to (1) work from an organized list (2) to draw a picture (3) to check out their procedures and, (4) to write about them made sense to them because in so doing, they began to understand the problem better. They now could understand, from participating in this shared experience, that being systematic and organized was part of the solution.

Those students who had trouble keeping track of their web-like lines and connections, and who had to re-start because the problem was getting out of control, could now appreciate the value of this strategy.

When those children who could not follow this systematic format with ease, perhaps because it did not reflect their learning style, the teacher reminded them to remain calm and not to be afraid of making wrong choices. She high-lighted the value of risk-taking.

As researcher, I found that those students who wanted to solve the problem abruptly (like the *quick* multipliers) did not give themselves enough time to "dwell with" the problem. They became over-anxious after the first twenty minutes of exposure to the problem without giving themselves sufficient time to set up a framework for solving it. I appreciated the manner in which the teacher handled this problem. She encouraged those anxious and flighty students to stop working on the problem for some time and to do something else in the meantime. In this way they could relax and start afresh. Some students picked up a book to read or made drawings in their notebooks. Again, this was not only a good classroom management technique, but also an excellent problem-solving one. Mathematicians, scientists and problem solvers in general need to distance themselves from the problem they are working on. In this classroom, the teacher's reaction to this natural, non-productive stage was one of thoughtful understanding instead of rushing students or reprimanding them for seeming off-task.

Arbitration among students is also a part of the teacher's classroom management task. Often, teachers avoid situations where they have to group students that do not work together well. Usually, students like to work with their friends. However, I not only appreciated the manner in which the teacher solved this problem, but also the way the students addressed each other in this classroom. I realize that children do not stop being children in classroom settings. A lot of the usual ten-year-old behavior did surface in the classroom while I was there. For example, when working in groups, some children would snap at each other abruptly, yelling: "Guys! We've got to get this down right!" At one point, Dianne and Alana yelled at Don and Jerry who started building an airplane out of lego blocks instead of focusing on the problem.

However, these students talked to each other very candidly, saying what they mean to say. The teacher dismissed unacceptable behaviors before they got out of hand and managed the children wise and productively. She would approach groups who were too loud and would stand there until the noise-level settled. She would also call on delinquent children and speak to them in private.

One day, I arrived in the middle of a "Town Meeting" (which is an informal group meeting where everybody has a turn to speak.) The teacher had kept the children in during "first play" to speak to them about an issue. She told them how she had interpreted this particular behavior, cited examples of how it could be improved and listened to the children's reactions. The issue was settled then and there and the children were dismissed.

In terms of groups of children working with each other, success and survival in a classroom setting for a youngster depends a lot on the way she integrates into a group and how she adopts the classroom's discourse style. I noticed that certain children did gravitate towards each other cultivating group preferences. However, the teacher monitored group-behavior closely keeping a list of who worked more frequently with who and re-grouping children frequently. She managed the groups by a problem-solving style reflected in the classroom notebooks. Hence, she used her own criteria to form groups depending on the problem and avoided group-preference requests from the children. Her decision to distribute the classroom's demographics fairly was a wise classroom management choice.

Time, as a classroom management issue, was well-handled both by the teacher and the program. Sufficient time to carry out the different components of the problem-solving process was addressed adequately in this program. Time is considered a factor that contributes to the problem-solving process. Hence, most of the problem-solving sessions that I observed were extended periods of time that lasted for two ninety-minute classroom periods.

Time-on-task was also addressed adequately in the sense that the problem-solving task was divided evenly among these sessions. For example, during the first session, or the exposure portion, the students gathered around the teacher for instructions. During the following session, students were given new instructions about what to do next. Hence, they parsed the process into two or more sessions depending upon the difficulty of the problem or the time they needed to complete one of the portions of the problem-solving process.

For the written portion, it was clear, that once the students understood their instructions, they were required to reflect on the problem for an extended period of time. This was usually carried out as silent, independent seat-work time. After this independent seat-work session, the class would reconvene a week later to discuss the results of this silent reflection.

The teacher would have read the student's notebooks by then and would have responded to each of the students in writing. She then created the pre-organized groups that would work together during the following, the group-work session. Groups were formed according to either similar problem-solving strategies or similar problem-solving processes reflected in the students' notebooks. She would often share her grouping criteria to clarify her choices.

Miss Z avoided making judgments of the children's ideas or strategies. On the contrary, she would share the uniqueness of student responses publicly. In this way, she allowed the children's originality to surface and celebrated their inventiveness. To illustrate, in the case where Wayne insisted on doubling his tunnels, the teacher allowed him to convince her that his answer was correct. She engaged him in conversation, was not confrontational or reprimanding and allowed him to proudly present his solution to his peers. Lakatos (1977) would probably agree with Wayne in saying that "Nothing is right until it is proven so." Wayne insisted that there were 72 tunnels when there were only 36. His explanation was rich in detail.

However, the teacher and his peers managed to temporarily convince him to halve this figure and to "use" 36 as a viable answer. This reaction was much in the spirit of mathematics, where testing out possible solutions helps find the right one and to prove it to be so.

Noise and distraction might shock an unfamiliar onlooker or visitor. He might also be surprised to find students sprawled and huddled everywhere. There was a lot of movement in the classroom, and the teacher encouraged mobility, during this, the group-work related portion. She circulated among groups of children tolerating quite a bit of noise while the children were productive. She did re-direct students to engage in more focused and productive activity if she had to. Generally speaking, this open form of classroom management resulted in a good problem-solving atmosphere, because most children were engaged in: (1) listening to each other, (2) working with with each other (3) generating productive strategies and, (4) exploring a unique form of learning.

An advantage to this particular classroom management style, is that it frees up the teacher allowing her to circulate and to observe children more closely or to become a "kid-watcher". It also allows her to reflect on her own practice and to adjust her teaching style to her learners' needs. She has more time on her hands and can also assist needy students individually.

The Silent, Independent Student

I noticed that some of the more withdrawn and quiet students benefitted from being in this interactive classroom. Don, Cora and Adelso, for example, would watch their group-members at work and would only speak when spoken to. They learned from watching other group-members or took on the role of designated archivist, or record-keeper for their group. Sometimes, to ease them into a group, Miss Z would assign them this role. When I spoke with these silent students informally I could appreciate that their participation was as active as the more dynamic group members. They had gleaned as much from the experience as everybody else, expressing what they had learned in their writing or when they conferred with the teacher. I also talked to their peers who worked with them and asked them how they felt about their partner's quiet demeanor. The usual response to this was that it was either a matter of shyness or simply a student's personality. They implied that these students were good listeners and were appreciated for being that way.

Group Work in a Multi-cultural, Co-educational Classroom

I observed how girls and boys work together and apart, depending upon who they were assigned to work with or on the problem itself. I was able to come up with interesting observations on the nature of gender dynamics in the elementary classroom. The dynamics of the problem, the timing and group dynamics affect how boys and girls work together. Sometimes they work well and sometimes they don't. Girls like to take on a diligent stance in the initial, setting-up stages while boys pick up a pace of their own as they process the problem. To illustrate, while Dianne was explaining the Readers of Samwana problem (see appendix # 9) to her group of four, she picked up a set of lego blocks to illustrate her point. Two boys in her group began playing with the lego blocks building toys to play with together. In this short time-frame several events happened, such as the following: (1) Dianne laboriously explaining her point of view assisted by the lego blocks, (2) Donna obediently watched and agreed with Dianne, and (3) the two boys were playing and not paying attention.

Now, who is to say that at that point in time, while the boys were playing with the lego blocks, they weren't figuring out the problem in their heads? I did not have time then to ask them, and did not want to. However, when I watched the video-tape many weeks later, I did notice that they appeared to be listening while playing. Their playfulness was a form of *process delayer* which masked their apparent non-involvement. Dianne did snap at them by saying that their playfulness was distracting.

My concerns about inter-gender interaction were shared with the classroom teacher, who tried to address gender differences as wisely as she could. I met with her after the school year was over to discuss some of my observations. I asked her about the playful boys and about these girls who like to take on the more laborious tasks of archivist or secretary. The teacher contended that this secretarial role **is** an important role and that some students take pride in assuming such a role. She pointed out, that from sheer observation, most girls take pride in their organizational skills at this age (conversation with Miss Z, 8-27,1998) cherishing their working tools like markers, pencils and other *colorabilia,* a word that I have coined to group these items. She added that girls like to cultivate different styles of writing and different forms of address at this age. From her point of view, it is a natural growing stage that girls experience when in grade 5. As per the boys who engaged in playful schemes rather than staying on task, we also talked about the different work-desk behaviors of boys and girls. We agreed that boys in grade five need to be active and bouncy. Many children cannot be expected to sit still for extended periods of time. Looking back at personal experience, I might add that girls at this age are also dynamic and cannot be held back either.

The Public Problem Solver

A culminating portion of the problem-solving process, and an important component of this classroom's schedule, was to present the group's solution in public. One student had to represent the group in front of the entire class with her group's findings. Usually, students would appoint a designated speaker to represent them. Frequently, the student who understood the solution best would be selected. Often, the teacher would re-appoint somebody who had never had a turn at the front of the room. There was a marked difference in the demeanor of the child presenting in front of her group and presenting in front of the entire class. However, if the child understood the problem well enough, she was successful at both presentations. Some groups had their designated speaker rehearse ahead of time to avoid embarrassing situations.

From watching these groups closely, I noticed an interesting phenomenon. I consider it an age-related form of self-induced effacement when sharing a group-related activity in front of the entire class. To illustrate, when students came up to the black-board to demonstrate their workings, they tended to quickly erase whatever diagrams or calculations they had written on the blackboard. My interpretation then was that they did this to avoid criticism. On one particular occasion, a group of girls had decorated their blackboard samples, ornately displaying the problem's solution with added detail. They suddenly erased it all off without allowing anybody to see their drawings. On another occasion, an all-girl group drew a chart that they had developed to calculate the problem. Before anybody said anything about it, one of the girls erased her drawing saying: "It's silly, it won't work. Forget it." I then attributed this erasing reaction to audience sensitivity. I now view it as that sensitive problem-solving state when these raw calculations are still un-sustainable conjectures that this age-group is yet not ready to share. For example, while watching a child explain something to his group, he would quickly erase whatever *raw* predictions he'd been making on the paper. Somehow, either the child wasn't sure of what he was producing or he interpreted group reactions negatively and was discouraged. What I learned from watching these public and group interactions was the importance of positive confirmation from peers. I realize now that youngsters need positive confirmation from their peers. I describe an interesting dynamic that reflects this type of positive form of peer-confirmation.

I noticed this peer-confirmation while watching Jerry and Dianne who were working on the same problem but not in the same group. They had both perfected a little system of their own for counting and for keeping track of their calculations. After frequently succeeding they cheered happily. Dianne walked over to see what Jerry was so happy about and vice-versa. This went on for an extended period of time without anybody else noticing. They both took joy in the fact that they had devised a system of their own. They also gave each other secret encouragement. (F.N.5/18/98)

Boys and Girls Secretly Sharing

Watching the interaction between Dianne and Jerry more closely, I noticed something exceptional. Towards the spring time that year, when students had already had lots of exposure to the problem-solving process, and had refined their particular ways of knowing, I noticed a series of new dynamics emerge. Dianne and Jerry would pace the floor watchfully helping each other out on several other occasions. They would walk over, peer over each other's shoulder and hint at the possible solution. This form of collaboration was a very quiet almost unnoticed form of peer validation. I now interpret this collaborative support as a form of shared problem solving, a form of *kibitzing.* When Dianne walked over to Jerry's desk for the first time, she asked him, "Did you get it?" He didn't answer much. The next time, he answered "I'm getting it." She didn't say much at that. Finally, when she had already put all of her things away and was ready to move on to other activities, she walked over a last time and whispered a procedure to him. He hunched his shoulders and said, "I know. I already did that."

Talk and Interaction

Talk and classroom interaction gathered during the mathematical problem-solving events in this classroom was representative of the learners and of the activities that they were engaged in. There were different forms of talk as well as forms of non-talk which revealed the different stages of the problem-solving process and the different needs students have while experiencing them. Sometimes, the youngsters uttered rhythmic chants that resembled the physical processes they were engaged in while problem-solving. For example, if they were counting sets of items, their counting was assisted by an invented song or chant that used the words of the problem. Sometimes the words to these chants were un-intelligible, but the rhythm and the movement that accompanied them resembled the strategy being used. At times, the youngsters engaged in individual or joint activity that required extended periods of silence. Students were either very concentrated, counting and keeping track of numbers, or they were thinking silently. Some children were quiet during most of my visits. They enjoyed watching others at work and seemed to learn in this quiet way. Sometimes talk and interaction were minimal, perhaps a few brief comments, or a nod. At other times students asked each other procedural questions about how to get started or where to hand in an assignment when done. These brief exchanges merely ensured them that they were on the right track, but were not geared towards discussion and engagement. Forms of parallel talk also surfaced. These showed the youngsters talking along as they worked, perhaps sounding out ideas to themselves, not necessarily establishing a line of communication with each other. The common denominator was that different forms of talk and interaction did assist the problem-solving process, and these forms of interaction represented the children's learning styles. Most students found it helpful to think out loud and to be in close proximity with somebody so that they could explain what they were thinking about out loud. Some students would even talk to themselves, or as I have described it previously, they talked to an imaginary interlocutor. This need to have somebody to tell things to leads me to infer that talk and interaction during certain portions of the problem-solving process assist the learner in a positive way.

Summary

This chapter has provided some contextual background from which to view the problem-solving process in this particular school setting. The structure of the school, its problem-solving environment, and child-centered mission, allow for a successful problem-solving program. Such general factors as a distinct problem solving program in and of itself, a nurturing and supportive staff, parental and community engagement, and a global perspective, contribute to the successful implementation of such a program. Classroom management that addresses such needs as sufficient time, adequate explanation of processes, scaffolding and supportive frameworks for children to build knowledge bases from, context-rich and challenging problems to work with, and a cultivation of talk as a form of explanation, are also factors that contribute to a problem-solving program. The children were able to experience the various steps of the problem-solving process presented to them in different time-frames. This parsing of the process allowed the students to reflect on each portion of the process and to interact with each other while focusing on it. Students were able to voice their views and to develop their audience sensitivity enabling them to develop a language for asking questions, for giving explanations, and for proving solutions. This problem-solving language is explained and described in detail in chapter five, where each problem-solving language form is examined in isolation.

Chapter 4

Methodology

In this chapter, I describe the methodology used, how I gained access to the school and the grade 5 classroom and how I established a comfortable working relationship with the students and the school staff. I also describe the manner in which my research tools and methodological approach assisted me in interpreting the realities and phenomena that began to emerge, and how both the methodology and approach shaped the research.

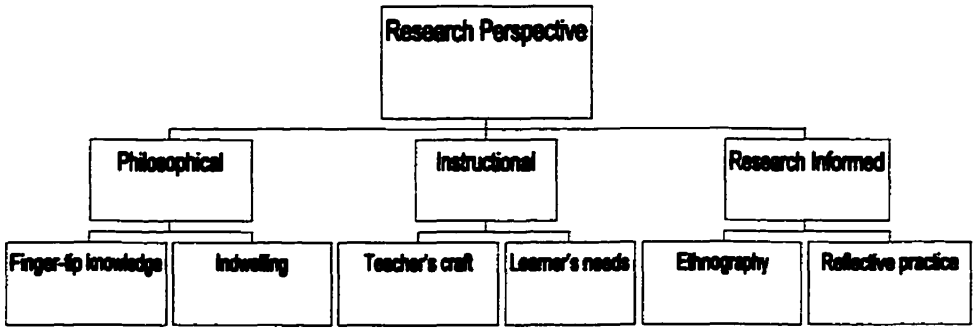
I begin by narrating how I gained access to the classroom for the 1997/1998 school year. I had already visited the school informally for a brief pilot study during the 1996/1997 school year. These early visits were different. I sat in the back of the room and did not engage in classroom activity. I re-defined my role as researcher for the 1997/1998 study. The teacher enjoyed my presence in the classroom, but did not want to be the object and focus of the study. She also shared a few concerns about classroom demographics and about a few structural changes alerting me to the fact that sometimes she would modify the schedule on short notice, or work on other material that was not necessarily related to mathematics instruction. I realized that my role was going to change because I no longer was a sporadic guest, but an in-house researcher with filming equipment and recording devices. Integrating into this classroom environment would also be different this time because as *participant observer* (Bernard,1998) I was also going to produce a written account of what I had experienced. To facilitate this entry process, the teacher, the principal and I planned a progressive classroom integration.

Having gained entry to the ninety-minute weekly mathematical problem-solving events, I agreed to spend the first few months merely observing and writing field-notes of my classroom observations. I would then progressively introduce audio and video equipment to record whatever classroom sessions were of particular interest to me. As a result, I gathered thirty (30) hours worth of video recordings, ten (10) hours of audio-tapes and many student-generated artifacts. I also interviewed staff members, students and some parents. Figure # 4 below shows the type of data that I gathered:

field notes	**30h videos**	**10h audio**	**artifacts**	**interviews**

Figure 4

My *research perspective* (see diagram on next page) was based on three strands (1) philosophical (2) instructional and (3) research informed. Each strand represents a personal data-base from which I drew inferences and came up with conclusions.



The philosophical strand is informed by my cumulative knowledge and 25+ years of experience as elementary school teacher.The instructional strand is informed by personal experience and by careful observation of how the teacher's craft and the learner's needs meet. The research-informed strand is informed by ethnographic research methods and reflective practice.

To illustrate how the three strands operate together, it is interesting to view the impact they had on entry, permanence and decision-making processes. For example, my presence would inevitably affect the flow of events in the classroom, so the teacher and principal decided to approach my introduction strategically. I would introduce myself to the children as another temporary member of their class, telling them who I was, what I did and why I was there. For this purpose, I shared samples of personal drafts of my writing in process and brought copies of personal research journals and diaries as well as photographs of my former students and Olympiad teams. I also told them personal anecdotes and brought my collection of photos from recent expeditions to the Amazon Jungle, thinking they might be interested in them. As I pulled out photographs of *Anacondas* and *Piranhas,* and began to tell them what it feels like to explore in this area, they began telling me about what they had learned in their *Rain Forest* unit. I stopped my account and listened to theirs. I think gained my entry into that classroom at that very moment, because we established a comfortable line of communication. I was able to work in close proximity with them from that moment on, and became to them Ana Maria, not just a researcher from the university.

Researchers often forget what an impact they have when they try to gain access to a research site. No matter how friendly or natural we appear, everybody knows that we are watching them closely. At that very moment when I cut my account short, I became Ana Maria, a person with whom anybody can talk to and at any time. Without having planned this informed interaction ahead of time, I gained their trust. There was a comfortable proximity that went beyond courtesy— they were not trying to be accommodating or polite, but were very natural with me. I also felt more comfortable about moving around the classroom and engaging them in conversation, or looking over their drafts, drawings and problem solutions.

I was able to incorporate technological equipment slowly, bringing my video camera (a portable, battery-operated Panasonic PV-704-K) after the first two months of my entry into the classroom. I would carry the camera over my shoulder and let the children use it whenever they liked.

At times, I could not capture their written work on my viewer and would need to leave the classroom to photo-copy a page of work. I brought in a palm-sized digital camera (PC-Still-CAM-KODAK-DC40, see appendix # 9) with a built-in flash to replace photo-copying. The digital camera allowed me to store legible records of the children's work in my computer and to retrieve and reproduce it later on paper.

Role of the Researcher

As *participant observer* I tailored my moves to the needs of the children, the school setting, and classroom management. I would usually test my ground before attempting to do anything new or to introduce something different. Changes in routine were usually shared with the students and the teacher ahead of time. For example, I would usually arrive early on Thursdays and Fridays before the children's "first play" (recess). I cherished this extra time to talk to the entire class informally, before they broke off into their two groups. I was also able to catch up with the week's events. Bernie, for example, provided the weekly update, keeping me abreast of the progress made in the mechanized lego block projects. Donna would share her Middle Ages project and the costumes she had carefully designed while John offered me a tour of classroom displays. These ten minutes of extra time became a special time where I would also share my own progress and whatever new equipment I would be bringing. I would test the impact of new filming devices on the students prior to entering the classroom and would also let them manipulate it avoiding distractions during the class period. What usually happened was that they would all want to take turns filming, and I allowed them to do so. Hence equipment, accessories, and my drafts were no longer a coveted mystery.

Some students became my regular assistants. Mark, for example, was my designated equipment monitor. He would help me package all the accessories before I left, keeping track of such small items as light-bulbs, cables and batteries.

Most children are sensitive to adult presences, however, this particular group was comfortable with mine. In this particular school setting, students interact frequently with adults engaging in informal conversation. They usually address adults by first name and work collaboratively with their Library, science and art teachers. It was not hard for me to engage them in conversation or to entrust them with responsibilities and duties.

Gathering the Data

Data-gathering required intuitive decisions on my part. I developed a keen sense of observation, knowing which child to talk to, when not to move around and when to leave. At times, the classroom atmosphere was such that it was not appropriate for me to be there. The teacher would warn me ahead of time that, there were parent-teacher conferences that day, an open-house, visiting day was scheduled, or that it was report-card conference day. On those days, I would avoid filming, and would merely observe in my corner. Such extra-curricular constraints as rehearsals for the *operetta,* student council elections, or preparations for out-door education week caused a few minor interruptions as well. On these occasions, the teacher would often post-pone or extend a problem-solving lesson, depending on the intensity of extraneous events. She would plan other activities that required less immediate concentration.

If I happened to be in school on those days, I would engage in other research activities, such as reading through the children's *math logs* and classroom journals, or merely observe them while engaged in non-mathematical activity. I developed a good working relationship with both the teacher and the students, establishing the fact that I was not there to evaluate their progress. I earned access to this classroom based on a level of trust and inclusion. Hence I was able to witness and record daily classroom events involving the children and the teacher

A Seasoned Teacher's Perspective

Anderson & Burns (1989) remind classroom-based researchers of how delicate their position is and alert us to be aware of the impact caused by our presence.

> *Given the role of values in research, we ask but two things of those intending to engage in research in classrooms. First, be aware of your values and their impact on the decision you make concerning research. Second, research by its very nature requires that you make your values explicit...(p. 15)*

The way we see and do things and the way we operate in a research setting affect our data-gathering processes and their subsequent interpretation. Hence, a clear portrayal of our perspective and our goals, to our intended hosts clarifies our purpose and makes this a more transparent process.

I realized on my introductory day, for example, that I was dealing with an interesting group of children. My perceptions, garnered from that introductory episode, affected the rest of my intentions and my movement around the room. I had to place the needs of the students first and foremost above whatever else arose in the classroom. They came before any of my research interests. For example, during one classroom episode, a memorable moment happened just when I was engaged in filming something else. Had I moved the equipment around or stopped what I was doing, I would have interrupted, or disrupted the other groups as well. That memorable moment did not get captured in film, but remains a vivid memory. Fortunately, I was able to reconstruct the events of the day with the help of the classroom teacher and the classroom assistant who had also noticed the memorable moment in great detail. This shared reconstruction of the events not only allowed me to share with the classroom teacher and teaching assistant, but also to establish my priorities more clearly. We all understood how wrong it would have been had either one of them beckoned me to stop what I was doing and to come and film Mark's special moment.

The shared verbal account was sometimes as valuable as a video or audio recording on that occasion. I had recourse to the drafts in progress and to other examples of Mark's strategy and could also interview him, which I did later. That day, when everybody had left for "first play" I asked Mark to tell me about his problem solving strategy. Mark had confided in me previously that he didn't want to be filmed because he didn't feel that he was a good problem solver. However, he conceded to a one-on-one interview and was very excited to talk to me about how he came up with a strategy that worked, and above all, how he felt after succeeding (see appendix # 10). He was also very excited to view himself on the television monitor and shared it with his friends.

Focusing on Learners

As I focused on each student as a learner, with a unique learning style and particular sensibilities, I made sure that they felt comfortable with my presence and with my recording devices. I identified those children who were intimidated by apparatus and avoided approaching their working spaces. I chose to walk around note-pad in hand writing down my observations generically, to avoid intimidating them. Because children are naturally curious, I avoided making particular remarks about them in these field-notes.

This openness with the children and the candid disclosure of my in-class field-notes was again a spontaneous research decision that I made conscious of the fact that children learn from observation and that they are naturally curious about what we adults do and how we do it.

Observing the students in other settings and other contexts was also helpful for me. The music and gym teachers would allow me to observe their classes as long as I did not distract the class. As I began to focus on individual students in different settings, I learned more about them.

For example, I got to know Cora, who was usually very silent better. during the mathematical problem-solving lessons. I watched her at play time and listened to her narratives about life in her community. Cora liked to draw and paint in art class, and she would often share her art-work or affectionately autograph a piece for me. She would usually watch others work during group work. However, I was able to identify this as her unique learning style. It was based on careful observation and a silent acknowledgment and recognition of somebody else's efforts. It was a form of validation and also of silent imitation. As she watched, Cora understood what was going on and was often able to represent what she had seen in writing. I often talked to her after class and found that she was very vocal outside the classroom. Lea and Gina enjoyed working with her. Lea in particular, enjoyed rehearsing in front of Cora and telling her what she was about to do. Both these girls valued Cora's silent presence.

My data-gathering methods, the spontaneous decisions that I took, and my relatively un-obtrusive presence allowed me to probe in areas where I hadn't thought that I would go to learn about the problem-solving process. Hence, I had informal conversations with other teachers in the school to find out how this same class worked in other settings. I also had informal conversations with the school principal and the teacher about my initial observations.

A Research-Informed Perspective

Working closely with the children allowed me to develop a new sense of awareness. This special sense was the result of my *seeing eye,* which I used to peer through the camera lens, and my *informed eye*, which I used to see where I was going. I developed these technical skills as my data-gathering stages progressed. Sometimes I would hold one camera in one hand and a notebook in another, to do both things at the same time, to film and write. I was able to look and to see with a renewed sense of awareness which emerged from the approach and methodology that I was using. This double perspective contributed to my research in teaching me to weigh, sift, and distill information from a new perspective. It is also perhaps due to the fact that I wrote and revised my field notes frequently and viewed my videos periodically.

Managing the Data

My original intentions were to look at the language, actions and symbol systems developed by the students engaged in problem-solving activity within a specific time-frame. New focal areas of interest emerged while gathering the data. This is why ethnographic methods and a qualitative research approach were more appropriate tools than statistical accounts or only quantitative research methods. The nature of classroom research, its unpredictable forms and the time-frame in which they occur requires a wide perspective that would not be well represented had I only used a quantitative research approach. I hence used interpretive inquiry (Bogden & Taylor,1975) and Grounded Theory Methods, (Glaser & Strauss,1965) to manage and analyze the data. In so doing, I produced early *write-ups* (Appendices Part II) of the *raw data* in order to carry out a coarse-grained analysis, hence collecting detailed accounts of events as they emerged. I avoided making preliminary judgments or jumping to conclusions while gathering the data, saving the analysis until the end. Once I had put together both the generic classroom write-ups and my after-class field-notes, I wrote *analytic memos* (Maxwell, 1996) to assist me in the preliminary descriptions that I needed for managing the data.

This writing process allowed me to choose where to go and what to focus on each visit. I kept accounts of these decisions in *contact summary sheets* (Miles & Huberman,1994) in point-form summarizing the objectives for each visit and the results. These written accounts were kept in a loose-leaf folder for easy access and retrieval.

Technical Constraints

Early technical constraints, were for example, failure of equipment, noise, and interference. I used Erickson & Wilson's (1982) sage advice, "...sacrifice the technical matter rather than inconvenience the people you are filming..." (p. 47). I eliminated the audio-recording sessions and introduced the Cam-Corder and digital camera instead.

Data Transcription

I transcribed my own recordings and developed a system for managing the hard-copy versions. Elinor Ochs (1979) suggests strategies of selectivity for filtering information, thus distilling that which is pertinent to the study, to the research questions and to the research trend.

Hence, I developed a system whereby I viewed the ten 3-hour videos several times. The first viewing was to write up a generic plan or trend about the classroom process. In order to support this viewing, I used my generic field notes, artifacts and summary report for the first video-viewing. Next, I wrote a vignette combining these with thoughts, perceptions and ideas about what I had viewed. While working, a *contact summary sheet* portraying that day's seating arrangements as well as an attendance sheet allowed me to account for detail and external events. Groupings for the day, times shifts, interruptions, announcements and other external factors were included in this account. My final account was written as a narrative which included

(1) seating arrangements (2) the type of mathematical episode (3) who moved where (4) who did what, and (5) conclusive remarks about the day (Appendix #11). I viewed each video several times and often avoided reading what I had written to see if I noticed any patterns emerging. I tried to *triangulated* my data from (1) the generic classroom notes and processed field notes of the day (2) the analytic memos and vignettes generated after the first viewings, and (3) my reflections and review of pertinent literature in the field. For example, the day that Mark figured out a problem and I reconstructed the events with the teacher and the teaching assistant, I wrote summative field notes about my personal interview with Mark and then viewed the reconstructed facts, the results of the interview, my own field-notes and annotations and Mark's reaction to the video as an event in and of itself (see appendix # 11). When I viewed the video a second and a third time, I brought previous notes along with me and wrote new and more detailed notes. At the time, I was exploring the concept of success as the result of *self-efficacy* beliefs, Bandura (1982). I might have attributed Mark's future success to his having succeeded that day. However, viewed within the time-line of this school year, Mark was more confident about his problem-solving ability; yet, he always sought assistance. His renewed confidence did not necessarily translate into problem-solving achievement.

Cataloguing the Data

My next task was to catalogue the data in some form. My first cataloguing format was based on viewings. This system changed as I accumulated more data to catalog. Dating events was another cataloguing device which was soon replaced by task-related cataloguing.

During third and fourth viewings I began to highlight events that had any particular pattern. After four thorough viewings of each video, I typed up all of the verbal interactions, all the student-teacher exchanges including whatever environmental or external factors affected the event. I re-typed these transcriptions as theater scripts as follows:

Example # 1

Visit #6 Jan.22/23 1998 Yogurt Ice-cream Sale Problem (tape-recorded) (Jan.22) *2.* ***Zack:*** *You can't repeat the number four times! We're using the wrong strategy! (F.N.1/22/98)*

This excerpt happened during one of the early stages, when I was introducing the first recording device (the tape recorder). I taped the children's conversations and also wrote detailed field-notes as they worked. When I transcribed the recorded information. My field notes assisted me in filling in for whatever events I missed. After typing an original draft, I then numbered the children's interventions during particular episodes and intercepted these with my own comments about what I was observing.

I identified the speaker and the action, spacing and numbering each speech event so that I could process it later on. I printed out these scripts in hard copy keeping all of them dated and properly sequenced.

When I started filming, I also used the same transcription strategy. I used a seating chart and my field notes to assist me.

Example # 2

I scan the entire classroom with the camera. I include close shots of bulletin boards and all sorts of classroom artifacts.
Video Transcript #1
Date of visit: Thursday, January, 29 1998
Group A
Problem of the Week: The Readers of Samwana
Gendered pairs assigned by Miss Z.
Time: 9:00-11:20
The children are assembled on the rug...

On my transcriptions, I identified the event, date, time, group and problem that the children were working on. I began an entirely new numbering system for each event. The following example illustrates my second video-recorded visit. Here, I record every event that occurred within that particular time-frame. Time is recorded along with student interactions as they go from listening to the teacher's instructions to working on their own.

Example # 3

Video Transcript #2: Date: Friday, February 13:Time: 9:00-11:20
Problem of the Week: Readers of Samwana-discussion: Group B
1. 13/2/98 Jerry's excited about "an easy way to solve the problem" he is cheerful and confident.
2.13/2/98 Dianne comes and sits across from him. They're all setting up their dividers...

The next example illustrates Zack's memorable moment. The transcription also shows what the other children were doing at the same time. This format was an interesting way to transcribe the data because it allowed me to revisit it later on.

Example # 4

> *18. 13/2/98 Zack's very excited about his diagram...he's got it all figured out and starts cheering like Mark did the day before. He checks with Bernie about the effectiveness of the color coding system. He begins to move rhythmically...getting up from his table...*
> *27. 13/2/98Zack starts yelling:* **"Oh, yeah...this is so good..."** *He's contagiously happy...clicking and singing...*

Creating the Strips

At this point, I was ready to hang up my coding strips. I used the hard copy to build a preliminary coding system for myself and hung up 26 strips of *masking tape* along my kitchen walls (see appendix # 12) I cut separate strips for each child's verbal and non-verbal intervention and participation. For example, Cora's strip does not contain much dialogue, because she is a silent student. However, I accounted for her group participation in brief narratives of what she did while others talked. Dianne's strip, on the contrary, is rich in dialogue and classroom interaction, yet dependent on Donna's participation. So Donna's strip hangs right next to Dianne's because they complemented each other in much of the group activity that ensued in the class. The same is true for Don and Zack, who enjoyed working together. Don, the more reserved student, usually held things up for Zack or assisted him in tracking number patterns. Don's participation is also a narrative that follows from Zack's verbal interaction. The following is a partial example of Dianne's strip:

Example # 5

3. 30/1/98 Dianne explains what Donna she and Don have worked on. Dianne takes the lead.
5. 30/1/98 Dianne smiles as she explains the group's calculations
8. 30/1/98 Dianne, Don, Donna, Alana and Zack eventually use the lego blocks. The girls are calculating with the blocks the boys start playing with the blocks.. flying them in the air. Dianne shows Alana and Donna what she has figured out.
9. 30/1/98 Dianne snaps at the boys and tells them to stop playing.

I hung the clippings of each classroom intervention or interaction in a dated and timed sequence. Don's string, for example, hangs next to Zack's and either contains explicit dialogue or the non-verbal activity resulting from Zack's intervention because both boys frequently worked with each other. This system for relaying verbal and non-verbal interaction not only assisted me in devising a coding method, but also helped me find recurrent patterns; in this case proximity. For example, being able to look at the strips individually, I was able to point out how frequently Zack sought Don out and vice-versa. I would not have noticed this proximity between the boys had I not broken down the events in this way.

Displaying the strips in this visible way, I was aware of all of the events that were going on in a particular segment and how they affected participants in close proximity or who were frequent partners. As I read the strips, I realized that length or frequency of classroom interactions were not important for my research. I started reading them more closely to decipher what was in them and what I could sift or distill to capture the essence of what I had observed in the classroom.

I frequently examined the 26 strips and decided to add two more strips, one for the teacher and one for the teaching assistant, because they frequently intervened and participated in the classroom. I was only able to notice this from examining the strips. Much later, as I examined the children's strips even more closely, I had to start a third strip— for the school principal. I had not realized how important her presence had been throughout the process. However, whenever she walked in to make an announcement or to join the children, I had written her behavior down as important. Hence, adult presences surfaced as significant data in the research.

Coding: a First Phase

During the first coding phase, while I was hanging the strips, I high-lighted and coded different types of intervention and classroom participation solely reflecting the problem-solving process. At that point in time, I was looking at dynamics of talk and group interaction. I then focused on individual children watching what they did while working on their own. I noted what it was that they talked about when addressing peers or an adult in the room. I later began to focus on more specific items such as, (1) children talking to one other child, (2) children talking to two other children, (3) children not talking at all. At one point, some gender-governed interactions seemed important to analyze, like the following excerpt:

> *Boys usually make the opening remarks...teams are sizing each other up. When asked to form a group of four, the girls side with each other and the boys do likewise. There's little collaboration or cooperation here. When asked what she plans to do...she speaks in a girlish/babyish voice..the other girl looks on playfully, also adopting this girlish/babyish demeanor. (F.N.1/18/98)*

Gender differences were not very significant as the school year evolved. After the Christmas holidays, for example, I brought a puzzle ball as a gift for the children. I watched them solve the puzzle. The following excerpt illustrates what I saw:

> 9:30 a.m. *Bernie takes the puzzle-ball I brought. I watch him assemble it. Edward and Jordan join us. They're all working quietly and on their own...one boy works while the others watch...there's very little collaboration...they watch each other, they each other instructions...they don't intervene or interrupt each other... Jon has joined Edward but they are not collaborating either.*
> 9:40 a.m. *Amalia approaches... (F.N.1/18/98)*

After watching closely, I decided to look at collaboration as a form of giving assistance, watching boys and girls helping each other out during other moments that required collaboration. As the year progressed the children's group dynamics also changed. I did not notice that many differences in the ways in which boys and girls collaborated with each other. The isolated incident with the puzzle ball happened during the first week of school after the Ice Storm of 1998, (Appendix # 13). The children had been away for over two weeks, and were still struggling with the effects of the isolation and chaos during this natural disaster that affected the entire province of Quebec. The teacher had also noticed the gender dynamics. She was dealing with this as a class issue, trying to break the pattern. For example, she would frequently have a boy and a girl work together on a task. Towards late spring, a lot of these gender differences had subsided. The children were working on the school operetta, which required joint rehearsals and lots of group work. They had also been working on a long-term project in class in which I observed lots of movement and activity. I quote from my mid-May field-notes:

> *I notice that youngsters have matured and are more down-to-earth with each other. They're not embarrassed to work in gendered-pairs anymore. The children are beginning to look different too. Some have styled their hair and are wearing trendy clothing that I hadn't seen before. (F.N. 5/15/98)*

Now, the hanging strips became a familiar landscape in my home and I "...was being close to and familiar with my data" (personal communication, Maguire, 1998) becoming more and more familiar with the children, with their growth and with the way they process classroom material. Although I wasn't their teacher, I think I got to know them almost as well as their teacher did because I watched them, read what they wrote, talked to them and saw them within a chronological time-frame.

I started to have a clearer idea of what some common threads were. I continued focusing on talk and types of talk. I looked at (1) who initiated talk (2) who changed the direction of a conversation (3) who initiated new talk. I found that there really was not much talk! An example from my early March notes illustrates this form of competitive talk:

> *Edward and Jon begin working. They start by measuring up and comparing how big their pictures look. Their dialogue is, " same with me...not me..." as if*

they were comparing...When one boy talks, the other boy agrees, saying, " I know...not really..." Or "so did I...I did this...no I did it like this..." I approach them, film them and let them photograph their work... they say, "It's mine...it is bigger than yours.." This sizing up dialogue continues until I leave. (F.N.3/24/98)

Sometimes talk was replaced by intent and by action. The brevity of some of the hanging strips led me to observe action and intent more closely. I viewed the videos for a fifth time. On the fifth viewing, I focused on physical actions and intentions observing such features as proximity, partnerships and other classroom activities that affected the particular group.

Collecting Artifacts

I collected anything that was printed and handed out such as school announcements, newsletters, student-generated writing and art-work and photo-copied their drafts and drawings during my school visits. I also made it a point to read whatever was posted on hallways and bulletin boards to keep me informed of the school's projects and community involvement. I also visited the library to see what the children were reading and to talk to the librarian, who provided me with an outsider/insider's glimpses into the reading interests of the children from her perspective.

Analytic Memos, Vignettes & Contact Summary Sheets

My *analytic memos* (Maxwell, 1996) were written in free style. After each visit, I checked the classroom report and wrote down whatever I couldn't write during class-time. I focused my writing on events that seemed pertinent at the time. I also kept a researcher's journal where I wrote down personal questions and trends I was seeing. *Memoing* (Glaser, 1967; Lincoln & Guba; Taylor & Bogdan, 1984) was a helpful research tool. Dated *vignettes* (Erickson, 1986) allowed me to triangulate and make sense of what I was seeing. Some examples of these research notes follow. This *Analytic Memo* (March 9, 1998) shows what I was thinking about towards the end of the data gathering sessions. It included my thoughts and doubts at the time and was written as a free-write draft.

Example # 6

> *Analytic Memo - March 9, 1998*
> *I've now made ten visits to the school. I don't hesitate each time I go anymore or worry about Miss Z not wanting me there. The Principal, Mrs. B accepts my presence and introduces me to visiting parents as the "in-house researcher who takes it all in"...*

I also created *vignettes* after several visits, which along with the analytic memos, allowed me to understand the events that were happening within a time-frame. This particular sample, shows how I worked around the concept of *talk as breakthrough.*

> *Talk as a breakthrough: Once Zack started explaining it out loud, it seems that the pictures in his mind did not coincide with the numbers... he's getting frustrated.* (Big.#1:/2/15/98)

I attempted to explain Zack's memorable moment in a manner that helped me formulate some answers to why this is so.

> *Once Zack started explaining it out loud, it seems that the pictures in his mind did not coincide with the numbers. He'd remembered the role-play activity the*

class had performed during the explanation stage.
Zack said: "That can't be, if someone tells someone else, then 12 people would be telling 12 other people, all at once, we'd have 24 people who knew and there's four opportunities of telling, so this won't work."
He only came to this realization by telling me and his partner about it.
(Big.#2: 2/25/98)

I also used contact summary sheets (see appendix # 12) to record events in sequence. These various recording systems allowed me to visit the filmed scene or the strips or even the particular moment that I was interested in. I would also make notes to myself in the form of *bracket*s and talk to the teacher about them.

I'm also noticing...that there is like a "second wind" once the student becomes"familiar with the problem"[stage] he realizes...that the process is deeper...It usually happens after the first half-hour.[Bracket on Vignette #1 to share with teacher]

I also noticed a particular silence after the first thirty to forty minutes of problem-solving time. This silence showed the children actively engaged, yet very diligent and quiet. Sometimes children drifted off into their own corners, working independently. If they worked together, the groups were also quiet:

Comparing the Data

I used the *Constant Comparative Method*, Glaser & Strauss (1967) to assist me in deriving more permanent categories which I then grouped into *Rules of Inclusion*, Lincoln & Guba (1985). Once the strips were individually completed, I color-coded significant patterns and similarities. I read the contents frequently, gaining familiarity with the codes and with the emerging patterns. This method also allowed me to compare data within the time-frame and to develop more permanent codes that withstood the time factor. For example, the gender dynamics viewed in early January 1998 were not coded in because they did not represent behaviors that prevailed throughout the entire year. However, *talk as breakthrough*, *competitive talk* and *extended silences* were codes that helped me formulate the *rules of inclusion* described in the next chapter.

A Glimpse into the Strips: What The Children Do

Not all the students in the class solved problems right away or devised symbol systems and a language of their own. During many of the problem-solving sessions that I observed, students worked independently. Some students shared tools and classroom materials or watched each other as they worked. The group discussions were also very different from the front of the class presentations. Since students are not assigned a particular group-role to play, usually one student takes over and directs a group's attention. Sometimes, depending upon the problem, students drift off and work on their own within the group. There is lots of movement within the classroom. Students come and go freely or move off to work in more quiet, private spaces. People come and go and visit the classroom often, offering students yet another audience to talk to. Hence, the unique nature of the school and the program surfaced on these strips, almost as much as the student-interactions. For example, many of the strips allude to the presence of the principal, or the lunch-monitor who promptly brings fruit to the classroom at

10:30. When visitors peer through the door to watch the children at work, their presence is accounted for in the strips. The interesting aspect of this recording system is that every event is accounted for in its entirety.

Sample Classroom Episodes

In order to present the many unique representations that surfaced, I illustrate some of them which I have termed episodes. I define these episodes as moments that illustrate many events in one, and that remind me of a particular aspect of the problem- solving process. Following these episodes are the rules of inclusion which take a part each segment of an episode describing the context of a particular strand, category or area.

These episodes in particular describe what the child was doing and how he or she was processing the problem along with everything else that goes in this classroom.

Episode # 1 - Jerry's Writing Device

Jerry put together a writing device which consisted of a pencil attached to a pen. This instrument was well crafted and served a dual purpose— for writing and for correcting. It operated much in the same way as a "referent" in a Vygotskian sense, where the tool itself plays a mediator role. Jerry told me that he enjoyed writing and flipping it over to check his work. I wondered why he didn't use a store-bought one. He took pride in his instrument, a bit rough to the touch, yet useful and meaningful to him. In this excerpt from my field notes, I described my initial observations:

Watching Jerry closely, I notice how he enjoys making little gadgets. He frequently uses them to assist him in figuring things out. They become meaningful for him, like a chalice or amulet— assisting him in getting over rough moments. He rubs them and strokes them as if they had magical powers. He is now using a colored pencil and a pen wrapping them together as a dual-purpose concoction. He has also created straight, little even piles stacking them up so he can count with them...He looks so busy and seems to know what he is doing. He reminds me of a banker. (F.N.2/25/98)

Jerry frequently left his seat taking the pen-pencil concoction with him and flying it through the air like an airplane. He would talk to it and tell it what he was doing, as if it functioned like a *side-kick*. Jerry needed to talk out loud while he problem solved, not necessarily to a person— just to talk. He also needed to create a system for tracking down things. His gadget was a handy tool. He used the dual-purpose correcting pencil both as interlocutor and *personalized calculator*. He systematically jotted down numbers on the upper right-hand corner of his paper using the pen side which created a more permanent record. He used the pencil side for erasable, messy calculations and the pen side to commit himself to a final solution or decision.

Episode # 2 - John's Lists

John, on the other hand, was very quiet. He would retreat into a reflective mode, abstracting himself from the rest of the group. He would retreat from his group to find a quiet corner and could sit quietly for extended periods of time thinking or merely doodling. He would frequently pull out his pocket calculator and create long lists that covered his page. These resembled *book-keeping lists* as for example, in the following excerpt from my field notes.

John likes to verify accounts by using a pocket calculator. He also likes to check his work on a chart as if he were book-keeping. (F.N.2/25/98)

John liked to be in control. He didn't like sharing his pocket calculator with others or talking about his *book-keeping lists.* He would only share these with others when he was absolutely sure of what he had done.

Episode # 3 -Jordan's Pencil-Case Counters

Jordan, on the other hand, usually fumbled with the contents in his pencil case which were treasured and handled frequently like a set of *prayer beads.* The act of rummaging and fumbling with these familiar objects helped him concentrate on his task. For example:

Jordan cherishes his possessions...especially those in his pencil case. They embody a small universe all his own. He resorts to this little world of his when he is bored or perhaps needs to reflect. (F.N.2/25/98)

An Interpretation of These Episodes

Dianne's singing and dancing, Zack's eureka moment, Jerry, John, and Jordan's personal codes and systems illustrate how children thrive when they are free to move around and to speak out and when nobody silences, ridicules or tells them to keep still. The absence of confirmatory or judgmental remarks is an important and relevant feature conducive to the problem-solving mode. The students, actively build and refine a problem-solving language that is relevant to them. During the initial, rough stages, their attempts might have seemed futile or distracting. However, these initial attempts represent what is known as the *problem-finding* stage, (Wertheimer, 1959) which is a highly productive stage in problem-solving process and conducive to deeper exploration. I now Interpret Jerry's playful yet industrious need to build gadgets as a form of *process delayers* or ways to slow down the process indicating a need for extra time to engaged in active thinking. Jerry's stacks and rows allowed him to slow down or to *delay* the process in a physically engaging manner as well. Thess *process delayers* resemble the search engine in a computer. While the search engine is set to motion the screen performs other menial tasks keeping the user informed of the process, yet not coming up with an answer right away. The user, in turn, continues working at other tasks. During this process, Jerry experienced frequent interruptions. He got up from his desk several times and even left the room at one point. He usually managed to find an excuse to go somewhere perhaps to look for something or to sharpen pencils, get a drink of water, even read or play. Mobility was important for Jerry. When told to stay still, he would always find an excuse to be physically mobile, be it by walking in place or bouncing about, even bobbing up and down and hopping around. He also liked to drum on the table and to accompany these rhythmic sounds with clicking and humming. I noticed that children like Jerry are frequently reprimanded for being so highly mobile and active. It is extremely difficult, "almost painful", personal conversation (personal conversation, Gradwell, 1999) " ...for some boys to sit still acquiescing, listening, when they'd rather be doing" I include girls into this category as well, personally because I found myself in the same situation as a student. Throughout my youth and adolescence, I received innumerable reprimands for my inquisitive behavior. Raphaella Best (1983) talks about the pain experienced by these types of learners and reminds her readers how children's secretive games and explorations in the classroom are often misunderstood and considered unacceptable by some teachers and school systems.

John, as a student in this dynamic class, for example, enjoyed using his pocket calculator frequently. The regular onlooker would have interpreted his pocket-calculator activities as playful and distracting. However, he managed to create many innovative number combinations with it and to discover number patterns and properties by exploring the features of this learning tool. He was not being mischievous or off-task, but merely inquisitive. Jordan, on the other hand, enjoyed classifying the objects in his pencil-case constantly measuring and comparing them against each other. This was his way of uncovering their characteristics and distinctive features. He actually enjoyed this activity and subsequently developed a keen sense for detail.

As a teacher of mathematics myself, I view these misjudged off-task or distractive activities as mathematical explorations. I value them as such because I see students measuring real life items, comparing numbers and classifying them as relevant data. These highly tactile activities also contribute to the problem-solving process by encouraging children to explore the life-like contexts within mathematical problems. Children also activate prior knowledge and rehearse what they know by interacting and engaging in this highly mobile and creative activity. In this way, they are physically busy while their minds search within their problem space to make those necessary connections.

An adult onlooker may misrepresent or misinterpret these learning tasks because the adult problem solver's sense of timing is very different from that of a child. Time on task for the child and for the adult are very different, especially because our sense of timing is based on an adult's conception of time. Children need other kinds of time-frames than adults do. They need time to explore, time to find out, time to deal with surface structures, time to explore their problem space. Poincaré (1952) emphasizes the importance of *time* as a contributing factor in problem solving:

> *Time is important in two ways. First, a mulling over period is often necessary to find an appropriate solution (sometimes referred to as an "incubation" period (Poincaré, 1952, p. 106)*

What are some implications of this purposeful *delay* process? I interpret it as a time to recapitulate or to conclude a search as well as a need to stretch time and factor in the different problem-solving options. It is also a necessary frame-work for situating conclusions allowing thoughts and ideas to settle, to *incubate.* Wallas (1926) describes this process of incubation as a time where the individual is in an abstracted mode.

> *During incubation, the individual does not consciously think about the problem. He or she goes about other activities while, at some level, the mind continues to consider the problem or question.(p.30)*

This purposeful delay unravels yet another interesting phenomenon, that of a second phase, or what I termed it to be called a *second wind* in the problem-solving process. To illustrate, mountain climbers and hikers experience a new surge of energy when on the brink of reaching their mountain-top. They rely on remnants of stored energy that give them that final thrust. Csikszentmihalyi (1990) describes this as *flow*—a state of being where an unbound free, soaring force takes over the individual allowing him to perform a task painlessly. This state has an almost automatic, free-flowing quality to it, like when all the wheels are in motion and the machine is operating well. Students who reach this state in class seem to drift off into a realm of heightened sensibility where their sense of awareness is in tune with the task. They are productive, abstracted and effective. It usually occurs well-into the problem-solving process, after the initial thirty minutes of exposure to the problem. Once all the noisy fumbling, mulling and delaying is over, the young problem-solver is diligently putting things together with a directed sense of agency making accurate connections in abstracted silence. An excerpt from a visit to the school in January illustrates this sense of agency.

> *I've noticed an extended quiet period. It reminds me of the "second wind" of the mountain-hiker and of myself on the last lap when I run and haven't got much energy left. Once all the hubble and bubble subsides, the children become abstracted, quiet, lost in action. It never happens right away, when the class starts, but towards the end of the class.* (F.N.1/29/98)

Grouping and Comparing the Data

These episodes illustrate examples of the many events I observed in the classroom. As researcher, I've decided to group them in an understandable way and to portray them as they occurred. The *Constant*

Comparative Method (Glaser & Strauss, 1967) allowed me to catalogue them by assigning them an area, a category and a *Rule of Inclusion* (Lincoln & Guba, 1985). Six generic strands form the main hubs which are broken down into categories that attach the event to the hub. The *Rule of Inclusion* is a brief narrative that ties the interpretations of the episode. A narrative paragraph follows, offering details and explanations of the nature of the event and its connection to the main strand. The following are the six strands:

I problem-solving language

II Children's Unique representations

III Tools and symbol systems as scaffolds

IV Time

V Mobility

VI Adult presences

The following two examples illustrate how these rules of inclusion were constructed.

Example # 1:

(1) Area: *Problem-Solving* Language Category: Intimate Circles Rule of Inclusion: Going public-presenting group findings to the entire

Example # 2:

(2) Area: *Problem-Solving Language Versus the Mathematical Register* Category: Class Presentations Rule of Inclusion: Students use the *mathematical register* when addressing the entire class and teacher

Summary

This chapter described not only the manner in which the data was gathered, catalogued and managed, but also the impact of my presence in the classroom. It presented the manner in which I as researcher modified my actions, my stance and research approach. The methodology and the type of data that I was gathering led me to different directions as the school year progressed. For example, provisions had to be made for the changes in the children as a result of their growth. The impact of naturally occurring environmental events also had to be accounted for and the effect of curricular constraints had to be included. Hence, classroom schedules and events, which were frequently modified this particular year, became an important element of my research. The following chapter offers detailed accounts of classroom episodes in a systematic format (Rules of Inclusion).

Chapter 5

Classroom Episodes

Classroom events were catalogued into strands, areas and categories. These were grouped into units called "rules of inclusion" allowing me to break down each episode into a distinctive form for further analysis. Each strand was made up of an area, a category and a numerical rule of inclusion as outlined in figure # 5:

Strand # **Area:** **Category:** **Rule of Inclusion#**	Problem-solving language language intimate circle (description of category)

Figure 5

There are six strands with their subsequent areas, categories and numbered rules of inclusion as represented in figure # 6:

Strand # 1	**Problem-Solving Language**
Strand # 2	**Children's Representations**
Strand # 3	**Symbol Systems as Scaffolds**
Strand # 4	**Time**
Strand # 5	**Mobility**
Strand # 6	**Adult Presences**

Figure 6

Strand # 1 Problem-Solving Language

Area: Problem-Solving Language: a *problem-solving language form*
Category: Intimate Circles
Rule of Inclusion 1.1: The shared language is confined to the intimate circle

---

In intimate circles, students work well with the shared language or *the shared problem-solving language.* It becomes a tool through which students are included into the group. In this case, an example of this problem-solving language is the one where Dianne and Donna both used the term "teached" to refer to the Readers of Samwana problem where characters in the problem had to teach reading to each other. Students within a group use these words as their working vocabulary within the group, not necessarily outside it. This shared code acts like the language codes invented on the playground, where group membership depends upon mastery of the rules of the game and of this shared group code. For example, when youngsters play at jump rope on the playground, they repeat a series of rhythmic chants and songs. Sometimes, different groups of children create particular "in-house" chants that only their exclusive members know. Children who do not belong to the group are often excluded from this group.

In the classroom, students share this code with their working group and use it frequently to argue their point. It becomes part of the group culture. For example, while Dianne was using lego blocks with her working group, in attempting to explain the Readers of Samwana she referred to the one-to one correspondence using lego blocks to represent the problem visually. Carried away by her physical engagement with the blocks, she forgot to compose her sentence properly and said:

> *"This reader **teached** another reader. The problem is in showing how many readers he **teached**."*

Donna, who was also in her group, intervened a few moments later and also used the word "teached" as she reworded what Dianne had said. Soon, both Dianne and Donna were using the word "teached" frequently enough to make their point. They continued citing more examples of this numerical correspondence and pretty soon made themselves understood. The other members of the group continued adding red and blue lego blocks and group talk subsided.

When the teacher approached the group and the students were going to report to her, they did not use this term again. It was an in-group, agreed-upon usage that was acceptable while they were working out the problem, but not acceptable at other times, especially not when addressing the teacher. In this particular episode, while Dianne and Donna were struggling to establish their physical representation of the grouping strategy, the boys in the group were playing with the lego blocks. Dianne had to remind them to stay on task several times. Yet, once she had explained her strategy and Donna had reworded it, the boys soon started participating in the group interaction and were able to follow along well.

The next stage was to prepare a presentation for the entire class. The boys contributed to the preparation for it, and were able to translate the explanation into more public, presentation terms. Donna was going to be the designated group presenter. The group coached her on what she was going to say and on how she was going to illustrate her point.

The students in this group were able to develop their *presentation* register and did not use their *intimate circle register* when addressing the teacher, another adult or the entire class. I interpreted this to resemble family groups that speak a dialect or *creole* amongst each other yet speak the conventional language around strangers or guests. I have also observed this language switch on the playground while children role-play. While playing in intimate circles, they adopt a different persona, or speak in a shared group-language and switch back to the conventional language form when an outsider approaches them.

<u>Area</u>: *Problem-Solving Language* and Children's Preferences
<u>Category</u>: Use of the mathematical *register*
<u>Rule of Inclusion 1.2</u>: Shared language includes the mathematical register when going public; not in intimate circles.

Students use the mathematical register when addressing their teacher, another adult, an audience (as seen in the *presentation register* in Dianne's previous group), or members of another group. This is an interesting preference because it shows that students take pride in displaying their *problem-solving language.* Peer validation and peer approval support this use of language. Members of the group test out word choices that are acceptable to the group and that belong to the group's culture or discard them quickly when meeting disapproval.

For example, Gina wanted to introduce the term "square root" when suggesting a solution to the Burrows Problem. She suggested to her group that they find the square root of the final number they had derived. Most of her group members were not familiar with this word, and she herself was not too sure about it either. The term did not apply to the problem anyway, because the problem did not require squaring numbers. Gina withdrew her term almost imperceptibly, without insisting, because she knew that it would not meet her group's approval.

Area: *Problem-Solving Language* and Imaginary Language
Category: Shared and Imaginative Language Use
Rule of Inclusion 1.3: Evolution into life-like scenarios

Students are playful with language and use it inventively creating life-like scenarios. The following excerpt illustrates just how Myra and Elaine playfully gave life to the prairie dogs in the Burrows Problem:

> *Myra represents her group in front of the class. Myra and Elaine have decided to "give all of their prairie dogs a distinctive name..". Myra admits to this. Lots of giggling follows. They not only named them, but assigned them a gender and a profession so now, the prairie dogs are: ...Paul, the French artist...the girl...and so on...the auntie...The girls in this group built a story around this problem...Miss Z asks them to settle down a bit... and tells them that names are creative but that she wants to see the working...Myra erases everything...(F.N.19/2/99)*

This playful use of language is also a way of engaging and including other group members; in this case the girls in the group. Sometimes it is used to alienate group members; in this case, the boys. As Wayne was engaged in arguing the fact that there should be two exits in the tunnels so that the prairie dogs and ferrets would not get stuck, the girls insisted on imaginary names and life-like characteristics. Their creative and playful strategy was probably elicited by the nature of the problem as well as the children's playfulness.

Area: *Problem-Solving Language* and The Children's Representations
Category: Language as Personal Imprint
Rule of Inclusion 1.4: Each youngster leaves his imprint on his work

---

When using language that indicates action, students invent words that operate on things. An example that comes to mind is when John was working with a problem that required him to keep track of several coins at one time:

> *The problem involves figuring out how many different combinations of nickels, dimes and quarters can be configured to add up $2.25. Some John chants to himself...* **"This into a nine...this into a nine..."** *There's rhythm to this chanting. He checks back and forth using his index fingers, to check. He is engrossed in what he is doing. (F.N. 12/4/97)*

The chanting in "this to the nine...this to the nine..." represents much of what John was doing not only with the coins, but with his entire body. He was swaying back and forth, tossing the coins into their distinctive "slots". His "checking" style was also affected by this rhythm and this clerical role he was playing. At times, he looked like a busy grocer organizing produce.

Another example of this unique imprint is Mark's "heres". He had just experienced his first success when solving the Readers of Samwana problem. I had not caught this event on tape, so I decided to interview him the next day.

He then showed me the drawings he was preparing for the next problem, the Burrows Problem. These drawings were very explicit and detailed (See next page and appendix # 15). I noticed during the interview how he referred to each tunnel as a "here". When he spoke to me about the tunnels he said:

"I put these here's here and those here's there."

I did not want to change the course of our conversation and also included the word "here's" when referring to the tunnels. I asked him "Mark, if I put these other "here's" somewhere else, what will happen?" And he proceeded to explain the intricate tunnel system to me.

In retrospect, looking back at this episode and interpreting the reason why he selected the word "here's", I can almost say he perhaps used the word to represent the intention of the little prairie dogs who needed to go "here" in order to get out of the tunnel. He had un-intentionally called this "place to go to" a "here", and this word choice resembled Mark and the way he usually said and did things.

These personalized interpretations that resemble the children so much remind me of events I observed while my second grade elementary school class was in art class in 1978. Their art teacher pointed out how much each child's reproduction of a familiar portrait resembled the child more than the portrait that required tracing. At the time, I did not know that much about this personal imprint phenomena, and was glad to notice it.

Area: *Problem-Solving Language &* Grammar /Usage
Category: The Word Is "Close but not exactly"
Rule of Inclusion 1.5: Youngsters use incorrect grammar when explaining concepts to each other.

The "inappropriate" word is used as a place-holder for the real word which appears later and is used as the referent once the process is clearer to a child. Children progressively re-adjust their language usage when making a final committed explanation and soon, the mis-used word disappears making way for the more precise or refined term. The teacher did not correct this mis-use but addressed the concept very precisely so that the children listened to appropriate language registers. Often, the children talked about "*minusing*" instead of subtracting. However, once they knew what they meant to say, they used the adequate term.

Strand # 2: Children's Unique Representations

Area: Children's Unique Representations: Tangible Objects
Category: Counters
Rule of Inclusion 2.1: Youngsters naturally reach out for tangible objects using them as counters or scaffolds to make themselves understood.

Students reach out for tangible objects and use them to prove a point. An on-looker who is not familiar with the problem can easily follow along and understand what is going on because the tangible object speaks for itself. Sometimes it is both contextual and appealing.

For example, during the Readers of Samwana problem, Miss Z pulled out the box of lego blocks for the students to use. Dianne and Donna used red and blue lego blocks to create a visual representation of what they were trying to explain. They actually enjoyed creating this visual representation which had a predictable quality to it.

Prior to this problem, Miss Z had provided the students with sets of paper coins or playing cards or other tangible objects to encourage them to use them. After the episode with the lego blocks, the children sought tangible objects on their own, without the teacher's suggestions. Later on that month, Jordan W. and Dafne F. worked very closely with the contents of their pencil case as tangible objects. Familiarity with manipulatives is a problem-solving strategy in itself that if successful, remains in the young problem-solver's repertoire.

Area: Children's Unique Representations: Pocket Calculators
Category: Working tools and instruments
Rule of Inclusion 2.2: Pocket calculators are useful instruments

The children in this classroom have access to a classroom set of pocket calculators. Students usually use them when working with the text-book problems that require accurate calculations. They seem to associate the pocket calculator to the mathematical context rather than with the problem-solving session. Some students who resort to the pocket calculator during the problem-solving process apply the procedural, text-book motions of checking back and correcting their computations in the problem-solving session quite comfortably.

For example, John likes to work on his own. He usually resorts to his pocket calculator as an initial strategy. It is a familiar strategy that helps him get started. Once he gets started, he forgets the pocket-calculator and resorts to jotting down numbers in long lists. He usually checks his work with the pocket calculator when he finishes working. However, when Zack celebrated his "so, so good" episode, he tried to use the pocket calculator. This was not his usual or familiar working tool and he did not use it to assist him in solving the problem.

Area: Children's Unique Representations
Category: Personal Belongings
Rule of Inclusion 2.3: Some symbol systems acquire added value when they are personal.

Students fumble through their possessions and objects that are familiar to them when groping for tangible objects to count with. They acquire a "value added" meaning for the students who use them. As students sort through such pencil-case contents as erasers, rulers, pencils and pens, they also use this as time to think or "mull things over." Familiarity with personal belongings is just one less thing to worry about. For example, while Dianne and Donna were successfully explaining their Readers of Samwana problem to their group, Jordan W. and Dafne F. sat on the rug fumbling with all of their possessions. At the same time, Jules walked back and forth watching Dianne and Donna and commenting:

> "When are you going to stop emptying your pencil case, you'll never find enough objects in there to count with!"

Zack also watched Jordan W. and Dafne F. who were right behind him. He had not figured out the problem yet, but watching Jordan and Dafne so closely could have inspired him to get up and fumble through Miss Z's desk for markers.

Area: Children's Unique Representations: Charts and Counters
Category: Check-Off Lists
Rule of Inclusion 2.4: Symbol systems evolve from `tangible objects to written lists.

Some students devise check-off lists to keep track of things. Jerry used to create little box-like figures to check back his calculations. He double-checked by using counters and finally created stacks and piles. As his problem-solving strategy progressed, he refined his self-devised symbol systems and one system fed into the other. The check-off list developed into a series of visible counters that were then piled and stacked into rows of objects resembling the paper lists (appendix # 16).

I noticed that Jerry usually resorted to this "stacking" strategy as a starter for processing a problem. He needed to see a concrete representation of the problem, an actual pile of things in front of him. Once he had a clear vision of the pile, he transferred this to paper. I asked him what his system was and he told me, " I used two stacks, one to pile things with, one to check and count and finally pencil and paper to keep an organized list." His strategy is illustrated in Figure 7:

Jerry's Piling Stacks

paper stack used for piling bits of paper	**counter stacks used for piling counters**

Figure 7

Stacking Check-Off List

As Jerry worked within this strategy, it was refined and improved as he moved along. This process allowed him to focus more closely on the numbers that were emerging.

Dianne's *partner dots* strategy also evolved from dots on a page to a larger set of circles that slowly emerged into her own counting system or problem-solving strategy. In her case, this number correspondence was represented by a hierarchy of numbers. As Dianne processed her hierarchy of numbers, both the shape that was emerging as well as the succession of numbers, along with the dots, helped her formulate this one-to-one relationship and subsequent theory (see appendix # 15)

These two young problem solvers resorted to a symbol system that they were familiar with and to generating, discovering, and uncovering a strategy while they worked. The teacher's methods did have an impact on them and transferred onto their solutions. However, as I examined these strategies more closely, I realized that they represented a deeper form of "dwelling within". While both children rebuilt the problem they catalogued the numbers, saw the relationship and predicted the sequence in which they occurred.

Area: Children's Unique Representations: Color-Coding
Category: Color Coding as a Systematic Control-System
Rule of Inclusion 2.5: Color coding becomes an acquired coding strategy

---

Color coding is a preferred symbol system that the teacher uses, modeling it frequently for her students. In conversation, she told me that she learned to appreciate the value of color-coding while she was analyzing her data and preparing a qualitative research project at the university. She uses color-coding in different classroom settings, and for different purposes by teaching her students to color code their themes when they are analyzing a story. In order to do this systematically, she encourages them to identify the different components of a story (setting, character and plot) identifying them with a particular color.

Once this coding is done, students have to build an argument or analysis of the piece. They can reach for their color-coded lists containing the evidence to support their arguments. She also encourages her students to use color-coding while working on an extended writing project. In this case, each part of the project is assigned a color. Therefore, if the students are exploring the Middle Ages, for example, then they will color-code the professions, the life-style of different members of feudal society, the foods, the celebrations, etc. This strategy allows students to manage and retrieve large amounts of information. At one point, the color coding evolves from colored highlighting pens to colored folders where these materials are stored.

With mathematical problems this strategy is also useful. The students color-code identifiable "chunks" of information and group them so that they can re-arrange and manage this information at later stages. This strategy is useful for lengthier mathematical problems that require more than two or three problem-solving steps.

Area: Children's Unique Representations: Objects to "Fumble" With
Category: Purposeful Delayers
Rule of Inclusion 2.6: Fumbling with familiar objects allows students time for "mulling things over" or to think while actively engaged.

Students' familiarity with their personal objects, like those contained in their pencil cases frees and assists them as *purposeful delayers*, and as objects to sort while they think. While rummaging through their belongings students catalogue and classify their belongings quickly because they know them so well. Sometimes an unfamiliar object can be more of a distraction because the child wants to play around with it or to uncover its potential features. So, in the case where Miss Z offered the box of lego blocks to the students in Dianne's group, two members of the group began to play with the lego blocks and distracted Dianne and Donna who were struggling to get their attention. However, while Jordan W. and Dafne F. were using their pencil-case contents to count with, they did not stop to examine or compare their belongings but stayed on-task. It is probably wiser to offer students a set of generic lego blocks to avoid the natural temptation to play.

Area: Children's Unique Representations: Objects Used to Reduce Numbers to LCD (Lowest Common Denominators)
Category: Halving and Sharing
Rule of Inclusion 2.7: Putting things into smaller contexts— "chunking"— is another frequently used problem-solving strategy.

Students experience a special comfort when reducing or halving things into their lowest common denominators or smaller components. Sometimes small objects assist them in representing or in symbolizing a miniature version of the problem. For example, one youngster created a large drawing which squared off nicely into a figure that he could cut in half. He used his prior knowledge of symmetry to split the figure and to generate a set of calculations from one of the resulting halves. He then realized that he could double these early calculations for his final ones.

Another student took his figure and broke it into three components, tripling the numbers. This was a clear indication that youngsters bring with them earlier knowledge which has evolved from their pre-school folding and cutting days. This again, is a clear indication also that young problem solvers resort to activities and procedures that they are familiar with.

Strand #3: Symbol Systems as Scaffolds

Area: Symbols Systems as Models
Category: Tangible Objects
Rule of Inclusion 3.1: Reaching out for a tangible object is almost natural.

Many youngsters have been taught to use tangible objects during their early childhood years. If using building blocks is a comfortable choice for them, then they will use it in later grades as well. Some students were embarrassed to reveal their reliance on these, more juvenile sets of tools and feared being ridiculed by peers. When Miss Z pulled out the lego block box, she knew that lego blocks have a distinctive and special appeal for the children at St. John's School because students in grades five and six work on a year-long mechanized lego project which is later computerized.

However, much in the same way that she provided her students with paper coins for the Alexandra's Allowance (see appendix # 15) problem or paper playing cards for the Deck of Cards problem (Appendix # 16), she realized that endorsing the use of these tangible objects herself was a positive way of introducing them to her class.

Area: Symbols Systems: Refining and Improving Tools
Category: Improved Tools: Value-Added
Rule of Inclusion 3.2: Creative devices that get refined with use.

Students take pride in the tools they use for solving mathematical problems in the classroom. They also enjoy refining these tools and talking about them to their peers. If, for example, they begin working with two-sized lego blocks, they'll probably color-code them or begin selecting color-coded two-hole thick lego blocks, refining their process as they go along.

This constant cataloguing and refining of working tools serves as a process delayer as well. It not only allows the young learner to become a specialist in his own problem-solving process, it also allows him to become an expert performer of whatever process he's working on. As an expert manipulator of the object, the student is also endorsing its use for others. An example of this was Donna's adopting the red/blue lego blocks to explain the Readers of Samwana strategy to newer members of her group who had joined after Dianne had completed the first explanation.

Area: Symbol Systems: Personalized Gadgets
Category: Designer Tools
Rule of Inclusion 3.3: Designer gadgets as tools for problem-solving heighten a child's sense of well-being.

Students invent their own tools which become their *designer* tools. They take pride in these *gadgets* and adopting a new persona that is empowered by the gadget. Students who manufacture these tools usually enjoy sharing them with other classmates. They get up from their seats and show their friends who in turn imitate and create similar or improved gadgets of their own.

Jerry's pen/pencil device was a perfect example of this. As narrated in the previous episode, he used the device to help him count and check his calculations. He brought the device with him when he crossed the room to find something in his book-case. He also talked to the device playfully and showed it to Bernie on his way back. Because the students in this class were actively engaged in developing these mechanized lego machines, tools and devices like Jerry's had a particular appeal to his classmates.

Wayne had been struggling with part of a carousel mechanism he was devising for his mechanized lego. He told his science teacher that he practiced with several devices during free time and that the final solution came to him in a dream. This episode is evidence that students do test strategies beyond the classroom.

Area: Symbol Systems and Ownership
Category: Sharing
Rule of Inclusion 3.4: Students are only ready to share their tools when they have perfected them.

Youngsters in the midst of solving a mathematical problem and creating their own problem-solving tools hesitate to share these until they have perfected them. Students either avoid ridicule or need more time to become more familiar with their creations. This natural attempt at perfection reflects an almost instinctive desire to "share it when it's ready" much in the same way as defending a strategy. The young problem solver rehearses until he is in control. For example, I often hovered over John because he worked so quietly and required little or no assistance. Often, when I would ask him what he was doing, he would answer, "Just checking." He would never say anything more substantial until he had checked and verified that his system worked. He usually spent a lot of time "crunching" numbers on his calculator until the figures spoke for themselves. Jerry and Dianne were also reserved while they were processing a strategy. Their response would usually be a non-verbal nudge, which I understood to be a "I'm not quite sure what to tell you yet." I would usually wait until they were finished or until the next week to ask them to describe their strategies.

Strand # 4: Time

Area: Elapsed Time
Category: After First Half Hour
Rule of Inclusion 4.1: After a certain amount of time, a second wind assists the young problem solver.

Youngsters seem to gain a second wind after groping with the problem for the first thirty to fifty minutes. Usually, after the first half hour, perhaps after a mild *aha* or confirmation of progress, students start to "get wind" of things. A calm, quiet atmosphere permeates the classroom as youngsters who experience this heightened sense of concentration enter a flow-like activity. There is less classroom noise, less movement and less fumbling. At this point, youngsters cease to seek the teacher out for assistance.

I first noticed this while I was watching John working with his "This to the nines" strategy. I wrote the following in my field-notes that day.

> *John,[who I think is now in flow]. At this point checks back and forth using his index finger. He doesn't talk anymore and doesn't fiddle or sing. He's very concentrated.(F.N. 2/12/97)*

John was so engrossed in what he was doing that nothing could have derailed from his course. I watched several similar episodes of heightened awareness and un-detached concentration in students. When I spotted this engrossed behavior, I verified the time, it usually occurred after the first forty minutes.

Area: Useful Time
Category: Productivity
Rule of Inclusion 4.2: Children know how much time they need.

Children decide how much time they need. Adults are not the best time-keepers for children because they both have different conceptions of time. What is a short time span for an adult is an eternity for a child. Young problem-solvers need different kinds of time:

(1) to absorb the problem's requirements
(2) to configure a strategy that appeals to their learning style
(3) to settle down
(4) to ponder
(5) to test tools, trying them out and improving them
(6) to refine strategies
(7) to mull things over
(8) to try things out with each other
(9) to see what others are doing

Adults working in similar situations with young problem-solvers need to be sensitive to their movements, to understand and interpret non-verbal cues manifested in a youngster's claim for more time. In so doing, adults and care-givers should ask young problem-solvers what their time-needs are allowing them to be their own time-keepers.

Area: Fumbling Time
Category: Purposeful Delay
Rule of Inclusion 4.3: Fumbling time is a purposeful delayer.

Youngsters manifest a need for time-out or delay, just like adults do when they fumble with keys, jingle coins in their pockets, or dab at their eyebrows before answering a question. The young problem solver makes several attempts to gain time by stooping down to tie his shoe-laces, or straighten up things readying himself for the next task. Jerry, for example, resorted to taking walks or leaving the classroom. Zack resorted to visiting Bernie and watching him work. Sometimes Bernie would go over to the mechanized lego blocks and play with them for a while. Joseph would sit at the computer and start writing something. Elaine and Myra would usually go off to their favorite corner of the room with the pretense that they were looking for an overdue library book. Jules and Edward would frequently seek me out to show me what they were doing for another project or course. Somehow, all of these children used this wait period to get themselves "into gear".

Area: Recognized or Time/Time Allotted
Category: Validation
Rule of Inclusion 4.4: Children ask for time and need allotted time.

When a young problem solver's need for time is recognized it is a validating gesture for him. Allotted time has a value-added importance to a child. He knows that his needs have been met and that he has earned this recognition.

It might be helpful to negotiate how much time or allotted time is feasible for both parties. In this way, the teacher settles an adequate time-contract with the young problem-solver showing the boundaries of what this allotted time will be like.

Miss Z always explained clearly what the time-constraints were for each activity. At one point, when students were completing their problem-solving too abruptly, she would stop and explain what she expected to see them doing during "reflective time" as opposed to "checking-back time". Through these examples, she was able to model the procedural computational aspect of the problem-solving task and to show students that problem solving also engages the thinker in deep reflection that is required to be more time-consuming.

Area: Wait time
Category: A Child's Conception of Time
Rule of Inclusion 4.5: Wait time: a validator.

Children need to know how much wait time is expected of them for answering a direct question. When teachers ask students a question expecting an immediate answer, rushing them, youngsters act confused. They need time to adjust to the question-asking mode and to align their possible answers. Teachers often forget the importance of this kind of wait time, and it is only natural in settings constrained by a tight curriculum. What adults deem to be an eternity is not the same for children. Young problem solvers also expect to be told what they are expected to do when it concerns waiting. If we don't tell students that waiting and reflecting are expected behaviors, then they won't know. Miss Z, for example, after working with students at the rug, would always ask them if they had any questions before they moved on. She also told them that she didn't always expect an answer and that it was alright not to know. However, she usually reminded them that they were expected to remain calm and focused at all times.

Area: Catching-up Time
Category: Learning and Watching
Rule of Inclusion 4.6: Watching others: a catching-up time.

Children enjoy watching others at work. This watching time is also a time to catch-up and to relearn what they've forgotten. They cherish this time because it allows them to vicariously connect with other youngsters their age. Some youngsters enjoy watching the teacher in the same way. We all learn from observation. Apprenticing ourselves to a more capable peer is good and useful. Sometimes the observer switches roles and offers an observation arena for others. This is a form of learning that many teachers do not encourage because they think that all children should learn on their own at all times. Don, for example, liked to watch others at work. He would usually confer with students asking them what strategy worked best for them. Cora was also a contemplative student. Her quiet, observing presence was encouraging for other members of her group who frequently sought her out to share their ideas.

Area: Silent Time
Category: Time to "Mull-it-Over"
Rule of Inclusion 4.7: Mulling as delayer.

Youngsters like to mull things over when others aren't watching. They seek this personal time-out in a very special way. Sometimes they'll find an excuse to leave the room or to do something else during this time so that they can mull over things. A drink at the water-fountain or an excuse to see whether their favorite library book has been put on a shelf or whatever they can come up with to clear some space for themselves. They seem to be telling us, “Hey, I need a little time to think things over.” Youngsters seldom dare to do so directly. They think that they have to perform right away because they’ve been assigned to work to do.

Miss Z was aware of this and often told her student that she liked to hear the silence and their “thinking wheels turning”. She also frequently reminded them that she expected a calm, reflective atmosphere to pervade the room when they problem-solved. She allowed them to explore outside the classroom and to find those quiet spaces they needed letting them know that it was alright to be quiet and to mull things over.

Strand #5: Mobility

Area: Mobility: Bouncing
Category: Speedy, Rhythmic Movement
Rule of Inclusion 5.1: Bouncing: propelling, locomotive activity

Children run on a different energy source than adults. They need to move around and to bounce about a bit. Adults that work around children usually tend to stop this buoyant activity urging youngsters to sit still. We sometimes don't realize how necessary mobility is for them. They need to express themselves with their entire bodies and they also need space to do this in. This is very evident when they work on mathematical problems that they understand. Over and over again, I watch them as they get up from their seats and take off in different directions. They'll usually bounce up when they've figured out the problem, like when Jerry drummed and swayed at his desk or when Zack walked back and forth. They'll go for a little walk, return, and continue whatever they were working on. Then they'll probably work in a standing position which allows them more space. They'll again walk about or start drumming, skipping and chanting. The various examples presented throughout this study reflect this need for mobility. As each student works within her particular learning space using the tools that are familiar to her, mobility is just another enabler that assists her in her process.

Area: Mobility: Dancing Rhythmically
Category: Chanting and Dancing
Rule of Inclusion 5.2: Movement as celebration of success.

Youngsters enjoy inventing a chant and adding a dance to it sometimes. This is when they seem to be getting to where they want to be and are naturally joyful. This offers them an opportunity to be inventive, to celebrate and to move around. I have rarely seen this type of behavior when youngsters are still groping or immersed in thought. It's usually when they've made head-way and know what direction they're going. It's also evident when things start falling into place for them and they begin to understand the problem. The various examples that surfaced during the problem solving tasks witnessed throughout this study, (Dianne, Jerry, Zack, Mark) demonstrate the importance of this space for celebration. It is much needed and a valued tool used for children to acknowledge their own problem-solving capabilities.

Area: Mobility: Repetitive Chanting and Dancing (Mantra)
Category: Repetitive Chanting That Becomes a Dance
Rule of Inclusion 5.3: Freedom to move around allows for dancing.

While progressing in their problem-solving mode, students begin to chant, or make clicking sounds. They soon move away from their work space and start to dance around. This movement becomes more vigorous and is sometimes accompanied by a rhythmic chant that is repetitive and often contagious. People who are familiar with playground movement and chanting will recognize this as normal playful and joyful activity. I've seen it often when children head in a desired direction, like for example, before they line up to go to the playground or when they are getting ready for an activity that takes them away from small spaces (the home or the classroom.

Strand #6: Adult Presences

Area: Adult Presences: Teacher's Lists: Book-Keeping
Category: Organization Rubs Off
Rule of Inclusion 6.1: modeling behavior

The manner in which the teacher plans and performs tasks "rubs off" on the children in a very positive way. They observe and imitate her unknowingly. The children often work from previously conceived lists that resemble their desk-planners or the collection planners. Sometimes they color-code their work much in the same way the teacher does on the black-board. She seems to exude an organizational style that is appealing to them. She is very transparent about the way she thinks things out and models al lot of this in front of her students. They learn from her example. This is also true of what they learn from the school Principal. Her frequent classroom visits are appreciated by the students who watch her jotting things down in her note-pad or trying to solve a problem. Her problem-solving demeanor is also a transparent model that is appreciated because she explains how she problem-solves for different situations and occasions. For example, when she visited the class to announce Student Council elections, she clearly established the roles and options for the different students interests. One student asked her what would happen if a student didn't win. Her response was a solution to a problem. She told the students that not winning an election did not mean not being on the student council, because students who were interested could all join a committee and participate.

Area: Adult Presences: The Teacher Encourages Language Development
Category: Creativity in Language
Rule of Inclusion 6.2: a nurturing, trusting presence breeds creativity

---

The teacher selects her own words and register very carefully. She enunciates very clearly and composes her sentences with care. She models correct language use for the children at all times. However, she humorously incorporates new words either from a story, film or shared event. Whenever a child comes up with a unique term, she rehearses it and comments on its uniqueness. This form of accepting feedback has a positive effect on the children who do likewise.

I often hear children chanting or whispering new words to themselves, as if enjoying the new sound or the rhythm of the words. Some are too shy to do this in front of others.

<u>Area</u>: Adult Presences: The Teacher's Response to Student Writing
<u>Category</u>: Acceptance and Recognition
<u>Rule of Inclusion 6.3: approval and validation</u>

The teacher adopts an accepting, inclusive stance when she responds to students' writing. She comments on their ideas in a collegial manner excluding correction or judgment. She seldom marks the mathematical journals but simply addresses youngsters in a language that shows interest and respect for their ideas. At times, she challenges students to express ideas either more simply or more clearly. She writes a "come and see me" note on the top of the page and sets up a conference session with them. Conferring is done during a special session set up at a time when other students are doing something else.

The conferences are interesting processes. Usually the teacher asks the child to clarify. She nods and listens. Soon, the child realizes what he's left out or what isn't clear from the detailed explanation he's requested to offer. This is a very positive technique allowing the young learner's thoughts to crystallize.

<u>Area</u>: Adult Presences: The Teacher's Support of Language Creation
<u>Category:</u> The Teacher Adopts New Words
<u>Rule of Inclusion 6.4</u>: Two-tiered language

The teacher approves and validates the creative use language valuing the students' words. This is a particular contribution to language development, as it views language cultivation as a problem-solving process enhancing the classroom atmosphere, imbuing it with creativity.

As students struggle with new concepts and ideas, they are not constantly corrected for language usage. The teacher's particular stance on language development is such that incorrect grammar is not viewed as

a deterioration of the language. She uses the children's invented words incorporating them temporarily into her own language register. In doing so, she shows approval for the children's creativity and joins them in their playfulness. However, when children have rehearsed the concept enough and are ready to move on, she does indicate to them that language usage and correct wording is valued in the classroom.

The teacher's approval and use of this creative shared language makes it appealing to students. Youngsters know when to continue working and when to stop. However, it does not hamper their creative potential.

<u>Area</u>: Adult Presences: Approval of Student-Mobility
<u>Category:</u> Students Are free to Seek Comfortable Learning Spaces
<u>Rule of Inclusion 6.5:</u> unrestricted student flow

Students can work anywhere in the classroom and even outside. They report back at some time and maintain a relative focus on their work. This unrestricted flow allows youngsters to choose comfortable learning spaces. Youngsters appreciate this expression of trust. They use good judgment most of the time and work in other classrooms, or in the close proximity to their teacher and peers. The fact that they can get up at any time and go places makes it a comfortable, almost homelike learning environment. Children seek quiet learning spaces and they naturally enjoy special hide-outs. This un-restricted flow is another factor that contributes to their productivity.

Area: Adult Presences: A Knowing Presence
Category: Presence & Validation
Rule of Inclusion 6.6: an adult with a trusting, nurturing disposition contributes to the problem-solving process.

The presence of an acknowledging adult who realizes what efforts the child is putting forth is always a positive one. Children thrive on praise and seek it frequently. A tap on the back is an effective problem-solving promoter. Whenever a visitor comes to the classroom, youngsters who notice perk up and alter their behavior. Whenever the principal, librarian or lunch monitor appear, they seek her out, to share what they are doing

Chapter 6

Analysis & Interpretation

The data reveal a close connection between a problem-solver, the process of problem solving, and a problem. These elements work in tandem feeding on each other to guide learners. The rhythm, language and tone of the problem motivate the formulation of a strategy as each child interacts with these elements.

To begin with, a child is sensitive to the contents in the problem's story, its setting, and characters. He can not avoid interacting with these in context, converting the problem into a more life-like and tangible scenario. The child will try to re-enact or bring to life the problem in whatever format he is most comfortable with.

No matter how many new strategies are taught, a child will frequently begin by applying a strategy that he is most comfortable and familiar with. He will modify this initial strategy as he progresses. If color-coding, making lists, or stacking items, are familiar and comfortable strategies for the child, he will use them at the outset and perhaps invent a new strategy based on all the former ones.

During the problem-solving process, there is a lot of knowledge transfer from different sources, people, and environments. Children are sensitive to environmental cues, problem cues and adult presences. They learn how to operate and how to do things from observing these. Young problem-solvers also benefit from the assistance and guidance of a validating, supportive teacher who encourages risk-taking actions in setting up strategies and solutions. Insightful student-generated solutions flourish in a rich environment that encourages inquiry and exploration.

How Talk Was Represented

Talk in this mathematics classroom was defined by the problem-solving activity and by the environmental factors associated with each problem-solving occasion. Some of the problem-solving tasks did not encourage or generate much talk because the young problem solvers were engrossed in calculating and plotting responses to their problems. They had no time to talk. Other problem-solving tasks required quiet reflection or preliminary written responses; hence talk was discouraged.

Talk, as discussion and argument, was encouraged during certain occasions, when the problem had already been processed in a reflective or written mode, and the teacher had already assessed it.

Talk as shared problem-solving or collaborative thinking did not happen naturally or frequently. Much of the talk was abrupt talk (a few words, or a short phrase). It had an instrumental purpose and was used for clarification or for making polite requests. For example, when students did not know what to do next, they would ask each other what the instructions or procedures were and continue to work in silence.

The discursive, more extended forms of talk were sometimes governed by the power structures of the group. Usually, the more vocal group member became a group leader and governed group deliberations. The teacher was aware of this and redirected group structures to avoid this dominant figure from over-powering others. For example, when a group presented their findings to the rest of the class, there was a lot of argumentation and discussion over how the group representative would “say it”. However, even though the group member in power was not the designated speaker, he would dominate the discussion during this stage. At this point, the group was more concerned with its group-image so there was little competition over the dominant role. The group leader would continue to control the group until the group representative was ready, and at the point of presentation, relinquish his power to the rest of the group. The group representative, when rehearsing what he would say to the entire class, relied on the group leader and on other members of the group for reassurance, but he was much on his own from then on. This process of assigning and preparing the designated group presenter was masterfully monitored by the classroom teacher who circulated frequently during group deliberations.

The talk that ensued during these final stages of the problem-solving process was normative in the sense that students reminded each other of the rules they had to follow and gave each other instructions on whether he would say this or would not say that. These deliberations took the problem solvers into the presentation domain, where talk was regulated by the need to become more vocal and by the realization that a message had to be conveyed to a captive audience.

A lot of talk ensued while students were walking towards the group table or working in less centralized classroom spaces. This kind of talk was more private talk, where the less vocal and more reserved students had a chance to say something that they would have otherwise kept to themselves. Cora, for example, enjoyed talking to Dianne and to Gina, at these times, because although they had not been grouped for this particular occasion, they needed to share their experiences. Jules liked to approach Bernie, John or Zack to compare diagrams and drawings of the problem. Bernie and Jerry in particular, shared the accuracy of their tools and together sought out Jordan W. to compare their tools with his. As is natural in any social setting, groups of children who were friends took advantage of this "earned free time" to talk informally.

Another form of talk was talk in the public domain. Most of this public talk happened during circle-time, when the teacher gathered the students around her to explain the problem or to discuss current events. It was also encouraged when a designated group member would present the group's solution to the entire class. The teacher offered students several opportunities to practice talking in this public domain, where they had to be more selective about their word-choice, clarity of expression and development of their public voice. This allotted public-speaking time was designed to develop the children's sense of themselves as presenters and towards developing their audience sensitivity.

Group Work, Cooperation and Collaboration

Shared problem-solving activity in the cooperative learning classroom format (Johnson & Johnson, 1990; 1993) did not surface as a component of this inquiry-based program. Students were not grouped in the classical cooperative groups where each group member had a designated task to perform. The reason for this was that the young problem-solvers in this class were paired or grouped according to the written responses they had submitted to their teacher. They were hence assigned by their teacher to work in dyads or triads with similar learning styles or similar solution strategies. Close collaboration occurred when the activity called for it. Otherwise, students spent a lot of class-time in silent reflection.

Problem-solving activity in this classroom was tailored around individual differences and learning styles of the students and based on their reactions and initial responses to the mathematical problem. Group formation was based on the teacher's preliminary assessment of student written responses. Collaboration in group settings was dependent on the dynamics expressed by the dyad, triad or group of four. Within-group competition prevailed over collaboration.

Gender-Related Interaction

During the beginning of the school year, gender-based competition flourished. It subsided as the year evolved and the students spent more time together engaging in group work and shared classroom activity. Gender-based competition almost disappeared by the end of the year. It is apparent, however, that girls do work together collaboratively. This instance confirms gender-based research carried out in mathematical settings (Fennema,1975; Gilligan,1993; Tannen,1993; Walkerdine, 1989) which attests to the notion that girls seek each other out and foster group-related relationships. However, data gathered towards the end of the school year revealed mixed-gender alliances and partnerships formed after the students had spent three fourths of the school year together, traveled on out-door educational expeditions, and experienced conflict-management sessions on this subject. The following three examples illustrate these mixed-gender relationships.

Dianne and Zack, for example, helped each other out on several occasions, crossing social barriers to assist each other when others were not noticing. Dianne and Zack would walk across the room to help each other out or to borrow rulers, markers, and pencils. Many of these attempts to offer each other assistance or tools went unnoticed by their peers. During the *Diagonals Problem*, Dianne, who had been working on her own, walked over to see what Zack was doing. This behavior was not attributed to any form of relationship between Dianne and Zack, but more as a collegial form of sharing where their personalities and problem-solving strategies were often similar. Jordan W. and Dafne F. also established a collaborative working relationship during the episode when they were rummaging through their pencil cases. Later during the school year, they also sought each other out often, to provide assistance or to watch how a process or strategy evolved. Gina and Jordan T. often worked together, and enjoyed talking about their parents' technological expertise. These mixed gender groups shared similar learning styles and similar interests.

After the Spring, many other students engaged in mixed-gender activities as well.

Quiet Affiliations, Silent Presences, and Adult-like Talk

Quiet affiliations among some children were also interesting phenomena to observe. These affiliations were based on a form of shared silence and on a genuine appreciation for each other. Cora and Lea, for example, worked well together and supported each other throughout the year. They established a good rapport because one enjoyed doing the talking and the other enjoyed doing the listening. They not only enjoyed these roles, but supported each other continuously, sharing their progress even when they were not assigned to the same group. Donna and Dianne also enjoyed working together. Dianne was usually more vocal while Donna would hold things up for Dianne, or continue where Dianne had left off. Dianne seemed to relinquish her role of expert to Donna, who assumed the role quite well and could continue explaining a solution or perfecting a diagram.

Bernie, Jules and Edward enjoy talking to the adults around them. They would often seek me or their teachers to show us their productions. Bernie, for example, sought me out often to inform me of what his group was doing. I called him my chief narrator and class spokesman. He enjoyed this role, and his teacher enjoyed watching him get better at it. The kind of talk that ensued during these adult-oriented narratives was a learning process in and of itself for the children. It helped them re-formulate their ideas and wording for adult audiences. This was a strategy which required a lot of refinement and rehearsal, forcing them to select the words considered more appropriate around adults in conversation. They also rehearsed the clarity of their explanations as they exposed them to us, the adults who were immediately available to them.

Context-Rich Examples

Most of the talk and interaction gathered was shared talk or group talk, reflective of the interpretive aspect of the problem-solving process. The young learner doing the talking attempted to clarify instructions, to outline her mathematical procedures, or to interpret what she had to do. While seeking life-like contexts, the learners reached out for tangible and portable objects that they could manipulate to understand what they were doing. They also used these life-like models to add context to their explanations. This reliance on tangible/portable objects helped shape the representational models, and was a clear indication of the value of these.

Contributing Program Factors

The data also point to other aspects that support the problem-solving process. These aspects are represented by what I deem to be contributing and necessary conditions for successful problem-solving activity. For example, the fact that this class had an extended amount of class-time to explore, understand, and internalize the problem made a difference in this program's implementation. The fact that they had a choice of strategies, not a mandated one, and the availability of classroom tools and instruments for creating representational models was an important contributing factor. Another contributing factor, was that students could work in whatever environment they chose, and through whatever medium they were comfortable with. Hence, they were free to choose a work space and could write, read, talk, explain, draw, or build a model of their problem's solution. The young problem solvers in this classroom were given every opportunity possible to succeed, and most of them did.

The presence of nurturing adults acting as interlocutors and interested listeners was an asset. The reader-response (Rosenblatt, 1978) format used by the teacher to interact with the students' writing was another clear indication that she valued their ideas and their words. She cultivated a sense of voice and audience with them allowing problems to become stories and living scenarios. The child-centered assistance delivered to the children as one-on-one sessions successfully offered them a trusting, understanding environment in which to voice their concerns, doubts and views. Help-giving sessions were informally orchestrated by the teacher and the teacher assistant as private meetings where teacher and student worked together in close collaboration.

The Influence of Prior Knowledge

Problem-solving activity was affected by what took place in prior problem-solving lessons. Students applied techniques and strategies that they had used previously. Problem-solving activity was also affected by the environment and by what was happening outside the classroom. Students enjoyed relating to real, real-life situations bringing the world into the classroom and vice-versa. To illustrate, Gina's attempt at bringing her father's "marketing principle" (p. 50) to a situation that she deemed similar, found her saying: "My father explained this to me, it's like when a company wants to market a product..." .

Technological tools also became knowledge banks for frequent users. For example, Joseph usually needed assistance in writing and used the classroom word-processor while problem-solving. Because this was his familiar and preferred working environment, often his solutions represented computer-generated data-bases and drafts. He was also capable of explaining a computer-assisted strategy. John was also a frequent pocket-calculator user. He was adept at interpreting number progressions on it and using it for recording, planning and checking his work.

Tool Transfer: From Tool to Word

The problem-solving tool transferred over from tool to symbol system and finally to writing. Dianne's partner dots, that resulted from her need to put together a simple counting system, resulted in a more refined array of dots that revealed a progression of numbers in a pattern. Jerry's counters, stacks, and checking lists portrayed his personal learning style which was reflected in his constant need to count, arrange and check back. The body-engagement that accompanied this unique problem-solving strategy assisted him as a working tool, where thought and action worked in tandem.

Bernie's systematic use of color-coding surfaced when he was working on the *Alexandra's Allowance* problem. This strategy worked well for him on that occasion, and he resorted to it several times later on. It consisted in naming things and using these names as place-holders for the numbers that would follow. He refined this strategy while working on the *Burrows Problem* where he used sets of colored markers instead of *post-it notes* to code his figures. This refinement of a process is yet another indication that the physical- tangible-visible aspect of problem-solving transfers over as a problem-solving strategy.

Voice Internalization: Talk With a Generalized Other

Talk as the internalization of social processes (Mead, 1943; Vygotsky,1978) or as conversations with a generalized other surfaced frequently in the data. Talk brought to the foreground think-aloud processes that revealed the transparency of this process. Mistakes were made publicly and unabashedly, illustrating how appropriate it is to think out loud in non-judgmental environments. Talking out loud and explaining things to others was also conducive to theory-building and to promote shared discussions.

Models of problems were created by the children as *embodiments* (Dienes, 1960;1970) or logico-mathematical presences (Papert, 1980) of physical objects referred to in the problems. The conceptual level addressed in the problem designated for the problem-solving lesson was related to the procedural level addressed in the arithmetic component of the program. The rules and nomenclatures of the discipline operated in unison to assist the learner. Thinking in its purest sense (Bartlett, 1980; Dewey, 1933) was attached to real contexts and real representations surfacing as tangible/portable objects or creative language forms. Information was processed schematically (Bartlett, 1943; Anderson, et al., 1989; Spiro & Montague, 1977; Schank & Abelson, 1977) forming "memory structures" from past experiences in the problem-solving program. Problems from past experiences were *instantiated* (Bartlett, 1932) frequently as the students looked back at similar problems they had done before. There was knowledge transfer as one step or past experience led into the other allowing solutions to materialize. Words became place-holders for ideas and number progressions.

Problem Space as Search Engine

The extended time allotment allowed students to work within their *problem space* (Newell, 1990). Within this *search state,* they were able to apply mathematical operations, use dialogue creatively, and invent a language and tangible models to move forward and to solve problems. The manifestations of this recourse to problem space were many, as described in their need for delay, and the frequent episodes of focused abstraction and a heightened sense of awareness. Most problem solvers needed to work within specific contexts or life-like formats to get started. Either the problem was presented to them with illustrations, or the teacher provided students with life-like scenarios of what the problem represented. The students themselves often re-enacted the problem for themselves in playful ways. For example, Myra and Elaine's decision to create names for their ferrets and to give them life-like professions and appearances was an example of this need for context as well as a demonstration of children's sense of abstraction and playfulness.

Implications

The implications this study has for classroom research are many. The year-round time-frame in which the data was gathered made room for many processes to surface. These would have otherwise gone un-reported in a shorter time-frame.

It is not easy to find similarities in problem solutions from one school year to another because classroom composition changes and because each year, there are other environmental or educational changes. To illustrate this, the same mathematical problems processed during the pilot year and during the research year offered many variations of problem solutions. Children have unique learning styles and each solution is an interpretation which is unique to each child. The popular saying: "There is no one answer." might hold true in this particular setting.

Constraints

One of the constraints for this study was the effect of the "1998 Ice Storm". This was a natural disaster which occurred during the first week of January, 1998. The province of Québec was struck with sudden warm weather that quickly shifted to extreme cold weather resulting in frozen rain that hovered over tree-branches and power lines. Subsequently, most of the province suffered power outages that lasted over ten days, and in some cases three weeks. Families were up-rooted, schools were closed, and entire cities were paralyzed. This event affected this classroom in particular, because most of the children were returning from an extended vacation or travel. They not only arrived to Montréal in suddenly uncomfortable circumstances, but could not catch up with the rest of the school program. As instructional plans were affected in the classroom, so were other events which had been programmed for the 1997/1998 school year. The teacher had not expected to resume classes in February and the three weeks that were missed in January affected her teaching plans and the progress of the children.

Another constraint was the difference in learning styles in group A and group B. At one point, during the data-gathering process I had decided not to factor in this difference. However, while analyzing the data, I found many differences in group composition, mode of instruction, and support from the teaching assistant altering the dynamics of group B in particular. The teacher tried different things with group B, which usually met the day after Group A had attempted the same problem. Often the teacher banked on the success or failure of an approach she had tested with group A. Group composition in both groups was also different. The students in group B were a more cohesive group who enjoyed developing relationships more than those in group A.

An interesting constraint was that on Thursdays, Group A usually came to mathematical problem-solving sessions directly after gym class. The opportunity to play and work-out in a physical, competitive setting affected their classroom disposition. On Fridays, on the other hand, students could come to school in regular school clothes, not the school uniform. This change of routine also affected group demeanor because this particular age-group was sensitive to the power structures generated by appearance and by who had access to the more fashionable and "trendy" attire.

Classroom composition in general was also a constraint for this study, especially since at one point, there were three members of the classroom with significant physical ailments that somehow alienated them from their peers or resulted in frequent absences. As the school year progressed and the children went on their out-door classroom visits, these children usually did not accompany them on the three to five day excursions causing a brief but marked rift between them.

Finally, and interestingly, world events happening during the time I gathered data also affected classroom events. The children brought news clippings about the recent cloning procedures resulting in identical sets of sheep and calves. The students were shocked by the possibility of being cloned and seeing this type of progress in their life-time. They were also influenced by the effect of imminent war in the world as a result of the Middle East Peace talks as well as the Gulf crisis. The impeachment proceedings of the U.S. president were also being covered by the media at that time. Because the children discussed world events openly as part of their classroom program, these events surfaced in many of their problem-solving proceedings and calculations. For example, when they worked with the problem that required establishing a one-to-one correspondence between numbers, one child said that numbers could also be doubled or "cloned".

I would have liked to carry out a comparative study between this school and another school. However, this was not possible during the same school year and would have probably taken this research project in other directions.

This detailed portrayal of what it is that children do and say while they problem solve is a useful and valuable contribution to teaching practice. This program can be implemented in any classroom and with any group of students given the appropriate conditions. Students are capable of solving mathematical problems of varying levels of difficulty. Students need clear instructions, enough time to work, supportive and validating feed-back and an opportunity to express themselves in the forms that come more naturally to them.

Summary

In an effort to summarize these findings, it is interesting to look back at what researchers say about talk in the mathematics setting. It is interesting as well, to situate talk during the problem-solving process. As is evident from the results of this study, talk was indicative of student engagement with the problem; however, it surfaced at particular times during the problem-solving process, not always. While the young learner was deciphering the figures she had in front of her, talk was a form of internal dialogue or chant. As she started to envision a solution and to understand the problem somewhat better, she would talk to somebody else about it. Most kinds of talk collected in the data was talk used to explain or clarify, not necessarily in the form of a discussion or argument. Students argued and bickered while handling tangible objects and learning materials, or when sorting and classifying objects to count with. They sometimes exerted their power over others when selecting the designated group-representative or when assigning group-tasks to other group members. Their collaboration while working in groups depended on group-composition and on the task itself. Some forms of collaboration appeared when the group was preparing the designated group-presenter to represent them. A supportive form of collaboration occurred most of the time, especially among the girls who tended to lean on each other for validation.

Cooperative group work practices are not part of this inquiry-based classroom. Hence, children are not grouped arbitrarily and assigned designated group tasks. Students who work in dyads or in groups of three or four cooperate with each other more tacitly. They cooperate by sharing materials or by sharing similar strategies.

Some children established good group-related relationships with other children. Those children who had previously worked well together sought each other out and worked well together again. Group-distribution was directed by the teacher, so the children who sought each other out too frequently were discouraged to do so. However, once the classroom activities were over, they sought each other out during their free time to compare what they had done.

Context-rich and life-like examples were either introduced by the teacher as a form of scaffolding, or created by the children as a form of explanation.

Students were able to make the connection from the context-rich symbol systems they used and to transfer these into number sentences and numerical symbol systems. They were able to understand both the conceptual and the procedural algorithms of the problems presented to them. The language of mathematics was promoted and cultivated by the teacher who expected students to use this register. However, she allowed students to use their own word choice during the initial, hazy stages of their problem-solving process, knowing that students would seek the adequate wording when they needed it.

The impact that environmental and historical events have on children and on their thought processes are important. Children are able to incorporate a great deal of knowledge from what they experience in the world around them. Educators can benefit from knowing this because in designing work spaces, they can, as they do in this school, incorporate problem-solving solutions into the children's immediate surroundings.

Chapter 7

Conclusion

How can the results of this research study help us design interactive, dynamic programs for school children? Simple mathematical problems can be solved by most, if not all students in a regular classroom setting. More importantly, most students are capable of successfully embarking on a problem-solving quest and of completing a problem-solving task if we assist them. Critical thinking and creative problem-solving can be progressively fostered and incorporated into any classroom setting. Therefore, this type of mathematical problem-solving program could and should be integrated into any school.

However, a good balance between the highly structured, routine classroom tasks and the creative, innovative ones should be established. Young learners need a strong platform to work from and to build up a repertoire of positive problem-solving experiences so that they can solidify their problem-solving capabilities. They need to tread on a solid problem-solving ground built from positive problem-solving experiences that help them gain confidence and self-esteem. They glean self-confidence and develop problem-solving skills by successfully completing similar and familiar problem-solving tasks that are progressively paced so as to help them build a comfortable level of familiarity.

To illustrate this progressive pacing, the teacher selected the problems which she presented to her students. Often, the students relied on similar patterns they had discovered in previous problems to solve the new problem at hand. These similar strategies allowed them to embark on even more complicated strategies that required more demanding calculations and processes. The students never anticipated this progressive-pacing from their teacher and were able to work without interference from these previous similar problems. There was always an element of surprise in this classroom.

Young problem solvers also benefit from performing simple and routine tasks well. Often success at one task leads to success at another task. Being able to complete a task successfully, whether it be of a higher order or not, is always beneficial in building a child's self-esteem and self-confidence. Students in this inquiry-based classroom enjoyed the best of both worlds. Sometimes, they spent a lot of classroom time engaged in structured and routine tasks that gave them a sense of order and completion. At other times, they spent extended hours on open-ended, creative tasks that involved sorting through accumulated data or figuring out where to locate recent information on a topic.

Sometimes, the creative, open-ended tasks caused confusion and irritability at the beginning stages. This was mainly due to the breadth of the assignment and the amount of material available to them. In these cases, when the teacher would sense this unease she would wisely intervene suggesting applicable sorting systems or data-organizers for the students to use. Sometimes a useful archival system for organizing this material was a learning task in and of its own. Good, age-appropriate and sound learning resulted from the sorting applications suggested by the teacher. For example, in life-like settings, set-designers and decorators experiment with similar cataloguing and sorting devices in order to organize their work. Likewise, when solving work-related problems, the students were also engaged in meaningful, valuable and very human problem-solving tasks. As they became environmental problem solvers they also became excellent time-keepers, space-managers, and potential directors of real-life projects.

In mathematics, for example, the students worked in the text-book portion of the program independently, correcting their own work and concentrating their efforts on mastering those skills necessary for completing a unit of instruction. They kept their own records and managed a roster where they recorded the skills that they needed to master. They met with their teacher to share their results once they had mastered them. The teacher looked over this component of the program and recorded students' results in her grade-book. This skills portion of the program was hence built upon a solid ground where the expectations were clear and transparent. Any student could progress in this, the arithmetic component, by successfully completing the tasks at hand. Hence, the arithmetic aspect of the mathematics program was dealt with expediently and independently of the problem solvers' other skills and capacities. The students became more sensitive to the real, life-like and context-rich aspect of the problem solving process without excluding the arithmetical component.

That thin line that connects classroom life to life-like contexts was extended from the basic paper and pencil calculations to real contexts where distances were measured with pieces of yarn and actual fences were drawn to help build the tunnels and roads represented in the problem-solving samples they had worked on. When classroom life is no longer encapsulated into a forty-minute segment of the day, put portrayed within a real, life-like context, then young problem solvers can draw from these experiences and perhaps make more adequate connections with life-like applications.

Educators often tell students that what they learn in elementary school will transfer into life-long learning. They might not give students sufficient life-like examples so that they can appreciate this connection. Real-life problems, like the ones presented in this classroom, allowed students to relate to these life-like samples. As they measured items, calculated distances and projected numerical patterns, they began to understand how this often laborious process, translates into real-life settings in fields like chemistry, physics and engineering.

To illustrate, the year-long animated lego project served as a reminder of life-like applications. It was also an important contribution to the problem-solving process because some of the knowledge gleaned from these mechanical components transferred into the paper and pencil tasks performed in class.

As the students gained confidence from performing routine, skills-based tasks well, they also built a solid repertoire of classroom-generated expertise that proved invaluable to them and that transferred into further learning and exploration.

The absence of a competitive element also made this problem-solving venue a lasting and rewarding quest. Students set their own goals and met their own objectives. The solid, text-book-based program, allowed them to perform familiar, routine tasks well, giving them opportunities to carry out predictable processes and demanding, time-consuming tasks frequently. These arithmetic tasks gave them a sense of completion, assisted them in gaining self-confidence, and prepared them to work in a focused manner as problem solvers.

It is evident from watching them perform these tasks, that young problem solvers also enjoy basking in the familiar from time to time. They take pride in their simple exploits, in conforming to and following set rules. A classroom that provides this balance of the known/familiar and the unknown/unfamiliar is an ideal setting for implementing a classroom-based problem-solving program. Process-based problem-solving activities with a sharp focus on strategy-building and the generation of theory can be implemented in any classroom and in any school program, in good measure.

As evidenced in this study, problem-solving activities in a mathematical setting can be implemented within a process-centered approach combining both the routine skills-based program with the critical thinking, creative problem-solving one. However, a separate or parallel problem-solving program would be beneficial in most situations. This program would encourage students to work under special problem-solving conditions in isolation. These include an adequate problem-solving environment with a built-in time component that allows the teacher and the students sufficient time to process problems adequately. Two other important components are frequent dialogue and space for interaction. Young problem solvers need to work closely with their teacher and their peers to experience the verbal component of the problem-solving process. They also need to explore the problem-solving terrain by interacting with each other, with their teacher and with the tools made available to them.

A student's speed and accuracy become secondary in the problem-solving process. Problem-articulation, theory-building strategies, and an ability to break down tasks into component parts surface as more desirable behaviors to cultivate in young problem solvers. Validating presences and opportunities to test different tools and language forms are also conducive to successful problem solving in classroom settings.

Problem solvers seek a discursive presence or invent one while they problem solve. They need to talk about the problem-solving process and to talk to somebody. In talking and in explaining, youngster's articulatory processes improve and grow. Making way for this interlocutory presence and creating space for young problem solvers to explore their problem-solving abilities becomes a relevant need. Teaching these "enlightened" students is transformed as youngsters begin to make connections with life-like examples and structures.

Teachers usually argue against implementing such time-consuming processes in classrooms because they feel that they have to create more time within the existent curriculum. Classroom teachers are genuinely rushed not only by these curricular constraints, but by the many social and environmental events that affect their teaching schedules. Classroom teachers tend to become "schooled in the process of rushing" and teach to meet these mandated objectives putting aside the other, more interactive and student-centered forms of teaching. Perhaps teachers would have to be freed of their classical teaching styles to begin appreciating these more interactive, inquiry-based approaches that subsume the problem-solving process. Laymen and onlookers have an easier time suggesting solutions for educational reform and implementation of these more student-centered instructional formats. However, programs like these take time to build. They need to be processed slowly and cautiously allowing teachers to become used to the process before expecting their students to do so.

Rushing through the problem-solving process is a very unwise solution. It can easily thwart the problem-solving capabilities of young learners who have not tapped into this resource yet. The effect of this rush interrupts the necessary layers of the problem-solving process, which need to be experienced in isolation. For example, as the young problem solver begins to unravel the problem, she often abstracts herself from what is going on around her and reaches a very high level of concentration. This focused and dedicated attention to the task at hand can be short-lived and easily interrupted. She can either be lost in her thoughts for very brief moments or until she stirs herself away. It is through this close, focused thought processing, that the young problem solver enters her exploration terrain, or problem space. She becomes attuned to her own independent thinking and weaves a delicate thread through which she evokes past experience, memory or merely her innate common sense to process the problem. This fine thread can easily be broken and short-lived, especially with reprimands, ridicule and discouraging comments from observers. Youngsters "caught in the act" are often hesitant to pursue this concentrated activity, let alone, to accept it fearing that it is wrong undesirable or, off task.

As educators, we usually wonder what it is that we do to encourage learning. We rarely consider what we do to discourage it. We can be critical about our teaching styles, our program and our objectives, yet we rarely sit down to analyze what we did that didn't go so well or could have been done better. One suggestion, that springs forth from observing the teacher and the students in this research site, is that we as teachers need to become problem solvers ourselves. We need to explore our own problem-solving capabilities and to learn about our own problem-solving style—which, usually resembles our way of thinking. This is much in the same order of things as the learning styles of our students. As our students are unique problem-solvers, so are we. Teachers who have not experienced their own problem-solving process and learned how to interpret and understand problems from this perspective might be the first ones to resist implementing a problem-solving program into their own classrooms.

Taking this need into consideration, one can only say that half the bridge is already built. The rest of the way is paved by slowly integrating the problem-solving atmosphere that is conducive to this type of learning. Change and innovation are part of a slow and progressive process. If, like this classroom teacher, we begin to accumulate information that is both helpful and useful in setting up such a program, then we can customize it to serve our needs and purposes. One key component must be sustained. That is the inclusion of problem-solving activities within an already existent and strong arithmetic, skills-based program. The problem-solving program should not and cannot exclude this rigorous and routine component. The next item to be kept in mind is maintaining a predictable format. Students need to be led slowly into the problem-solving process. They need to know what is expected of them, how to go about doing the tasks and how much room for exploration they have within a problem-solving session. The final, and most important aspect of the program is that of setting up and upholding the necessary conditions and learning climate for incorporating problem-solving lessons of this kind. As evidenced from these research results, the necessary conditions for an appropriate problem-solving climate include the different types of necessary time-slots that follow the rhythm of the problem, the flow and succession of the strategies and the capabilities of the students. Young problem solvers need opportunities to articulate their thoughts and to exchange ideas with peers and with their teacher. However, they also need time for silent reflection, time to toy with possibilities, and time to discard what is not conducive to problem solving. Students should not be forced by time constraints to come up with premature solutions that have not been well thought out. This is why educators and educational communities must tailor programs to their needs and to their particular teaching scenarios. As one program works well in one setting, it does not work well in others. Adaptation of existent processes and assimilation of those venues that work well for us, along with a wise selection of resources, is usually the best way to implement change and innovation.

Summary

Teaching in a problem-solving setting like the one described in this study places the teacher into another capacity, that of orchestrator. Her scaffolding, sense of timing, and progressive pacing are pivotal components of this program's implementation. Her role shifts from the purveyor of information, to that of observer of children. She monitors the direction her students take and makes wise choices with respect to responding to children's writing, talking, ideas and theory building. She also directs group composition, making adequate groupings based on procedural similarities. Her modeling of problem-solving strategies and her integration of context-rich examples allow students to build a repertoire of knowns that help them deal with unknowns. As the students improve and gain confidence, the teacher can step back and leave them on their own.

The young learner's task is to center his attention on what he is doing and to responsibly make decisions and integrate prior knowledge. Students are seldom reprimanded for being playful, creative, even loud. They are encouraged to take part in the process fully and to attempt building theory. All students should be encouraged to explore their search areas or problem spaces so that they too can experience the joy of solving problems.

Epilogue

A Confirmation

It is now ten years since I launched the enrichment program that set me on this inquiry. I began by seeking answers on how to guide talented and gifted youngsters towards the self-realization of their creative potential. After carrying out this study, I realize and confirm now, that youngsters do have tremendous potential and that it is our job to help them unlock it. I am glad today, that I did not cater my enrichment program to a select few, but rather to all of those interested students who wanted to join us.

The spontaneous manifestations I witnessed as I worked closely with children were also insightful. Hin Kin's enraged outcry, Dianne's "partner dots", Jerry's stacks, Zack and Mark's awakening and Bernie's enlightened narratives have strengthened my conviction that every child is unique. I observed this heightened sense of awareness in the children as they were concentrated on solving mathematical problems. I also noticed a unique and dedicated focus towards attaining their goal. This keen sense of agency resulted in a forceful drive, where the goal was the only thing that mattered. The level of abstraction and the drive to complete the task imbued them with a newfound energy— a *second wind.*

I had noticed these behaviors before in my own classroom and was now able to understand them better as researcher. Interestingly enough, even in lay terms, this type of activity is appreciated by parents as they watch their children play. To illustrate, in a recent conversation with a friend, she mentioned how her niece gets into her "eeehh" stage when she plays with her toys. I asked her to elaborate. She said that her niece would start humming in the E key when she liked what she was doing (sorting toys or building things). She would become totally engrossed in what she was doing and the family would leave her on her own, avoiding to disrupt her activity. This eventful coincidence reaffirms what I had experienced for so many years as a classroom teacher. As I look back at what I've gathered and what I have learned, I cannot say that I am back to square one, I have moved up—half a square in my inquiry.

I would like to conclude my work by quoting a segment of a long-time favorite, Benjamin Hoff's (1982) explanation of the principles of Tao in The Tao of Pooh:

> *To know the Way,*
> *We go the Way:*
> *We do the Way*
> *The way we do*
> *The things we do.*
> *It's all there in front of you.... (p. 158)*

In understanding what is out there and drawing on our own interpretive potential, our personal learning style, we should not complicate or interrupt the regular flow of things. We should not have to stop and explain everything as if everything has to have an explanation. We should allow this tremendous power to flow and in so doing, to guide us towards our goal. It is good to straighten things up once in a while and to level the terrain so that there ar no obstructions, very much like Hin Kin did when he found a mistake in an Olympiad problem. However, as learners and as teachers, we should strive for attaining that heightened sense of awareness— a gift that we all have.

Appendices

Artifact #1- Mathematical Problem - "The Sale at the Frozen Yogurt Shop"

Artifact #2- Mathematical Problem - "The Burrows Problem"

#3 Exterior Photograph of the School

#4a Interior Photographs of the School's Halls, Cloak-room, and Classroom

#4b Diagram of the Classroom

#5 Desk List Used for Organizing Desk Contents

#6 St. John's School Grade 5 Mathematics Program

Artifact #7- Problem - "Teaching Reading"

#8 Photographic and Sound Equipment Specifications

Artifact #9 Sample of Mark's Strategies

Artifact #10 Sample of Mark's "Heres"

#11 Photograph of Research Data Strips

#12 Sample of a Contact Summary Sheet used for Data Analysis

Artifact #13 - Sample of Jerry's "Stacks"

Artifact #14 - Sample of Dianne's " Partner Dots"

Artifact #15 - Problem - "The Magic Card Trick"

Artifact #16- Problem - "Alexandra's Allowance"

#17 Photograph - Quebec's 1998 Ice Storm

References

Anderson, J.R. (1990).Cognitive psychology and its implications. NY: Freeman & Co.

Anderson, L.W., & Burns, R.B.(1989). Research in classrooms: The study of teachers teaching and instruction. NY: Pergamon Press.

Appelbaum, P.M. (1995). Popular culture, educational discourse and mathematics. NY: SUNY series State University of New York Press.

Artzt, A.F., & Newman, C.M. (1990). How to use cooperative learning in the mathematics class. Reston, VA: National Council of Teachers of Mathematics.

Azevedo, R. (1998). Expert problem solving in a visual medical domain. Unpublished doctoral dissertation, McGill University, Montreal, Quebec.

Bandura, A. (1982). Self-efficacy mechanism in human agency. American Psychologist, 37, 122-147.

Barnes, D., & Todd, F. (1977). Communication and learning in small groups. London: Routledge & Kegan Paul.

Bartlett, F.C. (1958). Thinking: An experimental and social study. NY: Basic Books Inc. Publishers.

Bernard, H.R. (1988). Research methods in cultural anthropology. London: Newbury Park, Sage Publications.

Bershon, B.L. (1992). Cooperative problem-solving: A link to inner speech. In Hertz-Lazarowitz, R. (1992) (Ed.) Interaction in cooperative groups. Cambridge, MA: Cambridge University Press.

Best, R. (1983). We've all got scars. Bloomington, IN: Indiana University Press.

Bogdan, R., & Biklen, S. (1982). Qualitative research for education: An introduction to theory & methods. Boston, MA: Allyn & Bacon, Inc.

Boomer, G., Lester, N., Onore, C. & Cook, J. (1992). Negotiating the curriculum: Educating for the 21st century. London: Falmer Press.

Borasi, R. (1992). Learning mathematics through inquiry. Porstmouth, NH: Heinemann.

Brooks, F.B., Donato, R.,& McGlone, J.V. (1997). When are they going to say "it"right? Understanding learner talk during pair-work activity. Foreign Language Annals, 30, 525-537.

Bruner, J. (1993). Beyond the information given: Studies in the psychology of knowing. NY: W.W. Norton & Co., Inc.

Brubacher, M., Payne, R. & Rickett, K. (1990). Perspectives on small group learning. Canada: Rubicon Publishing, Inc.

Cazden, C.B. (1972). Child language and education. NY: Holt, Rinehart & Winston, Inc.

Chambers, F.K. (1995). Sociolinguistic theory: Linguistic variation and its social significance. Cambridge, MA: Blackwell.

Cobb, P., Jaworski, B. & Presmerg N., (1996). Emergent sociocultural views of mathematical activity. In Steffe et al. (Eds.), Theories of mathematical learning.Hillsdale, NJ: Lawrence Erlbaum, Associates, Inc.

Cohen, E.G. (1994). Restructuring the classroom: Conditions for productive small groups. Review of Educational Research, 64,1-35.

___________ (1994). Designing groupwork: Strategies for the heterogeneous classroom. Columbia University, NY: Teachers College Press.

Confrey, J. (1995). A theory of intellectual development. For the Learning of Mathematics, 51, 36-45.

Csikszentmihalyi, M. (1990). Flow, the psychology of optimal experience. NY: Harper & Row Publishing.

de Bono, E. (1969). The 5-day course in thinking. Harmondsworth, U.K.: Penguin Books.

Deering, P.D., & Meloth, M. (1990). A descriptive study of naturally occurring discussion in cooperative learning groups. Journal of Classroom Interaction, 28,7-15.

Derry, S.J. (1996). Cognitive schema theory in the constructivist debate. Educational Psychologist, 31, 163-174.

Dewey, J. (1966). Democracy and education. NY: The Macmillan Company.

Dienes, Z. P. (1960). Building up mathematics. London: Hutchinson Educational, Ltd.

Dumont, J.R. (1972). Learning English and how to be silent: Studies in Sioux and Cherokee classrooms. In C. Cazden, V. John, & D. Hymer (Eds.), Functions of language in the classroom, 344-369. New York: Teachers College Press.

Duncker, K. (1945). On problem-solving. Psychological Monographs, 58, 1-112.

Eisner, E. (1979). The educational imagination. NY: Macmillan Publishing Co.

Engle, P.L. (1975). The use of vernacular languages in education. Review of Educational Research, 45, 283-325.

Erickson, F., & Wilson, J. (1982). Sights and sounds of schools. Michigan, MI: College of Education.

Fennema, E.(Ed.),(1975). Mathematics education reports. Madison: University of Wisconsin.

Fenstermacher, G.D., & Soltis, J.F. (1992). Approaches to teaching. New York: Teachers College Press.

Forman, E.A. (1992). Discourse, intersubjectivity, and the development of peer collaboration: A Vygotskian approach. In Winegar, L.T. & Valsiner, J. (Eds), Children's development within social context. Volume 1 Metatheory and Theory. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Fosnot, C.T. (1989). Enquiring teachers enquiring learners: A constructivist approach for teaching. NY: Teachers College Press.

__________ (1996). Constructivism Theory, Perspectives and Practice. NY: Teachers College Press.

__________ & Schifter, D. (1993). Reconstructing mathematics education: Stories of teachers meeting the challenge of reform. NY: Teachers College Press.

Gardner, H. (1991). The unschooled mind: How children think and how schools should teach. U.S.A.: Basic Books.

___________(1993). Multiple intelligences. NY: Basic Books.

Garofalo, J.(1989). Beliefs and their influence on mathematical performance. Mathematics Teacher, 40, 338-341.

Getzels, J.W. (1979). Problem finding: A theoretical note. Cognitive Science, 3, 167-172.

Getzels, J. W., & Csikszentmihalyi, M. (1976). The creative vision: A longitudinal study of problem finding in art. New York: Wiley.

Gilligan, C. (1993). In a different voice. Cambridge, MA: Harvard University Press.

Glaser, B.G., & Strauss, A.L. (1967). The discovery of grounded theory. Chicago, IL: Aldine.

Goodlad, J. (1982). A place called school. In Brubacher, M., Payne, R. & Rickett, K. (1990). Perspectives on small group learning. Canada: Rubicon Publishing, Inc.

Graves, B. & Zack, V. (1996). Discourse in an inquiry math elementary classroom and the collaborative construction of an elegant algebraic expression. Proceedings of the 20th Annual Conference on Psychology of Mathematics Education, Valencia, Spain.

Grene, M. (1966). The knower and the known. London: The Farber Press.

Halliday, F. (1986). Re-Act teaching strategies of research & inquiry: Making the inquiry process work for kids. Montreal: McGill University.

Halliday, M.A.K. (1973). Explorations in the functions of language. London: Edward Arnold Publishers, Ltd.

_______________ (1977). Learning how to mean. NY: Elsevier.

_____________(1978). Language as a social semiotic: The social interpretation of language and meaning. Baltimore, MD: University Park Press.

Harste, J.C. (1993). Inquiry-based instruction. Primary Voices K-6, Premier Issue, 1-4.

Hayes, J.R. (1981).The complete problem solver. Philadelphia: The Franklin Institute Press.

Hertz-Lazarowitz, R. (1992). (Ed.) Interaction in cooperative groups. Cambridge, MA: Cambridge University Press.

Hiebert, J. (Ed.) (1986). Conceptual and procedural knowledge: The case of mathematics. New Jersey: Lawrence Erlbaum Associates.

Holden, C. (1993). Giving girls a chance: Patterns of talk in co-operative group work. Gender and Education, 5, 179-189.

Isaacs, A.F. (1987). Creativity and learning styles how achievement can be limited or facilitated. The Creative Child and Adult Quarterly, 12, 249-257.

John-Steiner, V. & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. Educational Psychologist, 31, 191-206.

Johnson, D. W.& Johnson, R.T. (1990). Cooperative learning and achievement. In Sharan, S. (Ed.), Cooperative learning: Theory and research (pp.23-37). NY: Praeger.

Johnson, D.W., & Johnson, R.T., & Holubec, E. (1993). Circles of learning Cooperation in the classroom. Edina, MINN: Interaction Book Company.

Jones, M.G., & Gerig, T.M. (1994). Silent sixth-grade students: Characteristics, achievement and teacher expectations. The Elementary School Journal, 95,169-181.

Katona, G. (1967). Organizing and memorizing: Studies in the psychology of learning and teaching. NY: Hafner.

Kohler, W. (1929). Gestalt Psychology. NY: Liveright.

Kostovsky, K. & Simon, H.A. (1990) What makes some problems really hard: Exploration in the problem space of difficulty. Cognitive Psychology, 22, 143- 183.

Kozulin, A. (1990). Vygotsky's psychology: A briography of ideas. GB: Harverster Wheatsheaf.

Lakatos, I. (1977). Proofs and refutations. Cambridge, MA: Cambridge University Press.

Lakoff, G., & Johnson, M. (1980). Metaphors we live by. Chicago: University of Chicago Press.

Lampert, M. (1990).When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. American Educational Research Journal, 27, 29-63.

Lantolf, J.B., & Appel, G., (Eds.), (1994). Vygotskian approaches to second language research. Norwood, NJ: Ablex Publishing Corporation.

Lilburn, P. & Rawson, P. (1994). Let's talk math. Encouraging children to explore ideas. Portsmouth, NH: Heinemann.

Lincoln, Y.S., & Guba, E.G. (1985). Naturalistic Inquiry. Beverly Hills: Sage.

Marshall, S.P. (1995). Schemas in problem-solving. U.K.: Cambridge University Press.

Maykut, P., & Morehouse, R. (1994). Beginning qualitative research: A philosophic and practical guide. London: The Falmer Press.

Maxwell, J.A. (1996). Qualitative research design, an interactive approach. Thousand Oaks, CA: Sage.

Meloth, M.S., & Deering, P.D. (1994). Task talk and task awareness under different cooperative learning conditions. American Educational Research Journal, 31, 138-165.

Miles, M.B., & Huberman, A.M. (1984). Qualitative data analysis: A sourcebook of new methods. Beverly Hills: Sage.

Mulryan, C.M. (1992). Student passivity during cooperative small groups in mathematics. Journal of Educational Research, 85, 261-273.

____________(1995). Fifth and sixth graders' involvement and participation in cooperative small groups in mathematics. The Elementary School Journal, 95, 297-309.

NCTM (1990). The teaching and assessing of mathematical problem solving. Vol. 3. R.I. Charles, E.A. Silver (Eds.) Reston, VA: Erlbaum Associates.

Nelson-Le Gall, S.A. (1985). Necessary and unnecessary help-seeking in children. Journal of Genetic Psychology, 148, 53-62.

Newell, A. (1990). Unified theories of cognition. London: Harvard University Press.

Newell, A., & Simon, H.A. (1972). Human Problem Solving. New Jersey: Prentice-Hall.

Newman, R.S. & Schwager, M.T. (1995). Students' help-seeking during problem-solving: Effects of grade, goal and prior achievement. American Educational Research Journal, 32 (2) 352-376.

Noddings, N., & Shore, P. (1984). Awakening the inner eye. NY: Teachers College Press.

Noddings, N. (1996). The challenge to care in schools. NY: Teachers College Press.

Ochs, E. (1979). Transcription as Theory. in Developmental Pragmatics. MA: Academic Press.

Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem-solving. Contemporary Educational Psychology, 20, 423- 443.

Palinscar, A.S. (1998). Social constructivist perspectives on teaching and learning. Annual Review of Psychology, 49, 345-375.

Patton, M.Q. (1990). Qualitative evaluation and research methods (2nd Ed.) Newbury Park: Sage.

Perkins, D., Jay, E. & Tishman, S. (1993). New conceptions of thinking: From ontology to education. Educational Psychologist, 28, 67-85.

Piaget, J. (1959). The language and thought of the child. London: Routledge & Kegan Paul Ltd.

________(1976). The grasp of consciousness. Cambridge, MA: Harvard University Press.

Pimm, D. (1987). Speaking mathematically. London: Routledge and Kegan Paul.

Pimm, D., & Love, E. (1991). Teaching and learning school mathematics. London: The Open University.

Poincaré, J. (1929). The foundations of science. NY: Science House.

Polanyi, M.(1958). Personal knowledge: Towards a post-critical philosophy. NY: Harper Torchbooks, The Academy Library.

__________ (1965). On the modern mind. Encounter, 15, 12-20.

Pólya, G. (1954). Patterns of plausible inference. NJ: Princeton University Press.

Pontecorvo, C. (1993). Form of discourse and shared thinking. Cognition & Instruction, 11, 189-196.

Prevost, F.J. (1996). A new way of teaching. Journal of Education, 178, 50-59.

Randhawa, B.S. (1994). Theory, research and assessment of mathematical problem solving. The Alberta Journal of Educational Research, 11, 213-231.

Resnick, L.B., & Ford, W.W. (1981).The psychology of mathematics instruction. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Rosenblatt, L.M. (1978). The reader, the text, the poem. Carbondale IL: Southern Illinois Press.

Sharan, S. & Sharan, Y. (1976). Small group teaching. New Jersey: Educational Technology Publications.

Schifter, D, & Fosnot, C. T. (1993). Reconstructing mathematics education stories of teachers meeting the challenge of reform. NY: Teachers College Press.

Schoenfeld, A.H. (1989). Problem solving in context(s). In R.I. Charles & E.A. Silver (Eds.), The Teaching and assessing of mathematical education.

Schon, D. (1983). The reflective practitioner. How professionals think in action. NY: Basic Books.

Sfard, A., Nesher, P., Streefland, L., Cobb, P., & Mason, J. (1998). Learning mathematics through conversation: Is it as good as they say? For the Learning of Mathematics, 18, 41-51.

Shuell, T.J. (1995). Teaching and learning as problem-solving. Theory and Practice, 24,102-108.

Simon, H.A. (1980). Problem solving and education in Turner, D.T. & Reif, F. (Eds), Problem solving and education: Issues in teaching research. NJ: Lawrence Erlbaum, Associates, Inc.

Spender, D. (1985). For the Record. London: The Women's Press Limited.

Steffe, L.P.&Tzur, R.(1994). Interaction and children's mathematics. In Ernest, P. (Ed),Constructing mathematical knowledge: Epistemology and mathematics education. London: The Falmer Press.

Stern, E. (1992). Spontaneous use of conceptual mathematical knowledge in Elementary school children. Contemporary Educational Psychology, 17, 266-277.

Stipeck, D.J., & Tannatt, L.M. (1984). Children's judgments of their own and their peer's academic competence. Journal of Educational Psychology, 76, 75- 84.

Stodolsky, S. (1984). Frameworks for studying instructional processes in peer work groups. In Peterson, P.L., Wilkinson, L.C., Hallinan, M. (Eds.), The social context of instruction: Group organization and group processes. NY: Academic Press, Inc.

Strauss, A., & Corbin, J. (1990). Basics of qualitative research: Grounded theory procedures and techniques. Newbury Park, CA: Sage.

Tannen, D. (Ed.) (1993). Gender and conversational interaction. NY: Oxford University Press.

Thompson, A.G. (1985). Developing students mathematical thinking. Arithmetic Teacher, 9, 20-23.

Vygotsky, L.S. (1962). Thought and language. MA: The M.I.T. Press.

Walkerdine, V. (1989). Counting girls out. London: Virago Press.

Wallas,G. (1926). The art of thought. New York: Harcourt Brace.

Weade, G. (1995). When content becomes process: Talking knowledge into meaning in a fourth grade mathematics lesson. Journal of Classroom Interaction, 30, 41-51.

Wertheimer, M. (1959). Productive thinking. NY: Harper & Row.

Winner, E., & Gardner, H. (Eds.) (1979). Fact, fiction and fantasy in childhood. San Francisco: Jossey-Bass, Inc., Publishers.

Wolcott, H. (1995). The art of fieldwork. Walnut Creek: Altamira Press.

Wolfe, L.F. (1982). Toward understanding the ideas about science communicated by elementary school teachers. Toronto: University of Toronto.

Zack, V. (1994). Vygotskian applications in the elementary mathematics classroom: Looking to one's peers for helpful explanations. Psychology of Mathematics Education, Columbus, Ohio.

________(1995). Help-seeking while problem-solving: Adult care-givers and the zone of proximal development. Psychology of Mathematics Education, Columbus, Ohio.

Appendices

Part I

A. Certificate of Ethical Acceptability
B. Sample entry letters

Part II

Samples, Photographs and Artifacts:

1 "The Sale at The Frozen Yogurt Shop"
2 "The Burrows Problem"
3 Photographs of the school
4a Photographs of the hallways, cloak-room arrangements and classroom
4b Diagram of the classroom
5 Desk List
6 Mathematics Program
7 "Teaching Reading"
8 Equipment Specifications
9 Mark's strategies
#10 Mark's Heres
#11 The Strips
#12 Sample Contact Summary Sheet
#13 Jerry's Stacks
#14 Dianne's Partner Dots
#15 "The Magic Card Trick"
#16 "Alexandra's Allowance"
#17 Quebec's Ice Storm 1998

MCGILL UNIVERSITY
FACULTY OF EDUCATION

CERTIFICATE OF ETHICAL ACCEPTABILITY FOR RESEARCH INVOLVING HUMAN SUBJECTS

A review committee consisting of:

1. Prof. E. Lusthaus	1. Prof. M. Maguire
2. Prof. R. Ghosh	2. Prof. C. Mitchell
3. Prof. M. Downey	3. Prof. G. Isherwood

has examined the application for certification of the ethical acceptability of the project titled:

Mathematical Talk Generated in Group Work: An exploration of Student-generated language in an elementary classroom during mathematical problem solving sessions.

as proposed by:

Applicant's Name **Ana Maria Klein** Supervisor's Name **Prof. Ann Beer**

Applicant's Signature ____ Supervisor's Signature ____

Degree Program **Ad Hoc Ph.D.** Granting Agency ____

The review committee considers the research procedures, as explained by the applicant in this application, to be acceptable on ethical grounds.

(Signatures)

a) ____ Date: 97/10/08

b) ____ Date: 97/10/20

c) ____ Date: 97/10/23

Associate Dean (Academic) ____ Date 97/10/27

January 1997

Ana Maria Klein, Ph.D. Candidate
Faculty of Educational Studies
McGill University

September 30, 1997

Dear Parents,

I would like to seek your approval for a research project in your child's class. I will be observing and recording student interaction during mathematical problem solving sessions. My project is designed around **Qualitative Research** procedures where I closely watch and record classroom events as they occur naturally. As researcher I become a **participant observer** taking detailed field-notes of the mathematical problem solving process as it unfolds during each of my visits. At times, I will record the process by capturing some of it on audio-tape. At other times, I might film a small portion of it. I will also peruse children's note-books (not evaluating them in any form) but just looking at what they write, draw and conclude. I will not interfere with the regular flow of events in the classroom or with your child's learning.

Your child's teacher, Miss has graciously agreed to have me observe her classroom. It is clear to both of us that my study will not interfere with her teaching, with the class or with your child's progress.

It is important for me to emphasize at this point, that I strongly believe in protecting the rights of everyone involved in this project. Hence, I can assure you that anonymity shall be strictly guarded and that audio and video-taping will be for data collection purposes only. You and your child may choose not to participate and may also withdraw from the project at any time.

Sincerely,
Ana Maria Klein

Please fill in, sign, detach and return to

Authorization Form For Ana Maria Klein

Name of parent ________________ Name of child ________________

I understand the project:	Yes ___	No ___
I am aware that my child can withdraw at any time:	Yes ___	No ___
My child can be video-taped.	Yes ___	No ___
My child can be audio-taped.	Yes ___	No ___
My child's work can be perused.	Yes___	No ___

Signed ________________ Date ____________________

Ana Maria Klein
Ph.D. Candidate
Educational Studies
McGill University

September 30, 1997

Dear Students,

I am a doctoral candidate working on my final project at the university. I am very interested in working with your class, watching you solve and discuss mathematical problems.

My work involves careful observation of a process. I circulate among you without disturbing you while you work. I try not to interrupt your teacher as she conducts the class and do not take part in the problem solving process. I am mainly interested in watching you work, and in listening to your explanations and presentations. I might borrow some of your notebooks to see what you've written or drawn. I'd also like to make audio and video-taped recordings of a few classroom activities.

I'd like to ask you for your permission to do this. Your participation is completely confidential. I am not grading or evaluating you in any way. You do not have to behave in a particular way when I visit you or watch your group at work.

I need for you to check off the items that you agree to do with me, to sign this form and to return it to your teacher as soon as possible.

Thank you,
Ana Maria Klein

Please fill in, detach, and return to your teacher.

Authorization Form for Ana Maria Klein

Your name ______________

I agree to participate.	Yes ___	No ___
I know that I can withdraw at any time.	Yes ___	No ___
I know that I am not being evaluated	Yes ___	No ___
I agree to being audio-taped	Yes___	No ___
I agree to being video-taped	Yes___	No ___
I agree to letting you look at my written work	Yes ___	No ___

Your signature: __________________ Today's date ______________

The Sale at The Frozen Yogurt Shop

I was walking to school with a group of friends one day last week when Lyn found a flier in the gutter which said that Jake's frozen yogurt store was having a half-price sale on cones that afternoon to celebrate its tenth anniversary of being in business. Everybody got all excited because none of us had heard about the sale before, and we all agreed to tell only a few people (who wants to wait in line forever?).

During morning recess, each of us told one person. Then during the lunchbreak, everyone who knew at that time told one more person. Finally, during the afternoon recess, everyone who knew then told one more person. After school, the 48 people who knew headed directly to the store, and I still had to wait a long time for my cone. But it was worth it.

How many of us were walking to school together?

Problem of the Week:
January 27

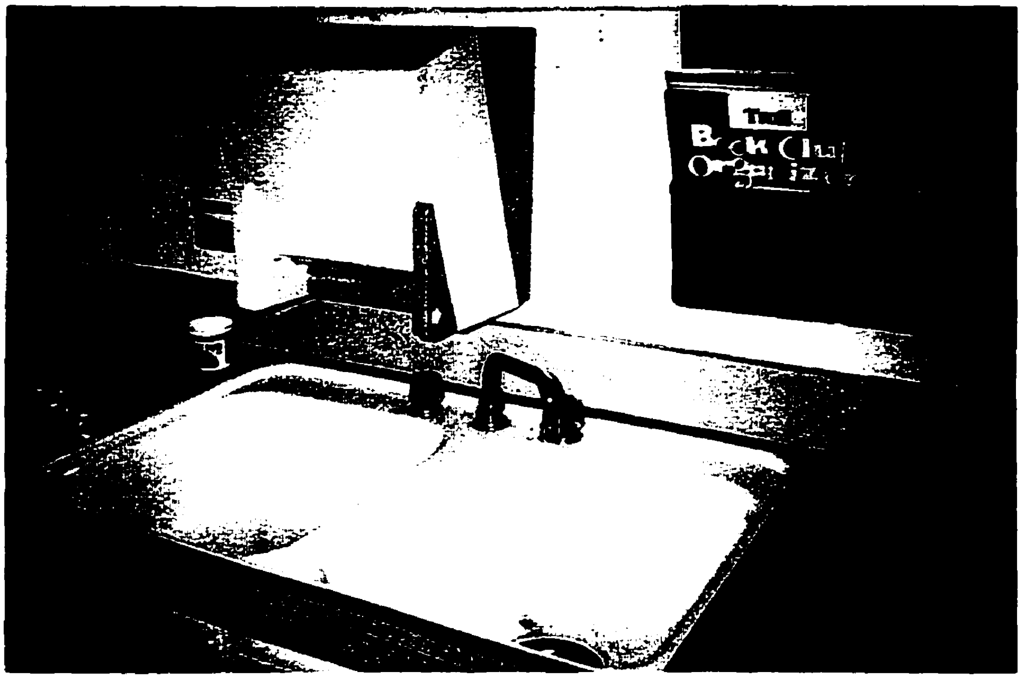
NAME: [handwritten name]
29/1

The prairie dogs were having a town meeting to talk about the blackfooted ferret that was terrorizing the neighborhood. One town councildog suggested building a network of tunnels connecting every burrow to every other burrow. Then someone said, "Are you crazy? We have nine burrows. That's too many tunnels and too much money to build them!" If each tunnel costs $1.00 to build, how much would it cost the prairie dogs to connect every burrow with every other burrow?

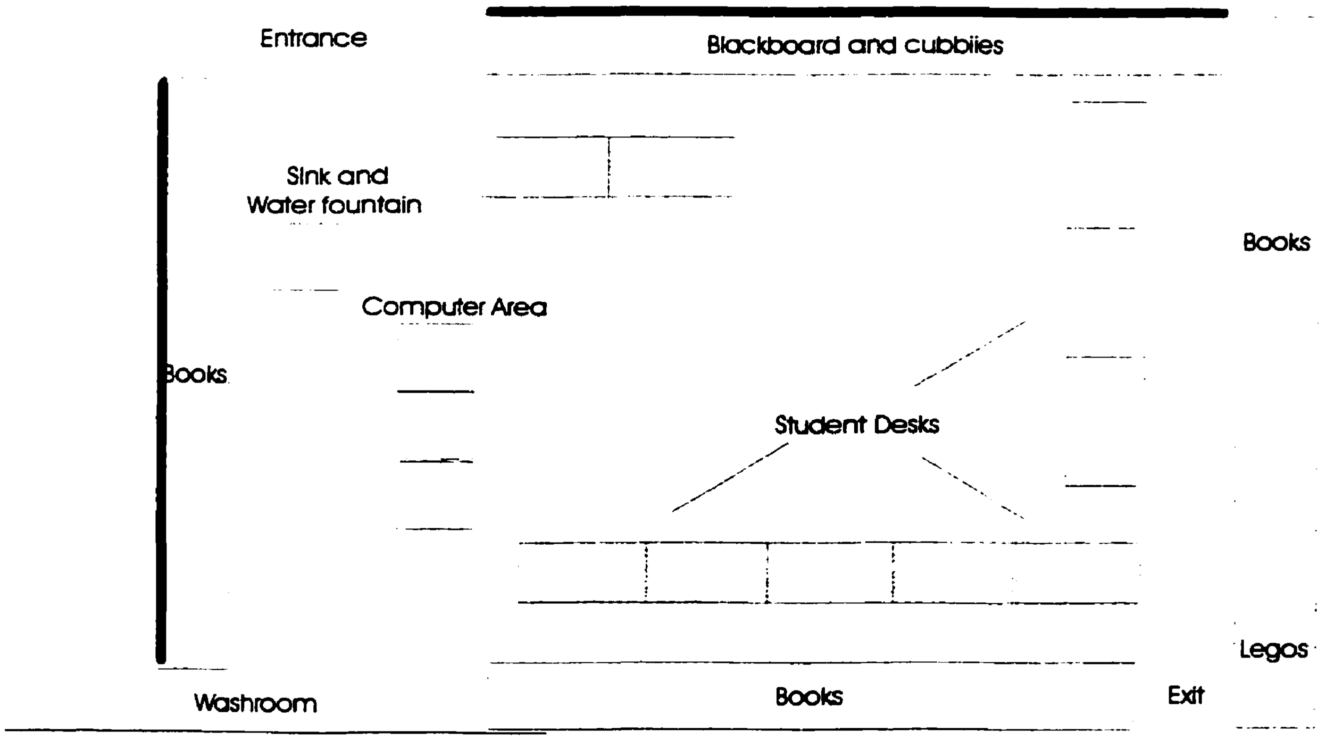
The Problem Solvers, Creative Publications

CHECKLIST for the Problem of the Week

- ☐ Write the answer for the problem in a sentence.
- ☐ Write a detailed explanation of what you did.
  Remember: Imagine that someone is standing next to you and tell that person what you are thinking, and doing. Show all your work in this log. (Do not work on scrap paper.)
- ☐ Write if you had any difficulties ________
- ☐ Write if you had any help ________
  If yes, who helped ________ Write how that person helped.
- ☐ Write the strategy used: ____________________
- ☐ Checking my answer: I checked my answer to be sure that it worked.
  (Remember to highlight, and to write what you did in your checking.)



Classroom


Entrance
Blackboard and cubbiies
Sink and
Water fountain
Books
Computer Area
Books
Student Desks
Legos
Washroom
Books
Exit

GRADE 5 DESKS

Divider (with 10 sheets of looseleaf)
Basic Facts
Math Puzzles
Problem of the Week

Gazette Questions
Canada Duotang

Creative Writing Folder
Eavesdropping Notebook
Words
Drama Response
Journals
Handwriting/Calligraphy
Spelling Lists
Spelling Tests

1 Novel to Read
1 Pencil Box
Agenda

Mathematics Program, Grade 4 and Grade 5

Problem solving will be the focus of the curriculum. We define problem solving in its broadest sense. Problem solving encompasses much more than working on `word problems'. The answer cannot be readily attained through the straightforward application of an algorithm. Thinking is required.

> An individual is faced with a **problem** when he encounters a question he cannot answer or a situation he is unable to resolve using the knowledge immediately available to him. He must then think of a way to use the information at his disposal to arrive at the goal, the solution of the problem. A problem differs from an exercise in that the problem solver does not have an algorithm that, when applied, will certainly lead to a solution.
> (Kantowski, 1977, p. 163) [1]

Problem solving is a complex activity. It involves coordination of knowledge, previous experience, recall of facts, and intuition. We will encourage the children to approach problems by deliberating carefully, questioning, discussing, supporting their points of view, considering diverse approaches, and persevering in their efforts. Our objectives are that the children will:

(1) develop their thinking skills

(2) develop their ability to solve mathematics problems both in cooperative learning situations, and alone

(3) self-assess their needs and tackle areas that interest or confuse them.

We will stress the aspect of **understanding**, the wanting to know "why". We will not be content with only knowing "how", the **mechanics** part, for example learning the operations-- addition, subtraction, multiplication and division. The mathematics program will encompass both aspects, understanding and skills. Facility with basic skills such as addition, subtraction, multiplication and division, is **essential**, and will be discussed further (see below).

. . .over

[1] Kantowski, Mary G. (1977, May). Processes involved in mathematical problem solving, Journal for Research in Mathematics Education, 163-180.

Success in problem solving, indeed in mathematics, very much depends upon the student's interest, motivation and self-confidence. It is our aim to foster in each child a positive attitude and self-concept in relation to mathematics.

<u>Contents of the program</u>

As mentioned above, the emphasis will be on the aspect of **understanding** (that is, the **conceptual**), with attention paid as well to the **skills** aspect (that is, the **procedural**). The children will deal with:

(1) the numeration system (base 10, numbers and their place value)

(2) performing operations, that is the addition, subtraction, multiplication and division, of whole numbers, and decimal numbers (including fractions)

(3) estimating and measuring length, area and volume in metric units.

(4) exploring geometry (line, angle, symmetry; transformational geometry)

(5) graphs (pictographs, bar graphs, line graphs, etc. . .)

There is a more detailed list of program objectives available for reference, based upon the MEQ (Ministry of Education of Quebec) guidelines. The skills part of the program will be covered within the context of the problems the children will be working to solve.

Please Note: The children will be expected to master certain "basic skills" such as their addition and subtraction facts, and their times tables. We will enlist the help of the parents in this effort.

Textbooks

Gr. 4:

MathQuest 4

Challenging Mathematics 4

Interactions 4

Gr. 5:

Mathematics 5	Houghton Mifflin Canada Ltd.
Mathquest 5	Addison Wesley Publishers

The text book will be used as a general base, but it will not necessarily be used every day. Materials from other resource areas will be frequently used.

Grade 4 and Grade 5 Computer Science

The computer science program is integrated into every phase of the Grade 4 and Grade 5 curriculum. Computers will be used extensively throughout the year. Susan van Gelder has outlined the aims and activities for this year's program on an accompanying sheet.

Evaluation

There will be 4 written reports throughout the year and 2 scheduled interview times. If necessary, additional interviews may be arranged through appointments with classroom teachers.

- January 30, 1998 -

Teaching Reading

In the newly developing country of Zamwana, teaching reading is a focal point of the government program. The plan is for each individual who can read to spend one year teaching two others to read. That individual is done, but the two new readers must spend one year, each teaching two others to read.

If 1,000 people can read in Zamwana now, how many people will be able to read in ten years?

Instructional Communications Centre
Audiovisual Arrangements Section
McGill University, Stephen Leacock Building Rm B-12
855 Sherbrooke St. W.--855 Rue Sherbrooke Ouest
Montreal, P.Q. H3A 2T7 TEL: (514)398-7200 Local 0870 FAX:398-8451

Loan Date: 14:26:30 February 11, 1998 **Due-back Date:** February 12, 1998

Client Id: 9552173 **Client Address:** 3404 HINGSTON APT. 16
Client Name: Ms Ana Maria Klein MONTREAL, QC
Department: EDUC(CURR & INSTR)
Phone Number: 481-4926 H4A 2J4
Course Number: THESIS **Account Number:** N/A

AV Number	Item Name	Charge	Returned Date
#1 PC STILL CAM 33402	PC_STILL_CAM_KODAK_DC40_EKD54002279	N/C	/ / Rental
#2 -CAMCORDER-- 95240	CAMCORDER__PANASONIC__PV-940-K__H5WA10169	N/C	/ / Rental

GST: *N/A*
PST: *N/A*
Total : N/A ***Rental***
Amount Paid: N/A

Did you know?

We have multimedia laptop pc's and portable data projectors available for classroom presentations.

FINES IMPOSED ON ALL LATE RETURNS
AMENDES IMPOSEES SUR TOUT RETOUR RETARD

EQUIPMENT AND/OR FILMS RECEIVED, I UNDERSTAND THAT THESE ITEMS ARE NOT INSURED AND THAT I AM PERSONALLY RESPONSIBLE FOR THEM.

ACCUSÉ DE RECEPTION DU MATERIEL OU DES FILMS. IL EST ENTENDU QUE LES ARTICLES NE SONT PAS ASSURES ET QUE J'EN ASSUME L'ENTIERE RESPONSABILITE.

Our Office Hours: 9:00AM to 5:00PM
Monday to Friday

Visit our web site at:
http://www.mcgill.ca/icc/

Oper.

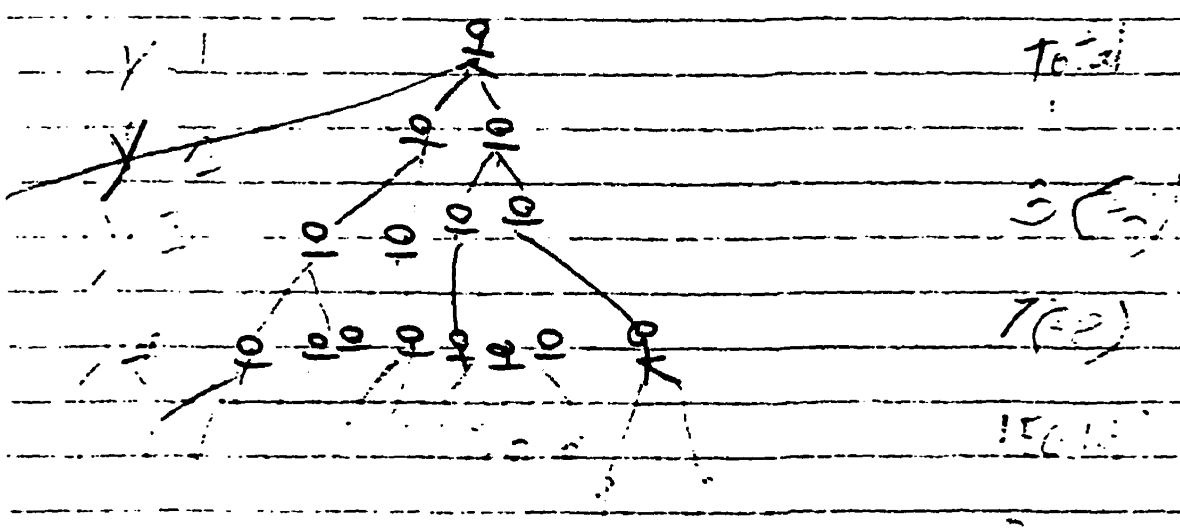
Signature : ______________________

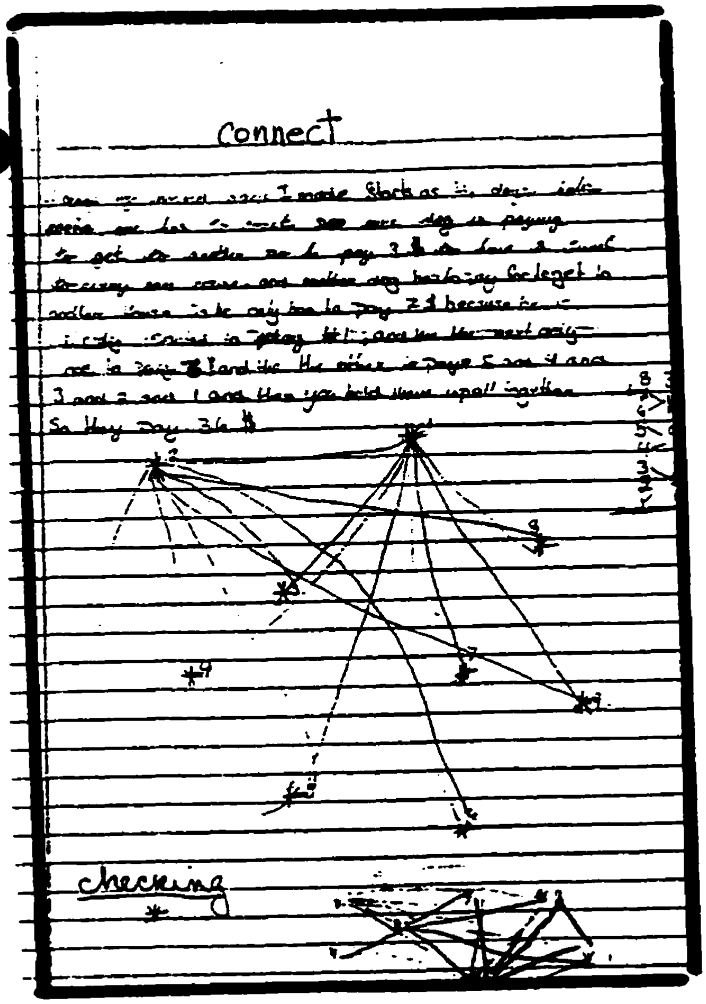
G.S.T. # R 119128981
Q.S.T. # 1006150787

Date Printed: ***14:30:47 February 11, 1998 by: ROBERTG***

Each person who knows how to read has to spend 1 year teaching two people.

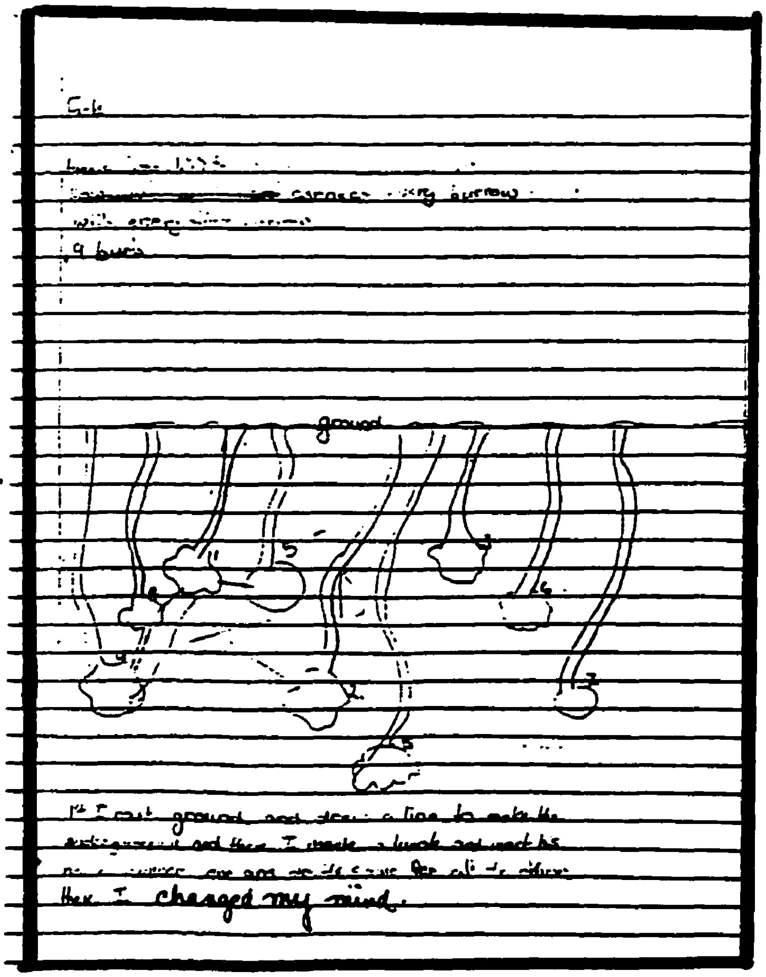
Once she has tought the two people the person can retire but the people who have been tought has to both teach 2 other people.





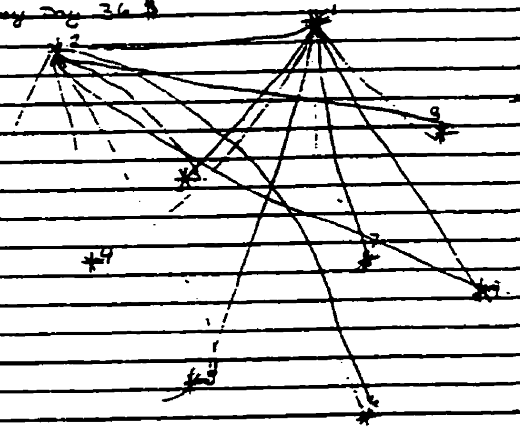
In this figure, the two pictures (one on top, the other below)show the way this child refined his diagram and improved it when he was checking his calculations. Another contributing stage in this child's problem-solving process was all of the writing he did before starting to draw the first diagram.

In this diagram, Mark is explaining his 'heres' to me, which are the intricate burrows he had drawn to describe where each ferret would go. Notice the detail in shape, distance and size of the burrows and their exact location 'under' the ground. Mark not only was able to add context to the problem, but was also able to locate each entrance so that there were no possible collisions. He also took the time to carefully number each to distinguish them from each other. His writing shows how he thought about something and then 'changed his mind.'

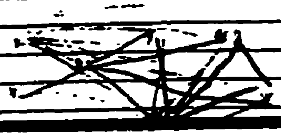


Connect

[illegible] I made 8 bark as [illegible] dog [illegible] [illegible] dog is paying to get [illegible] pay 3 $ [illegible] [illegible] forget to [illegible] only [illegible] to pay 2 $ because he [illegible] paying [illegible] and the next only one is pay 3 and the the other is pays 5 and 4 and 3 and 2 and 1 and then you add them up all together So they pay 36 $



checking



5-6

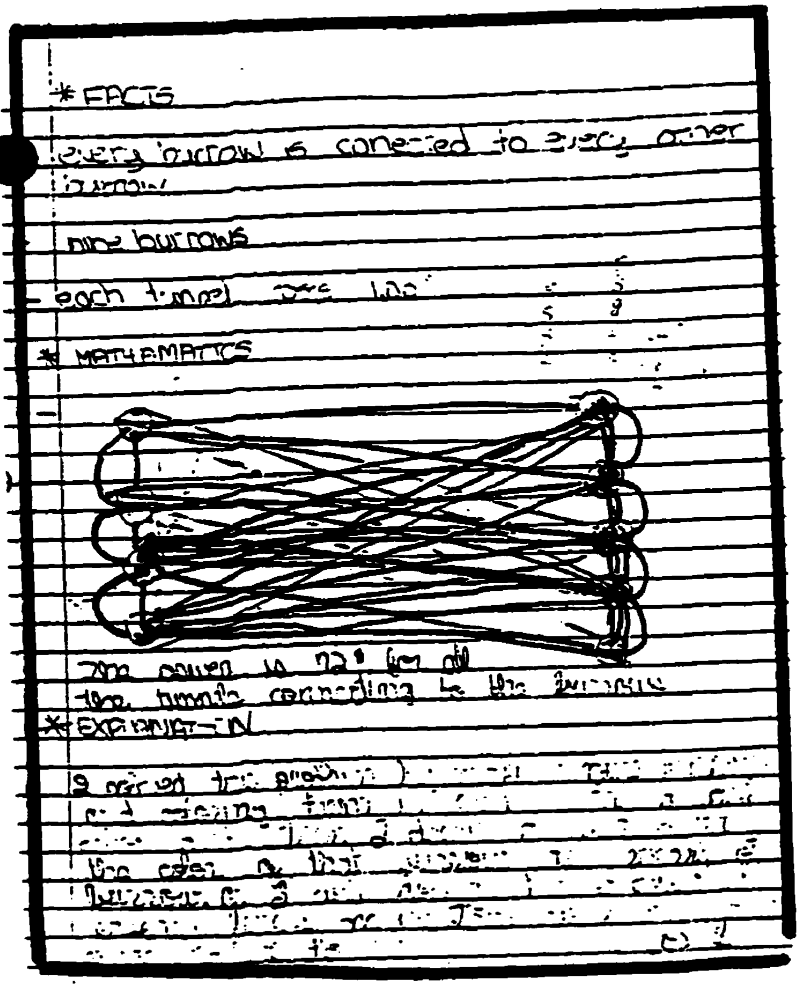
[illegible]

[illegible] burrow [illegible]

with [illegible]

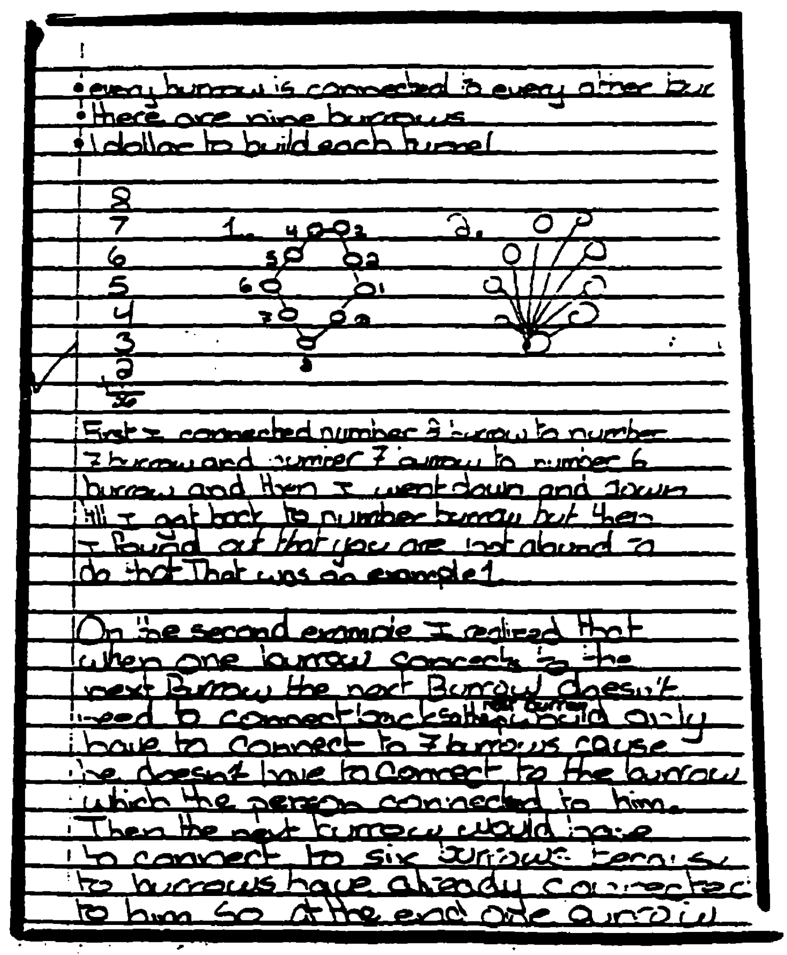
9 [illegible]

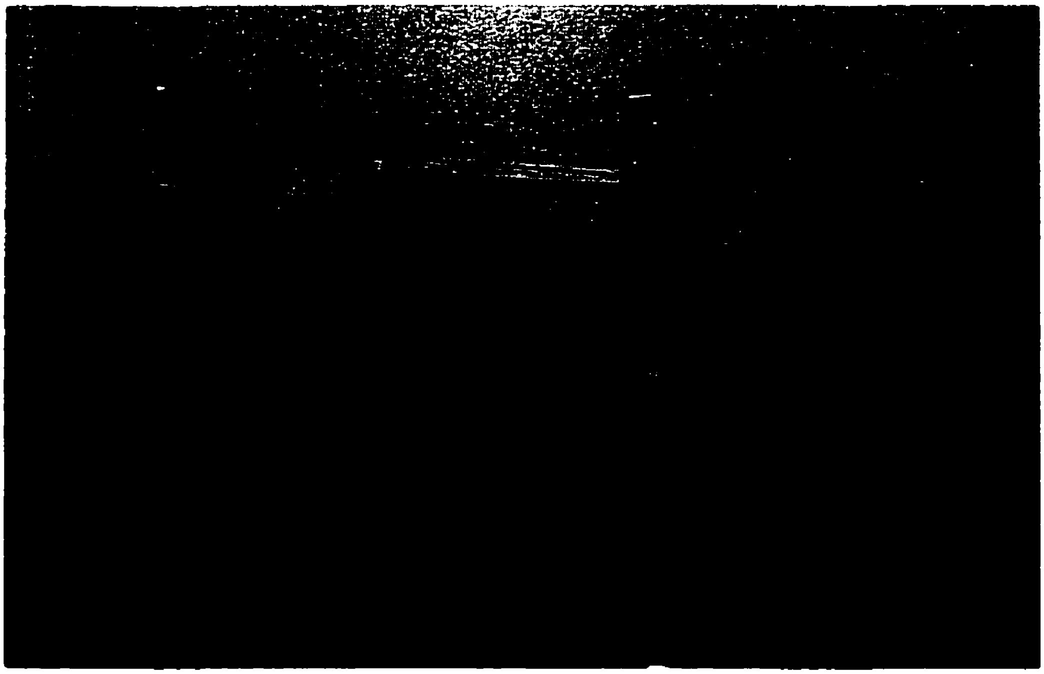
1st I [illegible] ground and [illegible] a line to make the [illegible] and then I made a [illegible] and [illegible] [illegible] for all the others then I changed my mind.

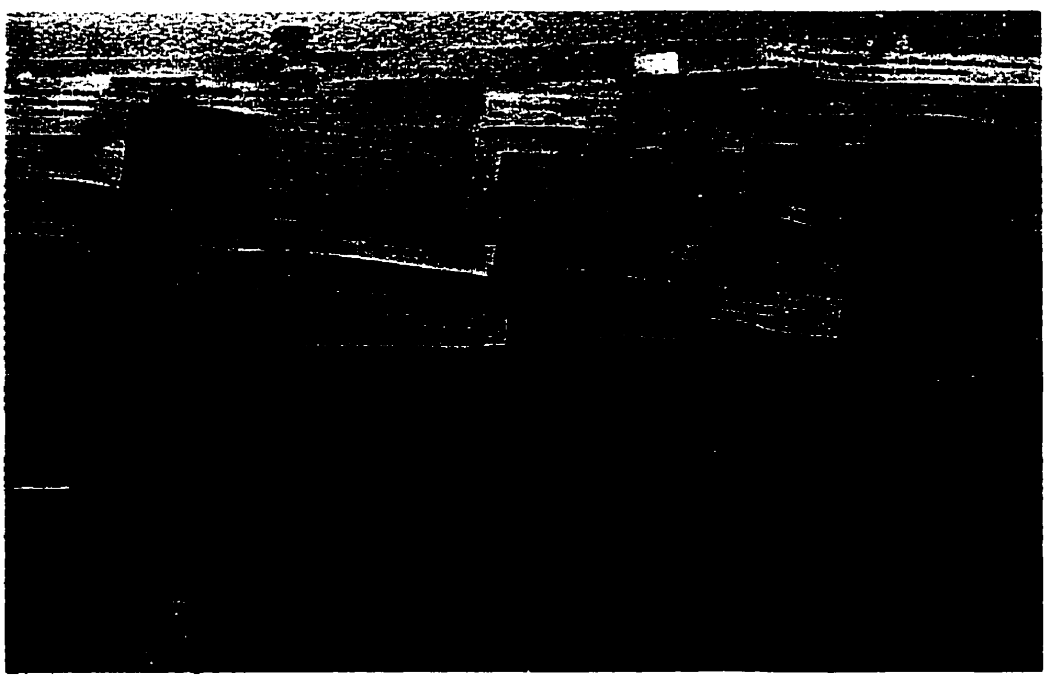


In both of these figures, we notice how each child had a totally different interpretation and view of the problem. This diagram in particular, shows how difficult it was to draw all of the lines and to keep track of them. However, this child in particular did a lot of writing while he was drawing the lines and thus was able to control his process better

This child had a circular conception of the problem and was also able to rebuild his original diagram as a form of proof. One diagram substantiated the other. He used a number column to tally his counting of the burrows and then wrote about what he did. He tells us that while refining his process he realized something new and changed his original thought process. Notice how in the second figure the burrows radiate towards a central focus.







Ana Maria Klein
Research Protocol
Video-Viewing Transcript #

Date of event:
Date of Viewing:
# of Viewing:
Problem-solving activity involved:
Other recording device used:
Classroom group involved:
Duration of class:

Episode Narrative:

Manner in which problem was presented:

Distribution (group work, individual work, paired activity)

Teacher-direction (presentation of problem/design of groups, modeling/scaffolding)

Environmental problem-solving:

Other major events going on in school:

Indwelling:

Research concerns:

Narrative of Events:

ier
s

set #3

set# 2

- group of them set#1

Morning each group tells one
Lunch = everyone who knew
school and Morning
told one

Afternoon - everyone (school
morning + lunch) told one
48 frozen yogurt

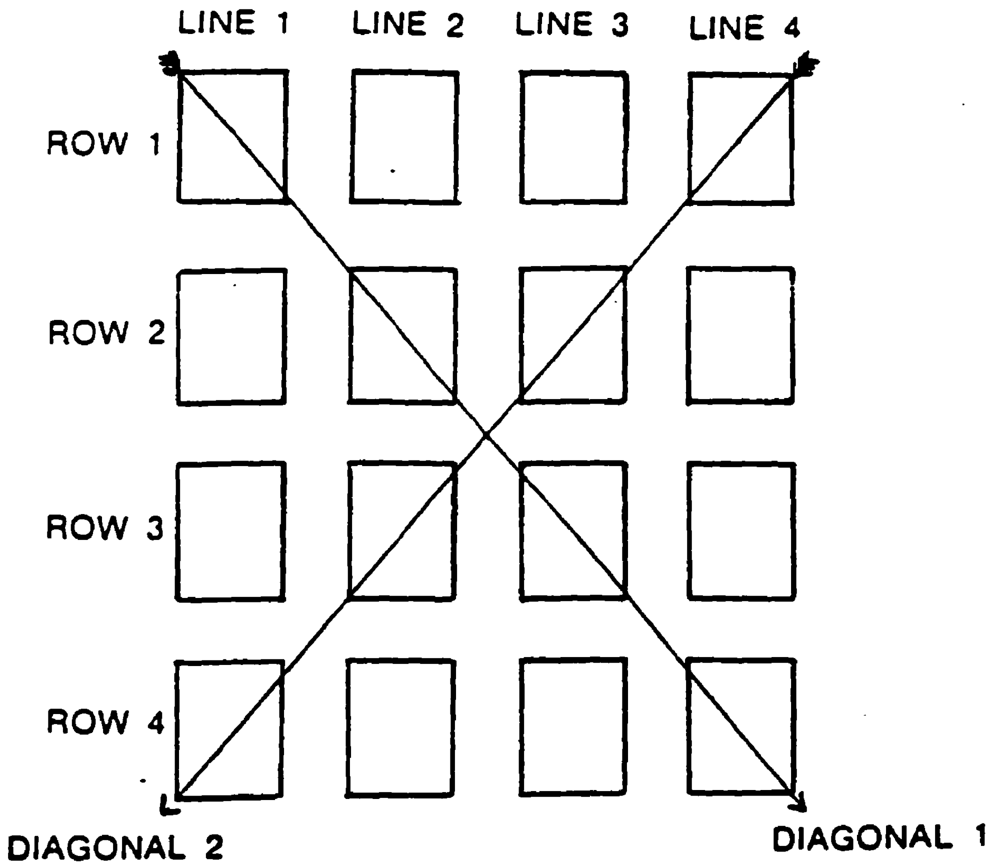
6			

A MAGIC CARD TRICK

For this activity you need 16 playing cards: the ace, king, queen and jack of each suit — spades, hearts, diamonds and clubs.

1. MAKE A MAGIC SQUARE

Take your 16 cards and make them into a square with 4 rows and 4 lines.



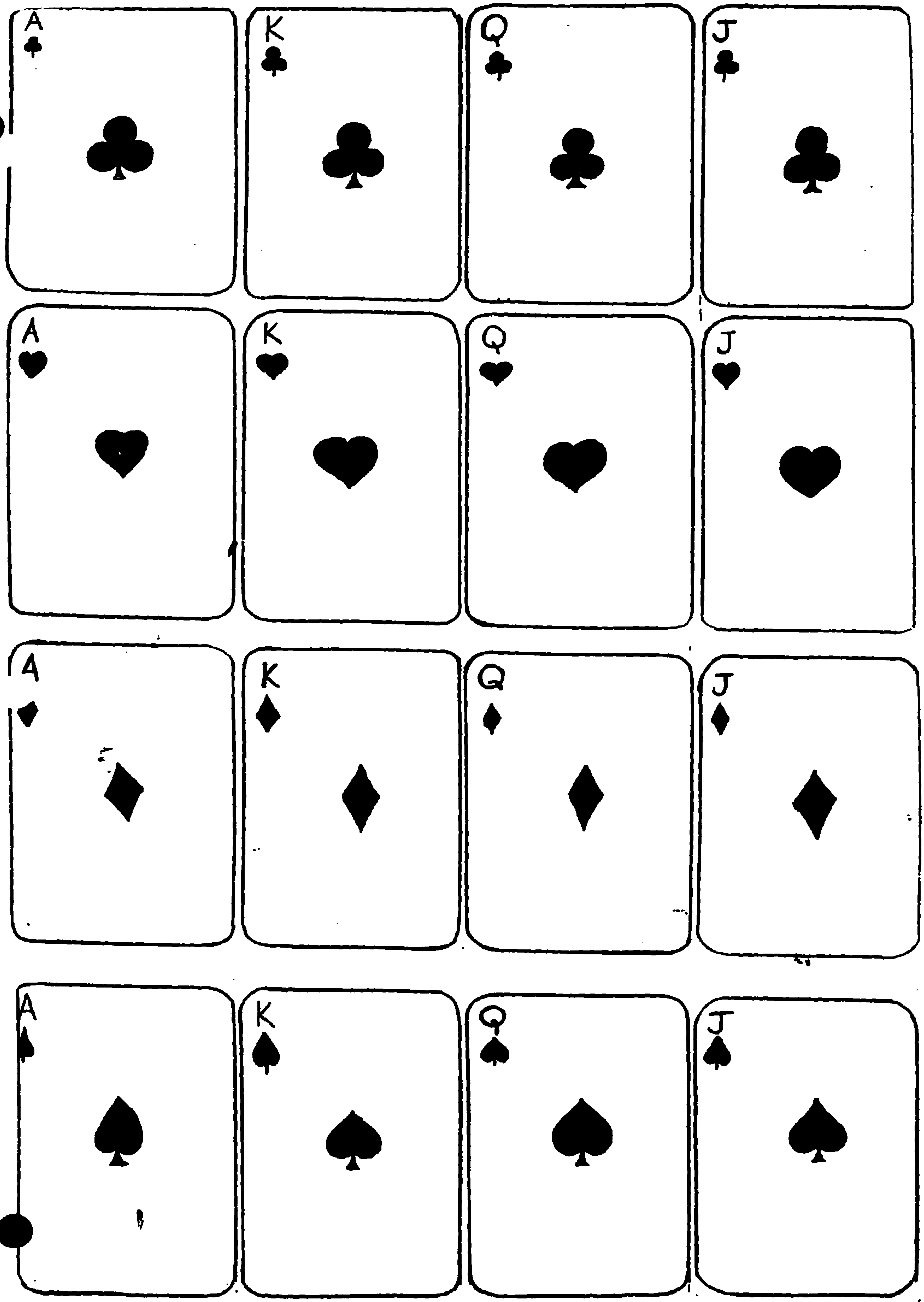
Follow these rules:

(a) Each row contains each face (ace, king, queen, jack) just one time and contains each suit (heart, spade, diamond, club) just one time.

(b) Each line contains each face and each suit just one time.

(c) Following the cards along the 2 arrows, each diagonal contains each face and each suit just one time.

If you have followed the rules you have made a magic square.


A
K
Q
J
A
K
Q
J
A
K
Q
J
A
K
Q
J

Name:

PROBLEM of the WEEK
November 26, 1997

ALEXANDRA'S ALLOWANCE

Alexandra is paid an allowance of $2.25 every Friday. One Friday, her mom gave her the allowance in nickels, dimes and quarters. Alexandra received 14 coins in all.

How many of each kind of coin did Alexandra get?

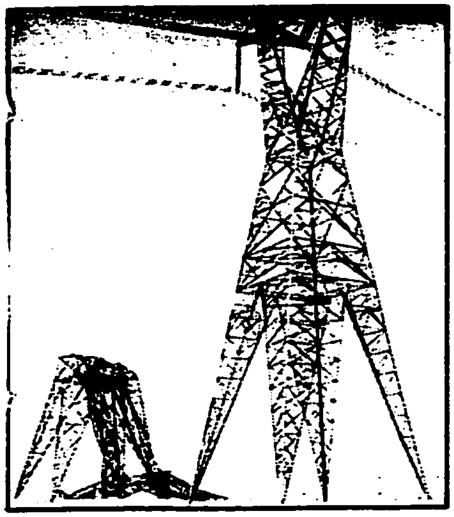
ANSWER: I got find the aner by using 8 25 cent cons and 1 10 cent cons and 2 5 cent cons

STRATEGY: draw a pic tur and guess and check

Checklist:

- [x] Did I write the answer in a sentence?
- [x] Did I write a complete explanation of what I did?
- [x] Did I write down the strategy that I used?
- [x] Did I check my answer to be sure that it works?
- [x] ~~Did I write about any difficulties, who helped and how?~~

Vol 6 no 02
January 15 - 21, 1998

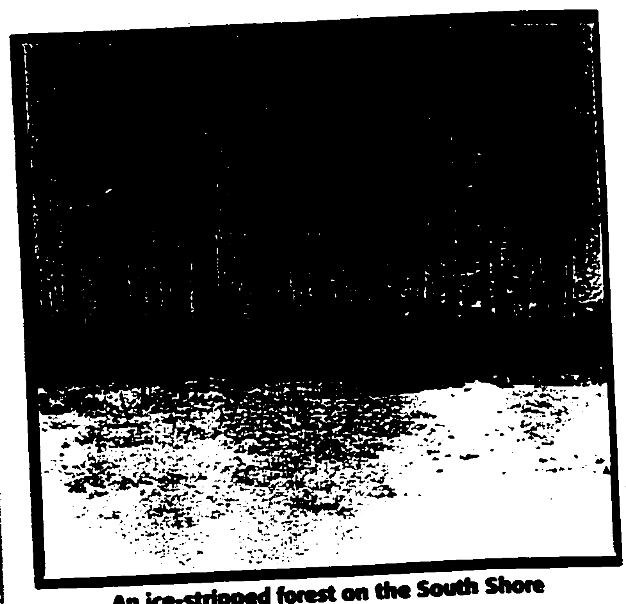


Ice storm highs and lows

Call it an alternative current: *Hour* writers put their spin on the storm of the century and its cold aftermath. Stories and columns by **Buffy Childerhose**, Linda Gyulai, MJ Milloy, Peter Scowen, Lyle Stewart and **Carl Wilson**.

Coverage begins on page 6

Cover photo by **Benoît Aquin**



BENOIT AQUIN

An ice-stripped forest on the South Shore

BENOIT AQUIN

Appendices
Part II

I Video Transcripts

II Analytic Memos

III Vignettes

St. John's School- Montreal
Video Transcript #1
Date of visit: Thursday, January, 29 1998
Group A
Problem of the Week: The Readers of Samwana
Gendered pairs assigned by Miss Z.
Time: 9:00-11:20
Researcher comments in italics, children's actual dialogue in bold characters

I scan the entire classroom with the camera. I include close shots of bulletin boards and all sorts of classroom spaces so that I can view them again if I need to. It is 9:00 a.m. The children are assembled on the rug, Miss Z's explaining the task to group A. They're discussing world news and setting up to do the Problem of the Week: The Reader's of Samwana. Miss Z has them read the problem several times. She encourages them to read and enunciate the problem several times. This allows them to "mull it over" she says, and organizes the children in gendered pairs. They are ready to begin working at 9:45.

Edward with Elaine
Myra with Wayne
Dafne with Jules
Armelle with John
Mark and Amalia (close to Miss Z)
Gina and Jordan T.

The Activity begins, 9:50. There is a lot of mumbling and general "getting ready" sort of activity. Nobody is engaged in conversation yet. Most of the talk is one or two work-phrases. Boys usually make the opening remarks as if sizing each other up. Girls get up and try to speak to other girls from other groups.

1. 29/1/98 *Gina is intent on her task. She's not afraid of confronting Jordan T.*

2. 29/1/98 *Dafne is lying on the floor figuring something out..*

3. 29/1/98 *Jules is trying to tell her something...*

4. 29/1/98 *Dafne's not sure she accepts what Jules says.*

5. 29/1/98 *Amalia looks around for help...she reclines on Miss Z's closeness..*

6. 29/1/98 *Gina is writing..*

7. 29/1/98 *Jordan T. seems to be talking to himself.*

8. 29/1/98 *Gina seems to know where she's going. They work well...she's a challenge for him...*

9. 29/1/98 *Jules takes things simplistically...as soon as the numbers arrange themselves, he's pleased and stops.*

There's a lot of scribbling, jotting down and mumbling. The students are not really engaged in discussions, arguments or conversation.

10. 29/1/98 *Wayne and Myra are both figuring things out...*

11. 29/1/98 *Myra asks Wayne a procedural question and continues.*

12. 29/1/98 *Amalia and Mark still rely on Miss Z.*

13. 29/1/98 *Elaine and Edward are thinking out loud... they're sharing nicely...*

14. 29/1/98 **Edward says, "O.k., that's one..."**

15. 29/1/98 *Elaine looks on counting in her head...*

16. 29/1/98 *Armelle and John don't speak much.*

17. 29/1/98 *Dafne A. approaches Gina...who's still working it out...Dafbe and Jules are through.*

18. 29/1/98 *Gina figures out the "marketing principle". She says,* **"This is like a marketing principle that my father taught me...First you plot down the numbers and then.."** *She doesn't pursue this explanation because the others are busily plotting down their own numbers. Gina and Jordan T. are busily jotting down numbers, very concentrated.*

19. 29/1/98 *Myra's very happy because she's figured it out. She's cheering away and smiling.*

20. 29/1/98 *Jordan and Gina continue working away at their solution.*

22. 29/1/98 *John and Armelle are also finished. They're correcting their text-book math.*

23. 29/1/98 *Miss Z continues helping Mark and Amalia*

24. 29/1/98 *Jules shares his work with me. I find his answer very simplistic.*

25. 29/1/98 *Jordan T. and Gina explain their work to me...here's where she expresses the idea she'd been formulating. They're talking about an 8 figure number.*

26. 29/1/98 *Dafne A. joins them.*

27. 29/1/98 *Gina tells Jordan T. and Jules to do a checklist so they can get extra points.*

28. 29/1/98 *Jordan T. reminds her that there's a difference in their results.*

29.. 29/1/98 *Jules, Dafne A. , Gina and Jordan T. form a group of four. They're supposed to negotiate. The girls side with each other, the boys side with each other. There's little collaboration or cooperation here.*

30. 29/1/98 *Elaine and Myra side with each other and share their work with me.*

31. 29/1/98 *Myra pulls up the calculator. They compare.*

32. 29/1/98 **Elaine says... "Me and Edward..."**

33. 29/1/98 *Myra urges her to show her results...*

34. 29/1/98 *Elaine says her strategy was "organized list" she explains what she had to do...she speaks in a girlish voice...*

35. 29/1/98 *Myra looks on playfully, also adopting this girlish demeanor.*

St. John's School, Montreal
Video Transcript #2
Visit dated Friday January 30
Time 9:00-11:20
Group B
Problem of the Week : The Readers of Samwana
Classroom structure - Gendered pairs assigned by Miss Z.
Researcher Comments in italics, children's explicit dialogue in bold characters

Miss Z's meeting the children of group B on the rug and has the students re-enact somebody teaching somebody. This physical involvement is very helpful. She hadn't done this with group A. Gendered pairs are...

Jerry and Lea
Adelso, Cora and Joseph
Zach and Alana
Jordan W. and Dafne F.
Dianne, Don and Donna

1. 30/1/98	*Lea tells Jerry what to do...they're having an I boss you you boss me relationship. They're also in a hurry. Lea doesn't seem to be bothered by details...*
2. 30/198	*Jordan W. and Dafne F. are working on the rug.*
3. 30/1/98	*Dianne explains what Donna she and Don have worked on. Dianne takes the lead.*
4. 30/1/98	*Don contributes with a brief nod.*
5. 30/1/98	*Dianne smiles as she explains the group's calculations.*
6. 30/1/98	*Jerry tells me what he and Lea have come up with.* *He's not too happy with it all.*
7. 30/1/98	*Jordan W. and Dafne F. use the contents in their pencil case to figure it out.* *In this pencil-case episode, they spend a lot of time fumbling and counting the contents. They spread them out on the carpet. Their conversation is basically in keeping up with the counting. They get up to reach for other objects to add to their array on the carpet.*
8. 30/1/98	*Dianne, Don, Donna, Alana and Zack eventually use the lego blocks* *The girls are calculating with the blocks the boys start playing with the blocks.. flying them in the air. Dianne shows Alana and Domna what she has figured out.*
9. 30/1/98	*Dianne snaps at the boys and tells them to stop playing.*

St. John's School
Video Transcript #2
Date: Friday, February 6
Time: 9:00-11:20
Problem of the Week: Readers of Samwana-discussion
Group B
Individualized work

Mark's celebration interview. I take him to the next room and ask him to share the success of the previous day with me. He's with group A and needs to run off to the other class, so I ask him a few questions and film hem. He reveals his process to me and tells me how he felt good about doing something that he's usually not good at doing. [To me this was re-enactment of the self-efficacy principle]I can almost predict that from now on he will experience success more frequently....[In terms of attribution theory?]...when I asked him what others did...he attributed their success to their own capacity and difference...his careful working of the pattern on paper reveals how the procedural assisted the logical...[I can almost anticipate that he'll do well in the burrows problem because he's not only got strategy...he's got confidence.] He's also able to explain things and to repeat an explanation...or to sustain his point of view without the influence or approval of others... End of interview with Mark.

The teacher has got the group gathered under the board in a circle. She's explaining something from the white bin. The teaching assistant is sitting off at a corner working on something...They're proceeding to glue the burrows problem in. This is group B. Miss Z asks them to start reading...She clarifies the vocabulary...children get creative about what they know about ferrets and prairie dogs. She experiments here with the yarn...I assume that by doing this activity...students will have a better image from which to work from. She has them work independently with the dividers up.

1. 13/2/98 *Jerry's excited about "an easy way to solve the problem" he's cheerful and confident.*

2.13/2/98 *Dianne comes and sits across from him. They're all setting up their dividers..*

Miss Z's putting away the yarn...Everybody's on task...

3. 13/2/98 *Jerry crosses out something he'd done previously...*

4. 13/2/98 *Don's busy at work*

5. 13/2/98 *Lea's getting serious*

6. 13/2/98 *Jordan W. is very concentrated*

7. 13 2 98	*Donna is reading*

8. 13 2 98	*Dafne G. is also on task*

Miss Z is walking around putting things away. She has now approached Cora and is helping her.

9. 13 2 98	*Donna and Adelso sit at that table.*

10. 13 2 98	*Jerry's smiling happily...I think early into this stage he's already figured it out.*

11. 13 2 98	*Bernie's getting into gear.*

12. 13 2 98	*Adelsoo's working away.*

13. 13/2 98	*Jerry starts to bounce back and forth and to make his voice sounds*

The room is quiet as children are ticking away with their pencils and markers.

14. 13/2/98	*Dianne's making colored connections in her design. She's finished, zippers up her pencil case and is ready to write. Dianne explains her process to me...pointing at all the lines and configurations in her design. She doesn't seem to lose count or to get confused. Her first attempt she crossed out because "it was wrong" she did it with different colors so as not to get mixed up. She talks about multiples of eight and one taken away. I probe more deeply and ask her how she worked it out...she multiplied 8x8 and take away 9 (there's nine tunnels they're connected to)*

15. 13 2/98	*Jerry's got a huge picture in front of him. He's making lines and working very quietly. He can explain what he's doing...he's got a system of bars over his page that he uses to count with or to check off. I ask him if he slept well. He tells me that he hasn't been sleeping well at night...I've been going through the same thing...it's the change of the season.*

16. 13/2/98	*Jordan's working neatly at his problem. He's got a chart and is working from the numbers he's placed on the chart. He's very neat and has made numeric connections which are very evident from his working...he's able to connect number theory to the procedural...he sees a numerical progression.*

17. 13/2/98	*Bernie's created ab interesting rectangle-arrow figure...he's able to explain why he moved from pencils to colors...he's got it all figured out...I ask if I can watch...this makes him feel good and proud...*

18. 13 2 98 *Zack's very excited about his diagram...he's got it all figured out and starts cheering like Mark did the day before. He checks with Bernie about the effectivity of the color coding system. He begins to move rhythmically...getting up from his table...*

19. 13 2 98 *Bernie comes over to see how he's doing...*

Miss Z asks them to start writing...

20. 13/2/98 *Don's sitting next to Zack.*

21. 13 2 98 *Zack starts waving his arms in the air in joy.*

22. 13/2 98 *Don's looking over his shoulder...*

23. 13/2/98 *Zack gets up to get other markers...he's also playing around with a calculator and stuff from Miss Z's desk.*

24. 13/2/98 *Jerry continues working quietly*

25. 13/2/98 *Jordan W. is also quietly and diligently working.*

26. 13.2.98 *Don's kind of getting it*

27. 13/2/98 *Zack starts yelling:* **"Oh, yeah...this is so so good..."** *He's contagiously happy...clicking and singing.*

28. 13/2/98 *Don looks on...*

29. 13/2/98 *Zack gets up and tells Bernie how his is working.*

30. 13/2/98 *Bernie has now created a larger diagram...to make it all come out clearer*

31. 13/2/98 *Zack gets up declaring he's finished and celebrating wildly.*

32. 13/2/98 *Lea's working quietly.*

Miss Z approaches her and sets her on the right track. She's sort of confused but works diligently.

33. 13/2/98 *Zack holds up his work.*

34. 13/2/98 *Don's busily making all of his lines.*

35. 13 2 98 *Joseph is also actively engaged making his lines.*

36. 13 2 98 *Dianne's writing her explanation. Her design is very large and explicit.*

37. 13 2 98 *Zack can't get over his enthusiasm and he continues to walk around and to hop about everywhere.*

St. John's School
Video Transcript # 3
Date: Thursday, February 19
Time: 9:00-11:20
Problem of the Week: The Burrows Problem
Researchers comments in italics: children's explicit talk in bold characters
Group A
Pre-formed groups

Miss Z has assembled the students on the rug. They have text-book homework and are also going to work on the problem of the week. She's talking about a bibliography section in their project. They're working with a three-ring binder where they make dividers and label them. The last one is bibliography. This is the beginning of the Middle Ages project. She's handing out reference sheet hand-outs. They're learning how to reference sources other than books and encyclopedias. When done with the problem of the week, they can correct their text-book homework. She has revised their writing about the burrows problem. Miss Z is interested in how they came to a solution. The problem is in the checking....she's interested in knowing how they checked their work. What evidence they left behind them. If they put numbers into the calculator, she needs to know which numbers they punched in.

They are going to work in pre-formed groups. They are now working with new partners based on how they solved the problems.

Dafne F. and Wayne
Elaine and Jordan T.
Amalia and Gina
John and Edward
Myra and Armelle

1. 19/2/98 *Edward and John begin working. They start by measuring up and comparing how big their pictures look.*

2. 19/2/98 *Edward says :* **"You got the same numbers as I did."**

3. 19/2/98 *John says:* **" I know."**

Their dialogue continues to be the same, comparing and agreeing.

4. 19/2/98 *Myra and Armelle are working together on the rug. They're showing things to each other, more in a sharing sort of way.*

Theirs is not really explicit dialogue but supportive nods and mumblings. One shows what she did while the other looks (I find this interaction very different from what I saw among boys... it's a like...let me show you.

5\. 19 2 98 *Dafne F. and Wayne are working together on rug. They're comparing...Dafne can't seem to get her edge in...she sits it out.*

6\. 19 2 98 *Elaine and Jordan T. seem to race each other they are competing to see who gets to the blackboard first.*

An argument between Dafne F. and Wayne ensues. It is a one-on-one they will they won't and they don't find a common ground...Dafne F. acquires a babyish tone to make her point...or to convince Wayne. She seeks Miss Z. out .

7\. 19 2 98 *Wayne is sticking to his idea that the burrows will get stuck...he's stuck and doesn't move on.*

8\. 19 2 98 *Wayne and Dafne F. have joined Jordan T. and Elaine as a group.*

9\. 19 2 98 *Wayne is trying to convince Jordan T. about the way the ferrets can get stuck within the tunnel and needing another exit.*

10\. 19/2/98 *Elaine and Dafne F. watch the boys and say very little.*

The conversation seems to be addressed to only Jordan. Finally, the boys talk to each other and the girls talk to each other in separate conversations.

11\. 19/2/98 *Elaine gets up to answer the phone.*

12\. 19/2/98 *Myra visits this group...she acts like an arbitrator.*

The girls take sides, the boys take sides. The boys are doing all the talking, the girls giggle and look on.

13\. 19/2/98 *Dafne F. informs Myra that she and Elaine are doing it all over again on their own.*

14\. 19/2/98 *Elaine tries to get her edge in by saying:* **"This is how I did it."**

John, Edward, Armelle, Gina and Myra are now in a group. John takes over. He controls the conversation. Then Edward takes over...re-explaining what John had done. The girls are watching. Myra tries to explain something with the support of Gina...there's a bit of an exchange, Myra's looking for the girls' approval. She adopts a babyish way of explaining, so as not to be interrupted. Gina is more assertive and Armelle watches. It takes a lot of courage to break from this. Gina starts to talk about square roots and drifts beyond them. Gina's explaining Wayne's idea of the ferrets getting stuck and needing two tunnels each. They all laugh. [I realize now how creative Wayne is...later on he dreams of the carrousel

and makes it]
Miss Z's sitting with Wayne's group listening to them. Elaine, Dafne F., Jordan T. and Wayne are explaining their strategies to her while she jots things down in her log book. She re-addresses them and tells them that when she read their work...some steps were missing. Wayne continues trying to convince Jordan T. They now gather on the rug for group presentations. Miss Z tells them the answer is not as important as the strategy and the checking. They're sitting in their groups around the rug.

15. 19/2/98 *John gets up to represent his group.*

16. 19/2/98 *Myra ends up going. They laugh at the girls who "named all their prairie dogs" Myra admits they named them...there's a lot of giggling. They not only named them but gave them gender...Paul, the French artist...the girl...and so on...the auntie...they've built a story around this problem...Miss Z asks them to settle down a bit... and tells them that names are creative, she wants to see the working...Myra erases everything...[I notice that this happens frequently...after all of that creative endeavor, they erase or make their work disappear.] Now there's a new design on the board. It looks like an electrical wire configuration...with rings along the sides and connectors going above and below them. She places the number configuration and creates a checking chart to show the progression. She's almost finished and explains Edward and John's strategy...*

Miss Z allows John and Edward to present their difference. Myra is their spokesperson...she's allowing for their differences kindly.

17. 19/2/98 *John goes up to board to show his point. He's numbering the tunnels.*

18. 19/2/98 *Edward joins John on board. He's explaining the way they counted and color coded their lines. They kept drawing the lines.*

Miss Z says that Myra abandoned drawing lines. Why, because it was messy. There are two solutions.

19. 19/2/98 *Edward had made hierarchical arrangements.*

Miss Z asks Edward to show his designs. What was the problem...he kept making eight tunnels, not thinking that one was attached and counting the same one over and over.

20. 19/2/98 *John explains his color-coding system.*

Miss Z goes back to Wayne's question and asks Dafne F. to show up how she checked it.

21. 19 2 98 *Dafne F. explains how she made her circles...from her designs she realized that the numbers went in descending order.*

22. 19 2 98 *Wayne asks a question he says:* " **There are 72.** "

Miss Z says in a semi-desperate voice.

23. 19 2 98 *Wayne insists on doubling because he says ferrets need an entrance and exit otherwise they'll crash into each other.*

The teaching assistant and Miss Z are sitting in a corner laughing at Wayne's thoughts on their getting stuck because they didn't have enough space in the tunnels.

24. 19 2 98 *Elaine got 72 as well...she seems to have counted them twice. She explains this...she also says this was too much money spent. They begin to discuss money. Miss Z intervenes because the discussion is getting out of hand and asks about other strategies.*

25. 19 1 98 *Dafne G. goes up to blackboard to explain her and Emily's strategy. She says:* **"Me and Emily..."** *They used the same strategies...they redid it because of a mis-calculation... she writes down 9 and an 8 connecting them...explains the descending order and realized the pattern which was in descending order...she proceeds to write these... and adding it up it equals 36.*

Miss Z asks for other strategies. She continues organizing the groups. Acknowledging William's benefits of two tunnels so that they don't get stuck. She has them read the question again. They now read it again...Miss Z's setting the ground for expanding on the problem so that they can generate more numbers ...if they got 36...they grade themselves..four out of five the answer called dollars. She seeks thoroughness. They use calculators to generate more figures. She's trying to use math language to develop a numerical representation of the problem.

St. John's School Montreal
Video Transcript # 4
Date: Friday, February 20
Group B
Problem of the Week: The Burrows Problem
Pre-organized groups with similar approaches

Miss Z has gathered students around her on the rug and has distributed the math log books. She's marked them and tells them the explanations were well done, a second mark given for checking...she wants deeper explanations on the checking portion...the checklist is the third mark and the fourth one is the answer, which is not graded. I zoom into the note-books and am seeing lots of new designs.

Bernie and Alana
Lea and Dafne A.
Joseph, Adelso and Amalia G.
Donna and Jerry
Jordan W., Don
Cora and Zack

1. 20/2/98	*Lea seems to take the lead as Dafne A. watches... there's lots of smiles and gentle interaction*
2. 20/2/98	*Donna approaches them as well as Jerry*
3. 20/2/98	*Joseph is working on the rug with Adelso and Amalia G. who is usually gracefully quiet and observant.*
4. 20/2/98	*Alana's seated next to Bernie who's seated across Jordan W. and Don she's the only girl. She quietly observes, playing with her key chain, sort of waiting...*
5. 20/2/98	*Bernie's leading the discussion*
6. 20/2/98	*Jordan W. listens and approves with a nod.*
7. 20/2/98	*Alana intercedes:* **"Then, oh, yeah...the force"** *and continues playing with her key chain.*
8. 20/2/98	*Don's observing...he's got a sense of what everything's about and where everybody's at...he's testing the ground playing with his pen.*
9. 20/2/98	*Bernie and Jordan W. take the lead...and continue interacting...*

10. 20 2 98	*Alana gets up to show something...then sits down again as if nobody listened to her.*
11. 20 2 98	*Bernie moves toward Don's paper*
12. 20 2 98	*Don's explaining his strategy...he's got a nice big rectangle with lines to show the burrows*
13. 20 2 98	*Alana now plays with her pen*
14. 20 2 98	*Bernie's talking...*
15. 20 2 98	*Jordan's listening to Bernie.* *Bernie's design looks like the magnetic field.*
16. 20/2/98	*Lea, Donna, Jerry and Dafne G. are deciding who'll represent them. Jerry's the only boy in this group.*
17. 20/2/98	*Lea seems to take the lead...the other girls look and giggle...They still haven't decided...*
18. 20/2/98	*Donna's talking about who'll do what*
19. 20/2/98	*Lea wants to do the drawing on the board.* *She negotiates with Donna saying:* **"I'll draw it on the board...you explain it."**
20. 20/2/98	*Zack's sharing his work with me...his picture looks like a large nut.*
21. 20/2/98	*Cora's sitting off at the edge of this table working quietly.*
22. 20/2/98	*Zack explains...he tells me what he did with each tunnel. He tells me how he did his calculations... He explains his little triangles...which didn't work...I ask him where his numbers are coming from...they seem to be in descending order...I ask him where he was stuck...it's usually the picture part...I ask him what helped him...he tells me the pictures...*
23. 20/2/98	*Cora's sort of stuck...she says:* **" I didn't finish**...*her drawing's very compressed...I ask her where she stopped...she forgot to connect some...I ask her what she discovered once she connected the ones missing...I ask her what makes her think she was wrong...she didn't know...somebody said an answer which misled her...a whole bunch of people had reached an answer so she figured she had to.*

Miss Z. is working with Joseph who's showing her his text-book work...I ask him to explain what he just understood...he's explaining the numeration exercise...he shows me his drawings...now he knows what to do next...He's got a pretty good notion of what to do procedurally. I ask him if he'll forget what to do...he says no...I ask him to show me...he's very capable of showing somebody else.
Miss Z. is gathering students...wanting them to sit with their group...They're getting ready to sit around the board for presentations. She talks about getting the most information from the least...she insists on making this connection...how can you solve the problem...

24. 20/2/98 *Lea's jotting something down on the board. She's making the burrow connections while other children watch... she uses colored chalk for color-coding...she fumbles as she explains...she does have good eye-contact with her audience...*

25. 20/2/98 *Donna observes closely...supportive...*

26. 20/2/98 *Dafne G. helps her out...*

27. 20/2/98 *Alana gets up*

28. 20/2/98 *Bernie tries to support her*

29. 20/2/98 *Alana's standing in front of the board, ready to write*

30. 20/2/98 *Zack wanted to intervene*

31. 20/2/98 *Alana continues...she seeks approval from Miss Z...who asks her to draw her set-up... (her picture uses dots) she explains her interpretation...Miss Z wants to speed up the process and to have her just summarize...she confidently explains orally what she did in writing... hers is a triad representation with three rows of three dots on each...she now creates the chart that plots the numbers down...this is an interesting chart made up of 9 descending lines...here's where he establish entrances to burrows...She takes advantage of this numeric representation to teach something else that was elicited...she has Alana label the top with the word burrows and the bottom tunnels... [The principal, Miss B. walks in to take something from the teacher's desk]*

32. 20/2/98 *Jordan W. writes something else down on the blackboard. He's devised another numeric strategy which he shows the class...his is a one-to-one correspondence of numbers...it's a reductionist approach...that configures an entire new approach...*

33. 20/2/98 *Amalia G. gets up and explains her representation...she explains "burrow one connects to line 2... and burrow two connects to..." she proceeds to elaborate and to draw everything on the board...Miss Z. tells her to speed it up...*

St. John's School
Video Transcript # 7
Date: Thursday, February 26
Time: 9:00-11:20
Group A
Problem of the Week: None "King and Queen gender role play"

The class has been exploring professions and how surgery is performed in the middle ages. They talk about blood-letting...etc. Miss Z's explaining this to Jules who'd been absent. This is their first week after a few days off on outdoor education at a ranch. Jules was not allowed to go. The bulletin board is rich with materials that explain life-styles in the middle ages. Miss Z's designed a hamburger to show the structure of a story and the things you put into a story to make it interesting.

1. 26/2/98 *Jules explains his color coding of weapons...capture of castles and castle defenses. He color-coded everything...made categories and is organized now...he typed it up in codes...his notes make lots of sense. He typed up his notes in columns...this makes it easier for him to work.*

The students are on rug with Miss Z.
She instructs them to stand up if doing castles and if doing knights to stay seated. She separates them and calls them primary resource persons for the brainstorming activity.

2. 26/2/98 *Wayne and John now each join a girl.*

[In a way I think Miss Z's forming gendered pairs on purpose.] The students have five minutes in which to brainstorm on a sheet of paper all the different types of people they can think of in the middle ages.[I notice that girls are immediately the group note-takers while the boys call the shots.] This is true with Amalia H. who takes notes for her group composed of Edward and Wayne. Myra does likewise for her group composed of John and Jordan T.
Gina does the same for her group composed of Jules and Dafne F.
Armelle is note-taker for the group formed by Elaine and John.[Again, I notice that even if it's two girls to a boy, the boy calls the shots, one girl takes notes while the other looks on.

Miss Z. reminds them of elapsed time and has them come back to the rug. This time they work with their group. They got about 22 per group. Then Miss Z. proceeds to jot all down on flip-chart coming up with over 60. She explains the two kinds of peasants (serfs and villeins) she describes the advisors and ministers, ladies in waiting. They seem to understand the roles very well.

They are now discussing the roles they've been given. There's little sharing, just parallel talking each awaiting her turn.

Elaine plays king.

3. 26/2/98 *Jordan T. says:*"Hi, King, what do you want me to do?"
They start discussing their power and their capacity. Although the roles aren't carefully gendered, students aren't ashamed of playing another gender. Now Miss Z. asks them to act out. They are responsible to know about their roles. She explains the hierarchy. As she does so students rise and represent this. At this time, the gender disappears as the role takes over. When Elaine is asked to imagine she's king...there's a little bit of laughter...being able to talk about it takes away the gender bringing in the person. They end up creating the hierarchy by standing up on chairs and tables.

St. John's School
Video Transcript # 8
Date: Friday, February 27
Time: 9:00-11:20
Problem of the Week: Middle Ages project
Text-book mathematics

They're working with the dividers up. Correcting their computation mathematics exercise. I interview Edward who's just celebrated over having figured out something. They're cleaning up... "Taking out all their straw and hay" as their teacher said. Mis Z's made a list of things that should be arranged in a particular order in their desks.

Jules explains how he figured out an exercise. He did the simple ones first and used simple deduction to figure out the rest. We repeat the primary resource people activity and re-enactment

St. John's School
Video Transcript # 9
Date: Thursday March 5
Time: 9:25-11:20
Problem of the Week: Review. "Puzzle Ball"
Group A
Individual activity

The children are gathered at the rug. Miss Z's explaining what they'll do as a group...she's talking about a group entry response log.
Students are talking about a good response log.
She is writing this down on flip-board paper. She's preparing them for future book discussion meetings.
It's 9:50 and they're getting ready for math activity and for response logs.

The teaching assistant is working with individual students who need help. She has devised a special plan to address such needs as simple operations, multiplication tables and other procedural aspects of mathematics.

1. 3/3/98 *Elaine tells me what she's doing with the chart he's working with. [Their confidence level at different steps of procedural math activity improves.]*

2. 3/3/98 *Don tells me he asks the teaching assistant for help when he needs it.*

3. 3/3/98 *Gina explains what she's doing. She understands what to do well. She doesn't think she needs help. She's just checking. She's preparing for her Singapore move.*

4. 3/3/98 *Wayne explains rounding to me. He doesn't think he'll need help. He gets up to verify something with the teacher. He asks, does yes mean I need help? She says yes I am confident. He tells me he forgot the rule for nines. He's writing down all the numbers. As soon as he's found a pattern, he's figuring out the rule. He says that the ones place always goes down one. He kept on counting down. I ask him for the relationship in the pattern he sees. He saw a pattern and tried it on another number. So it progresses to one less for each hundred. The one's digit reduces by one. He doesn't know yet that it works each time.*
We keep negotiating, I leave him.

The teaching assistant answers a few questions about help-seeking she says she created a summary since December. She asks them whether they feel comfortable on skills. If they choose yes, they do the example, she monitors where exactly they're stuck. They had to admit they needed extra help. She groups them. She believes that children choose the kind of help they ask for. With respect to help-seeking...tendency is a yes/no put me on the right track...help me find where I am.. She says it depends on the child. They ask specific questions...children who *are not as outgoing let her take on leadership. I ask if she hadn't designed this they wouldn't have sought her out in the same way. About help-seeking amongst themselves...depends on how they're sitting, who they're sitting with. If they have a chance they'll seek each other out. They have a hard time asking for help...it's "Show me your work and I'll tell you what to do." [I say it's a parallel activity.] She shares her chart with me. She breaks down the tasks and asks students to identify which one of the steps they're confused about. Getting back on track or re-aligning is a very necessary task as they progress. They seek Elana out for help.*

5. 3/3/98 *Edward shares his best poem selected from all his poems. He likes the way he's asked questions, made predictions and asked a lot of questions.*

6. 3/3/98 *Amalia shares her response with me. It's very well written I let her use the camera. She's very proud of her work. She shies away from the camera. She shares her thoughts with me openly. What she thought about the character in the story. I appreciated her critical sharing in the reading group. She held her ground well and says she didn't write the book much.*

7. 3/3/98 *Jordan T. tells me how he checked the hand-shake problem. He explains it to me. As he explains it to me he realizes what goes on. I ask if the picture help him. He says not much. I ask him if it reminds him of a previous problem. He says the Prairie dogs because it's in descending order. I ask if it will use the same strategy...he says logical reasoning... He says he'll add them up the same way, but this one has more numbers. He has to re-work his checking and show his work.*

8. 3/3/98 *John is also working on the hand-shake problem. He's got to correct spelling errors. He's done quickly and I ask him to explain the problem. He explains...he drew all the people and looked back at the prairie dog problem...he added larger figures...the picture didn't help him.*
He grabs the ball I brought. I watch him assemble it. Eric joins us. Justin T. joins. They're all working quietly each to his own...one works the others watch...there's little contribution or collaboration...they watch and give instructions...they don't intervene or interrupt each other... Now it's Jonathan and Eric together...they're contributing but not quite collaborating.

9. 3/3/98 *Amalia H. approaches...they guys don't let her participate...she watches from the side...she'd come to share her photo-copied piece of writing with me. I approach*

10. 3/3/98 *Armelle asks her what she's doing. She talks about people and shakes explaining what she's doing.*

11. 3 3 98 *Amalia H. tries to get her edge in with the boys doing the ball puzzle. She's still watching on the side.*

12. 3 3 98 *Armelle is starting to see a pattern and is writing out her problem*

Miss Z calls the class to order. Everybody needs to come over with response log, math log and math text and Hilroy.

13. 3 3 98 *Amalia H. remains behind trying to put the ball together.*
I engage her for later. She sneaks back trying to put the figure together while

Miss Z collects things...she's leaning so as not to be noticed. She's very much on tasks. She writes numbers on the board and asks about whether they're prime or composite. She's explaining factorization and asks Amanda to join the circle. They're correcting the text book exercises. Zenia asks for a rule for divisibility by three. They talk about digits and multiples.

14. 3/3/98 *Amalia and Dafne F. are trying to put together the ball. They collaborate, hold things together...talk with each other and contribute. Armelle approaches them. Dafne F. recognizes her contribution by saying "Armelle had an idea" they talk out loud explaining the maybes that could help put together the figure. They seem to prop things up for each other. They share their discoveries...look this is the piece... Amalia H. stands by putting her things away. She stays after all the others have left. She has almost got it together. Dafne F. walks over, they continue trying to put it together collaborating.*

15. 3 3/98 *Cora and Lea are working off at another table on their own. They enjoy each other's company...sharing and being together.*

Miss Z. sits next to them watching them work together. Amalia H. and Dafne F. continue working together nicely. They continue holding things up for each other and suggesting possible solutions. Their prolonged relationship around the ball baffles me. The boys were very different. They didn't collaborate. They waited until the other stumbled in order to take over. They didn't scaffold like the girls are doing. They find metaphors to describe what they're doing with the shapes.

16. 3/3/98 *Adelso approaches. He seems to want to grab the pieces away from Amalia H. Dafne F. has looked away*

17. 3/3/98 *Edward is on stand-by.*

Miss Z. is talking with Jerry, playing around with his rhythm. She's telling him a story in a funny way. They're preparing for a story-telling session.

18. 3 3 98 *Adelso almost put the puzzle ball together. I ask him how he did it*

19. 3 3 98 *Amalia H. says he doesn't really know*

The girls take over after I ask

20. 3 3 98 *Adelso...starts competing with the girls saying:* **"I'm the one who did it...it's my way...I was doing it."** *He's almost put it together. It's almost done. He doesn't let Eric handle it because he's wanting to get all the credit.*

21. 3 3 98 *Bernie comes in. There's a tug and pull...Amalia's left out. Bernie and Adelso take over, Edward views from the side.*

St. John's School
Video Transcript # 10
Date: Thursday March 12
Time 9:00-11:20
Activity: Reading Circle
Group A

Students are sitting on rug. Miss Z's explaining numbers that go into each other. She's explaining estimation. She's explaining long division, using the adequate terminology (divisor, quotient, remainder, etc.)

It's reading circle time. Miss Z's brought cookies for the children who are sitting in discussion groups discussing their stories. Jules, Edward and Gina are sitting in the bathroom corner. They pass around a play eye-ball to take turns speaking. They're talking about family, "El Niño". Jules shares how he'd like to have a sibling. Edward talks about his food allergies.

I ask Miss Z about help-seeking/giving and how it operates within groups and individuals. She tells me she hasn't seen much help-seeking other than what happens with the teaching assistant. She also says that in reading circles like the one we are observing, students take turns speaking and are anxious to say what they have to say. Yet in Mathematics class, it all depends upon the type of activity.

St. John's School
Video Transcript # 11
Date: Friday, March 13, 1998
Time: 9:00-11:20
Activity - " Gezinta's" and "Emate" with writing
Group B

Edward and Jules show me their e-mate and how it works.
Myra's working on her story on the e-mate.
Miss Z's giving out instructions. It's her birthday. She's dressed very elegantly. I've given her a Colombian necklace and a middle ages poem. We had fun celebrating. Now, it's time to work. It's the last class prior to a long vacation (three weeks) she's concerned that everybody is ready and has all the materials necessary for their middle ages projects.

1. 13.3.98 *Edward tells me about his work. He tells me how the e-mate works and how the information is transferred. He's not using one because he's using a big computer.*

2. 13/3/98 *Donna, Dafne F. and Dafne A. are signing up to use the photocopier. They now join Amalia G. who's quietly putting her work together.*

3. 13/3/98 *Gina and Jordan T. are working on their e-mate.*

4. 13/3/98 *Don is glancing at pictures*

5. 13/3/98 *Bernie is working at the computer*

6. 13/3/98 *Edward has just joined Bryan*

7/ 13/3/98 *Amalia H. is also working on an e-mate*

8. 13/3/98 *Jordan W. is looking at a book.*

9. 13/3/98 *Donna is looking at the books on the shelf.*

19. 13/3/98 *Myra and Dianne are helping each other. Dianne's speaking in a British accent. Mya's mother is from England. Myra's traveling soon and we're all having fun talking in a British accent. It's fun to see how they use this accent to give each other instructions.*

20. 13/3/98 *Elaine comes by to look on.*

The teaching assistant is working with John on the rug.

21. 13/3/98 *Elaine approaches the teaching assistant. She's reserving her turn next.*

Miss Z's getting her birthday gifts before the children are dismissed.

The teaching assistant explains what she's doing. It depends on the child's particular needs.

22. 13/3/98 *Dianne explains her system. Notes are written and notes are written on different colors and in that way different topics are written. Then they write it all down in sections and print it out.*

Miss Z's upset because the e-mate documents aren't printing off the mainframe. It's right before the holidays and three weeks worth of work has been lost.

The teaching assistant is helping individual kids. She's sitting on the rug making herself available to kids. There's a lot of hustle and bustle as children are trying to pack up their work before the holidays. They need to keep the written components, the photo-copies that illustrate their work...whatever photo-copying that needs to be done. The teaching assistant is working on the rug with Cora. She's helping her put her folder together. Dianne's writing on her e-mate. She's copying from text onto the computer. The assistant is working with cue cards so that Cora gets to practice her math drills. They're rounding off numbers. I think they're doing place value and rounding. She is explaining grouping and why the spaces are important.

23. 13/3/98 *Dianne tells me that convents were called nunneries back then. She's writing out her work on the e-mate.*

24. 13/3/98 *Amalia G. is putting her pictures together.*

25. 13/3/98 *Jordan W. is writing on his e-mate on the floor.*

26. 13/3/98 *Zack joins the teaching assistant.*

The assistant tells me what some of their problems are. Some of them have had skills-recognition problems to what they've learned back in September. She's checked Zack's subtraction and says he was very honest on his survey, revealing what his weaknesses about it. They'll rehearse and make do. Zack needs practice with writing numbers in expanded form.She simplifies this process for them and calls the place-markers or spaces "houses" and stories with neighbors...all kids having same names, calling them by last names to place them.

Ones, tens and hundreds. Neighbors moved in, called them thousands...etc.

27. 13.3.98 *Amalia and Dianne are working together putting together their projects.*

28. 13/3/98 *Jerry stands by looking at his work.*

29. 13/3/98 *Donna approaches them.*

30. 13/3/98 *Amalia's using white-out to write on black.*

31. 13/3/98 *Jerry stops what he's doing to make a comment or two.*

32. 13/3/98 *Dianne is singing while she works.*

33. 13/3/98 *Jerry gives Donna and Amalia G. instructions.*

34. 13/3/98 *Dianne joins in.*

35. 13/3/98 *Jerry says:* **"Here, use my shirt to dry it off."** *There's been a white-out spill.*

36. 13/3/98 *Donna comes to the rescue with tissue paper.*

37. 13/3/98 *Jerry is bouncing back, his usual rhythmic bounce.*

38. 13/3/98 *Donna and Amalia G. continue working quietly.*

39. 13/3/98 *Jerry and Donna have left.*

The teaching assistant is very encouraging and congratulates Zack for a good job. He rejoins Don at his desk. Don, as usual, likes to enjoy the periphery. He's talking to Bernie who's sitting at the computer and to Joseph who's working at the first computer.

40. 13/3/98 *Jerry continues standing and bouncing back and forth.*

41. 13/3/98 *Dafne A. is telling me about her choice pictures. She's telling me about people's occupations...skinning the beasts...the noble-women and how they weave...she tells me about crusaders and knights. She's going to color them and put them in a folder.*

42. 13/3/98 *Dianne's giving Amalia G. instructions*

43. 13/3/98 *Jerry is finally settled..[he needs all of that physical activity before he gets started.] He's now totally immersed in what he's doing.*

44. 13 3 98 *Dianne announces that she's finished. This is great for her. She's very demanding on herself. She won't relinquish until she's done.*

The children all gather around Miss Z now. She announces that they need a pencil. They've got their math textbook in front of them and are going to correct whatever they'd been working on in math. They're stapling something onto their notebooks. She explains long division in math. My tape is almost running out. I don't think I'll have the entire lesson on math. But it's only a procedural math lesson.

St. John's School
Video Transcript #12
Date: Friday, May 22, 1998
Problem of the Week: Diagonals
Full Class
Independent Work

Students begin right away, gluing it in. They're going to work independently on the Diagonals Problem. Miss Z is handing out the problems to all and asks students to glue it in and to read it over. She asks them to work quietly "there shouldn't be any talking" She announces that they'll read the problem through together and then work independently on the problem and putting together their Middle Ages project.

1. 22/5/98 *Zack announces he doesn't get it.*

Miss Z begins explaining...remember this is like a take-off from activity with computers...she explains a three-sided figure and the diagonal...at black-board. Describes diagonal as line that goes from one point to another point. She also describes vertices...diagonal as going from one vertex to another...can create diagonal lines to attach other vertices...nothing else to attach...in a three-sided figure there are no diagonals...in a four sided figure...four vertices...can make two diagonals lines that cross the figure...in a four-sided figure I have two...five sided figure...does anybody remember from computer class? They name the figure...pentagon...she announces the five vertices...how can I attach them...I can make a diagonal there...I can attach this. Point to this point...it doesn't have to be on an angle...attaching the vertices...

2. 22/5/98 *Zack "***Oh, it makes a star***!" (He sees a star embedded in the figure) Some diagonals are difficult to read..*

3. 22/5/98 *Dianne and John go up to show her on board...*
goes on to six sided figure...and the rest of figures on their page...problems are there to give an idea...don't need to draw diagonals on figures on paper...too small no way to keep track...draw a larger one to work on...goal is to find out how many diagonals on a ten-sided figure. They need to decide how to do it...creating shapes in computers...looking for formula, rule or pattern...welcome to draw, see how they are and to keep track. Make sure explanation is clear...Decide what is the problem...next question how to solve if a 25 sided figure and 52 sided figure...work on ten-sided on own...knights on floor with project binder...full explanation and checking [I know my answer is right because...and show work]...students now begin working...

4. 22/5/98 *Don, Adelso, Bernie and Joseph are on the floor with Miss Z,*

5. 22 5 98 *John remains at group desk working on problem of week.*

Students draw a circular figure which looks easier to work with...most students use another color to draw diagonals.

6. 22 5 98 *Jerry starts flipping back to read his burrows problem...he's seen a connection here early into the process. He proceeds to re-read this problem. The look of the diagram has piqued his curiosity...he looks back again.*

Miss Z has a number of children spread out in front of her with their project papers spread in front of them...

7. 22 5 98 *Mark, Zack, Myra, Jordan W., ...the rest are carefully drawing their diagonals...*

8. 22 5 98 *Dianne's gotten up...she seems to have finished...*

Miss Z tells her she's got forty-five more minutes.

I start talking to John who seems to have a system of bars.

9. 22/5/98 *Donna's made a huge circle to work from.*

The girls share colors and use calculators.

10/ 22/5/98 *Amalia G. says to Dianne:* **"Same strategy?"** *and smiles.*

11. 22/5/98 *Dianne sub-vocalizes as she counts out loud*

12. 22/5/98 *Amalia tells her she makes things so complicated*

13. 22/5/98 *Dianne's checking on the calculator and putting down her pencil each time...she checks something off each time... She's rhythmic, self-assured and efficient. She now closes her notebook and talks to Amanda.*

14. 22/5/98 *Amalia tells her:* **"Why are you doing that?"** *she insists on asking why. They seem to be checking answers.*

15. 22/5/98 *Amalia continues asking why. They're bartering and exchanging points of view.*

16. 22/5/98 *Dianne shows her.*

17. 22/5/98 *Amalia asks re-alignment/re-situating questions.*

18. 22/5/98 *Dianne's counting and sounding very convincing...*

19. 22 5 98 *Amalia says, but I've still got seven, because look...you can't see these...euw...*

Now another set of students is at rug with Miss Z, Donna, Amalia H. Amalia G....

20. 22 5 98 *Wayne continues working on math problem,*

21. 22 5 98 *Zack is helping Mark.*

22. 22 5 98 *Dianne and Gina are on carpet.*

23. 22 5 98 *Dafne F. is still working on math*

The boys are sharing results with each other..I'd peered through Don's who'd made a very neat large diagram so as not to get too muddled with lines...John's persisted on his work...

24. 22 5 98 *Bernie shares his calligraphy cover page of his middle ages project...he volunteered to spread it out for me...showing me the cover page and a separator...he used "old English" font and it looks very nice..illustrations are well photocopied and pasted with captions...I give him adequate feedback...weapons...in detail...he describes the weapons with lots of authority...crusades (first second and so on) one of the pictures opens up...finally the references... he tells me about the problems of armour and whether it was convenient or not...tells me about squire's life and training...squire is watchful...I ask him if he finds the squire to be a problem-solver...*
Bernie describes the tasks he has to do...learning and keeping track...he says he just remembers...practice makes perfect. They start at age seven and live in the castle doing menial tasks and learning to be obedient...training...keep trying until you learn...he wouldn't like that kind of life because it's easy to get killed. About oiling the armour, he doesn't think so...they had to keep it clean...too expensive for just anyone...He tells me about the medical traditions (drilling a hole in the head for head-aches) I ask if he's seen films...he says he's used books more. John's finally finished after a very long while.

Miss Z suggests they find a pattern if they've done the ten so that they can work on the 25 sided and 52 sided from a pattern or rule.

25. 22/5/98 *Jerry...is trying to find a pattern. I tell him I saw him go back to burrows pattern...he's trying to find the rule...minus a one...you times it...then divide it...he's not sure about his rule...going back helped a bit...*

26. 22/5/98 *Jordan T. Tells me about his adding...he's adding from 9 to 33 to get 25 you have to add so he's supposing that adding using the calculator will help him find the pattern.*

27. 22 5 98 *Jerry's using his corners...minusing one...trying to get the two numbers and answer divided by two...he's not quite there yet.*

28. 22 5 98 *Jordan T. tells me...zero plus to is two diagonals...3 plus three...found another pattern three sides plus the answer connects to the four sides...reason he looks for patterns, instead of drawing a big chart...it's a lot easier to go numerically...adding on...next to the nine would be fourteen, the following one 20...*

29. 22 5 98 *Jerry and Jules finally join the rug group.*

The girls are back at their places.

Miss Z doesn't want students to discuss the problem but to work on their own. Find a pattern, find seven eight and nine and then the 25 and 52.

30. 22/5/98 *Don seems to be using his observation skills finding out what others are doing.*

31. 22/5/98 *Zack uses a neat pencil attached to a pen...it's his little system...weapon...device...*

32. 22/5/98 *Don continues comparing.*

The group at the rug is piling and organizing their work. John has joined them as well as Wayne...they'd been working on math problem solving all this time. Daphne F. has joined them too...

33. 22/5/98 *Bernie takes his work to Donna...*

Miss Z catches this and stops it...

34. 22/5/98 *Joseph is "consulting" with Don.*

35. 22/5/98 *Bernie goes back to rug and then back to his seat. He'd wanted to compare with Dianne but changed his mind.*

36. 22/5/98 *Don continues consulting.*

37. 22/5/98 *Zack is counting on his fingers.*

38. 22/5/98 *Don now looks at Adelso's paper.*

39. 22/5/98 *Dianne comes over to Zack's, she's trying to help him...*

40. 22/5/98 *Joseph and Don are consulting*

41. 22/5/98 *Zack finds a way and celebrates...*

42. 22/5/98 *Dianne had helped him...he's now excited and looking around.*

43. 22/5/98 *Dianne's telling him something...he asks her...she won't give him her answer...*

44. 22/5/98 *Mark's talking to Seb...they're both erasing.*

45. 22/5/98 *Don says to Adelso:* " **What is it, tell me?**

46. 22/5/98 *Joseph yells:* **"I got 8."**

47. 22/5/98 *Zack has shared with someone and says* **"I think he's right"**

He's explaining what he's done to Wayne who realizes that it works.

48. 22/5/98 *Bernie comes by and tells them something.*

49. 22/5/98 *Dianne walks over to see how they're doing...*

50. 22/5/98 *Jordan T. comes by and asks them how they're doing.*

I call Dianne to ask her when school is over...Spring break was somewhere about April. We had spring break, easter and then I calculated the nine weeks I hadn't seen them. We talk about how people have changed since then. She tells me she's coptic.

51. 22/5/98 *Bernie is explaining his work to Josh.*

Miss Z announces that in five minutes there will be a presentation and they will switch gears.

52. 22/5/98 *Dianne walks over to group to see how they're doing.*

53. 22/5/98 *Bernie asks Joseph if he understands what he's explained to him. He coaches Joseph further. He explains his pattern to me...he says he sees a pattern...minusing one except the first two. I also ask him to explain the lego growth...which he usually explains to me.*

Miss Z's asking for her materials back...calculators, etc. it's pick-up time.

Field Notes # 1: Entry
Date: Wednesday, November 26, 1997

Portraits of the children

(All the names have been altered)

Jules - he's a hugger. He shared his epilepsy bracelet with me, and I shared my sun-protection-bracelet with him. He needed help with his math. I praised him for how well he stacked chairs.

Joseph - has a slight speech problem, however he has a lot to share and lots say. I enjoy listening to him. He asked me for an autograph, which I gave him. What he really wants is the anaconda picture. I told him I'd give him something like upon my retreat. He invited me to give my opinion on his writing at the computer. He's very jovial and knew all about me. He shared with his group that one of the sextuplets is called Hercules because he held all other six in his hands.

Dianne - She's rhythmic. She sings to herself while she works. I think she's exploring her own self-efficacy. I watched her work on her own, she cheers herself on as she works and is very rhythmic, making all kinds of clicking sounds.

Gina: had an incredible solution to the magic squares problem. She must have shared it with her parents her writing is also adult-like, she theorizes a lot. She knows how to make mature connections.

Don: shared his home-made greeting card collection. He concentrates and tries to work really hard. He's an artist.

Cora: She's very friendly. She offered me a poem on the first day. She also shared her play puppy "Husky 3". She invited me to lunch on my second day. She shared bits and pieces of her life. She's from Kahnawake and her father is an authority figure there. Cora was very friendly, she also wanted me to have her Earth poem.

Mark: I've been watching him closely, besides the fact that he's adorable, he's a quiet learner. He likes to take his time. He's contemplative. He had a hard time putting the card puzzle activity together. He gave up and started looking at the anaconda pictures.

Bernie: He's a steady thinker. He likes to take his time. He's systematic. I liked the way he worked out a system for putting stickies (usable/non-usable) to figure out the magic squares. He had a very neat system for solving the magic squares, he not only used the post its well, but stacked the useful ones below and the useless ones above so he would simplify his task and work more efficiently with less options.

Jerry: He likes to organize, stack things. His cheers are rhythmic, body movements. He's also a stacker, he likes to stack his materials and to organize things neatly. He does this stacking neatly, before taking on a new task. He's very efficient at organizing and coloring. He covers his work when he completes the task using the divider. He likes a "clear work-place"

John: My book endorser. He asks special questions has very good eye-contact, has a slight lisp. He's got a highly developed vocabulary, inquisitive and piercing questions
I was shocked by his wanting to know whether someone would "endorse" my writing, he had also mentioned that if I was to look into cubbies, his was not neat, neither his desktop.

Amalia H.: wanted to know lots of things about anacondas, piranhas, being a teacher and a student at the same time.

Donna: was kind of flighty, making fun of my name a bit. She'd been speaking in an English accent and was sort of testing me.

Armelle: told me about her skiing classes, new equipment and trips to a skiing lodge somewhere each week-end, this was during recess.

Zack: hates dentists

Jordan T: shared the Radarsat information on Antarctica, his mother works with this company. He described how through remote sensing they've discovered that a certain section will become an iceberg 300 ft. Long, "Thwaites Glacier".

Myra: seems to have a good logical mind. She was able to explain something by showing an example.

Amalia G.: (the one with the Adidas pants) reading my teacher-diary. I posted the anaconda/piranha pictures on the black-board. Students didn't know they could have free access to them and didn't know who to ask.

Field Notes #2
Date: Thursday, December 4, 1997
Problem of the Week: Coin Combination & "Un-made" Story
Individual work

1. *FN/4/12/97* *John chants to himself...* "**This into a nine...this into a nine...**" *there's rhythm to this chanting. I observe John, [who I think is now in flow.] At this point he checks back and forth using his index finger, checking...he doesn't talk anymore and doesn't fiddle or sing. He's very concentrated, he now has 13 out of the 14 coins. He erases and writes and doesn't seek me out anymore. He jumps back when he thin s he's got something. I interview him at 10:30 and he tells me first I nad 12, he didn't notice that I noticed and didn't feel my presence. He tried again and turned the 5's into 10's helped some 10's had 2 more coins, too many 25 cent coins by themselves 2.25 x/12 took away 2 10's and put 4 5's in their place and added a 10. Therefore he finally came up with 7 25's, 3 10's and 4 5's.*

2. *FN/4/12/97* *Don's working in his notebook.*

3. *FN/4/12/97* *Wayne has a calculator.*

4. *FN/4/12/97* *Don's made columns and adds in rows (he cups his head to think) his combinations add up at the end. He counts, adds up at bottom of page as he things 6 of 25's 5 of 10's 2 of 5's, which gives him only 13 coins. He's distracted looking at coins. He makes an organized list, uses the coin sheet. At 10:45 he says:* "**yes**" *successfully. He's ready to explain his procedure. I find his agency teacher directed...when he says he's used an organized list, I know that it's something he's learned to say. He continues when I interview him...:* "**I added numbers together...**"*are you superstitious?" he can lead a conversation while thinking and talking with me..." [according to creativity standards, he's creative...can chew gum and do something else at the same time...]he's created magnificent hallmark-like cards. He hasn't lost his train of thought.*

   They now have a story-sharing activity after mathematics class. Their teacher is reading a story based on imaginary figures.

5. *FN/4/12/97* *Adelso says:* "**I'm seeing a penguin enter a limo**" *they all laugh, one child adds:* "**entering a time machine...**" *there are more shared scenarios, comments erupt "a salesman inherited the earth..."*

6. *FN/4/12/97* *Don shares his "un-made story" by talking about what he's got in his head.*

7. FN 4 12 97 *Adelso's story has lots of dialog... "a pack rat and a time machine...they're also talking a lot about the amazon, piranhas and anacondas [my influence perhaps?]*

Field Notes # 3
Date: Friday, December 5, 1997
Activity: Newspaper stories
Individual work - group discussion at rug- whole class activity

1. FN/5/12/97	*Joseph won student council election,*
2. FN/5/12/97	*Jules didn't win.*
3. FN/5/12/97	*Jerry decided to wait another year because participating this year would not allow him to participate when he's in grade 6. This was a wise move on his part.*
4. FN/5/12/97	*Cora is absent.*
5. FN/5/12/97	*Donna is always aware of my presence. She wants me to go to the Christmas show tonight, but I have my son's school meeting and can't make it. They're preparing a news release and will be videoing all next week. This first exposure to video opens a door for me as I will be bringing in equipment in January. I've decided to post it on the counter next to the plants. I'll leave it up there without using a tripod.*
6. FN/5/12/97	*Myra - local and rest of world,*
7. FN/5/12/97	*Dafne A - all different types*

8. FN/5/12/97 Amalia H. - top news, shocking/impact,

9. FN/5/12/97 Myra - grouped by place,

10. FN/5/12/97	*Dafne A., what affects us,*
11. FN/5/12/97	*Dianne - air crash in Russia and new news as opposed to old news.*
12. FN/5/12/97	*Myra - abnormal not every day news.*
13. FN/5/12/97	*Bernie- postal strike*
14. FN/5/12/97	*Amalia H. explains follow up Jesse suggests new developments*
15. FN/5/12/97	*Alana offers interviews of famous people,*
16. FN/5/12/97	*Jordan T., live interviews,*

17. FN 5 12 97 Jules offers business,

18.FN 5 12 97 Josh offers Larry King and explains,

19. FN 5 12 97 Jerry Larry King live...[bracket boys participate, more boys participate] [bracket 2 Jesse has a special way of showing how he's understood, he offers a metaphor]

20. FN 5 12 97 Joseph is into Mt. Everest after Moby Dick. They need to report on one story and to highlight the most important news events of the last 2 months. They now pick up their own copy of a newspaper and lie down with it. They don't seem to get in each other's way. These kids know how to use space well.

21. FN 5 12 97 Mark collects his and puts it all together again and returns it. They're looking at advertisements...it doesn't seem to bother the teacher.

22. FN 5 12 97 Myra offers the problem with the Biodome and how the humidity of the jungle area affects the roof. I'm observing

Field Notes # 4
Date: Thursday, December 11
Problem of the Week: Deck of Cards
Individual Activity

1. FN 12 11 97 *Jerry who's very systematic about what he is doing. He swings and rocks back and forth. While he works, he's able to maintain two channels open. He listens to what the girls are saying on one end, to what the boys are saying at another end and still manages to keep on task himself. He likes to arrange his belonging and to stack them up neatly. He also likes to sing to himself when on task. He's spread out three pages in front of him and a fourth page is the one where he's synthesizing what he will do. These planning pages include what he needs, what roles he'll play with others and what roles he needs to find in others. He's dealing with the video development, not necessarily with the story yet. His sense of agency impresses me. He works on his own, makes his own decisions and is constantly aware of what others are doing. Another thing I've noticed again is that their help-seeking behavior is mainly to align themselves. They ask, brief one-answer questions, yes/no, what comes first, etc., can you do this...*

Field Notes # 5
Date: Thursday, January 29, 1998
Problem of the Week: Yogurt Ice-Cream
Individual work - then finding a partner

1. FN 29 1 '98 *Cora and Dianne, of course, had lots of stories to tell me after the winter holiday...especially after the Ice Storm kept everybody "locked-in" for over fifteen days. Schools and businesses were closed for over fifteen days. Some people had no power at home for over two weeks. Families had to move into shelters or with relatives.*
After the daily hug from Jules, kisses in the air from Dianne and art-work sharing with Cora I decided to connect the tape-recorder for the first time. Usually, Miss Z would discourage me saying that the wiring might disturb the children or that it would make them excitable. This time, she encouraged me, and helped me install an alternative microphone as the one I'd brought wasn't working properly. I proceeded very carefully ensuring that the wiring would not trip the children and leaving the mike in a steady place that I could maneuver on demand. I continued taking field notes recording everything I saw, leaving the tape-recorder on as a steady witness.

2. FN/29/1/98 *Amalia H. volunteers...what if you told 3 friends? Miss Z asks, why 3. The fact list on the board looks like this"*

3. FN/29/1/98 *Elaine asks two interesting questions, she insists on the importance of the flyer and asks why they didn't go to buy ice-cream before school. When they play let's pretend, Miss Z insists they partner up, holding hands perhaps with their partner. The enactment shows the numeric progression*

4. FN/29/1/98 *Wayne was off at first when he thought of 7 as a possible number.*

5. FN/29/1/98 *Dianne's "partner dots" is another instance of halving and illustrating this with pictures.*

6. FN/29/1/98 *Don is seeing that 6x2 gives him that inevitable 12 that does belong there, but not repeatedly.*

7. FN/29/1/98 *Wayne who that in 3 occasions to tell, if there's a teller told, then 3x2 is 6 which fits in with that inevitable 48.*

8. FN/29/1/98 *Zack and Don showed evidence of what talk can do to help you along with your thinking. They were both very sure about what they were doing as they had their little guess and check strategy in front of them, their little graph worked well for them on paper. If it wasn't a five, then a seven, or*

whatever number could be used to create the target number 48. In other words, the chart represented an easy outlet. Too easy I'd say. So, they easily found the 12 which if repeated on the chart four times would give you that easy 48. However, once Zack started explaining it out loud, it seems that the pictures in his mind did not coincide with the numbers. He'd remembered the role-play activity they'd performed during the explanation stage. He said: "**That can't be, if someone tells someone else, then 12 people would be telling 12 other people, all at once, we'd have 24 people who knew and there's four opportunities of telling, so this won't work.**" *He only came to this realization by telling me and Don about it.*

9. FN/29/1/98 *Don soon realized that this had happened with other numbers on his graph. He said* "**Yes, that's why we couldn't do this with all the other numbers we've got here "an 8, a 10, a 5"** *He also caught on and started thinking of teller/told and of four opportunities.*

Analytic Memo #4
February, 1998
On a Philosophical Perspective
Knowing

I am concerned and interested in the concept of knowing. What is it that we know? How and how much do we know? I ask this question at this point because as I observe the students in this fifth grade I wonder what knowing is all about. I've looked up knowing and include notes I took after reading, Grene (1966)

> Marjorie Grene, (1966) *The Knower and the Known*, explores knowledge from a philosophical point of view. She discusses Plato's Meno, Aristotelian certainty, Descartes views on errors, Hume's premises, Kant who sees knower as agent, etc. and dedicates her book to Polanyi *Personal Knowledge*. She quotes William James who's *Principles of Psychology* says "The mind...works on data it receives very much as a sculptor works on his block of stone. In a sense the statue stood there from eternity. Yet there were a thousand different ones beside it, and the sculptor alone is to thank for having extricated this one from the rest..."
>
> <u>In terms of problem-solving</u> "To know or to understand is not to follow blindly and mechanically a self-perpetuating chan of habits. It is a personal venture, itself an organic whole, like the wholes it recognizes, in which the responsible participation of the knowing person forms an organic and inseparable part..." P. 156.
>
> <u>On Polanyi.</u> The knower is limited by his bodily endowments, and he is also rooted in the traditions of his society; but as knower he stands, so far, alone. Knowing is a theme in Polanyi's life-history.

Analytic Memo # 10
Problem Solving

I'm trying to relate my background knowledge and readings to the experience. I've observed something for a second time. After they've figured out something, let's say after the first half hour, then there's like a *"second wind"* where they've been very concentrated and they enter into what I'll denominate a "beta level". This second wind is like what I experience as a sports-man, you can go further and further, only having experienced the extreme.

I'm finding that many research studies in classrooms among children are finite. Research teams come in, do what they have to do, analyze it and write it up. There's no in-between time or follow-up. I might be generalizing.

I'm relating to my musical back-ground more and more. As problem solver I want to resolve things to a major key.

Analytic Memo #12
On Mathematical Problem Solving
After Burrows problem

After analyzing my written field-notes of the day, I wondered why it is that young problem solvers resort to an easy strategy. Either they want to get it over with or they simply need that extra period of time to concentrate on the problem in depth. Is it that we have trained them to be quick respondents giving them the signal that speed means efficiency?

Some students jump to quick conclusions thinking this is a simple multiplication problem wanting to get a quick answer. This does not work because when they show their teacher, she redirects them sending them back to their seats to reflect. She asks them to write down the steps they take in responding to the problem and to determine what strategies they are using as they go along.

I watch as a student realizes that this cannot conduce him to a correct answer...the student is blocked at this point and gives up. Somehow, in doing this problem, children need to refine whatever they've done and to proceed in a systematic way that might be a little bit frustrating. However, those who see the connection adjust well. The systematic listing of numbers in descending order and the language of the problem (every other) indicated that this was a counting, not a multiplying problem.

Analytic Memo # 13
April 14,1998
Results from conversation with Colleague

There's a "knowingness" that is very personal. It comes from putting together a series of things that we already know about. What does it mean to know? Who are the knowers? These are questions that came up during our conversation. I quote from the article Delamont & Hamilton (1973) article:

> *Not all pupils 'know' the same things about their school lives... a study of pupil experience or 'knowledge' of school life must begin by looking at the way some pupils come to share common perspectives and how pupils influence each other in what they 'know'...Only when this process is fully understood will it be possible to go on to document what individuals or groups actually 'know'...(p. 24)*

Who are the "knowers" ?

I answered...the ones who are sensitive/sensible and interested in establishing lines of communication. As I collect words that help me look at pieces of classroom activity, I bounce these yet un-cooked ideas around knowers who help me put together what I know and what I need to know.

There is a need for an audience. The students with whom I'm working are critical audiences for each other. They share the same experiences and try to make shared meanings of knowns and unknowns. When we wonder what they're doing quietly, we both talked about silent periods. I've interpreted these to be a stage of adjustment— a time to re-align givens and unknowns.

Students are articulate in a shared language modeled by the teacher. Yes, they speak in a *register* which is language-specific (in this case the mathematics class) and yes, many activities they do in class are *scaffolded* by their teacher.

Do youngsters in this setting construct their own language? Are they creative with language? This is an excellent question. Because they are asked to reflect and to write about what they are doing, students are free to invent words and to go beyond accepted *registers* as they talk and write. The teacher encourages them to articulate their thinking and to build theory. This freedom allows them to invent names (partner dots) for one and (here's) for another example. Students are not reprimanded for saying things like: "First I times this number with this number and then I times it with this other number" (times being multiply). Once everybody understands what they are referring to, they start asking better questions.

Asking for help and giving help came up in the discussion. Learning how to ask good questions is an important feature in this communicative process. The activities I'm looking at are goal-oriented (the solution to a problem). Hence, most questions are subject-specific— short answer questions. Students say: "Do we times this against this?" or, "Do we take away this from this?"

You asked me if language is my way of knowing— my lens for seeing. Yes, it's my very own way of knowing and of rehearsing what I know. Some children use this technique while others don't. Some children are concrete builders. They take physical objects and build physical representations of the problem. Do they use key-words like I do? Some children do. They sing out words and bounce them around while engaged in physical activity. The "partner-dots" and the "heres" become chants and chimes.

Do they benefit from hearing each other's interpretations? Some students listen attentively while others wait their turn. Do they imitate the teacher's way of knowing during help-giving? Interestingly enough, no. Once young learners are thoroughly engaged in explaining something, they become territorial. They need to control the floor as they discuss their solutions: they're merely themselves. When gaining access to a discussion, they sound like a significant adult— perhaps a strong parent. In one case, a girl interrupted the group discussion by saying "Let's solve this by using a marketing principal like my father uses."

In conclusion, I'd like to say that the lines of communication in this interactive classroom are very special. Students are actively engaged and never bored. There's a constant shuffling of feet as students move freely in the classroom. They switch gears frequently as they move from one activity to another. A sense of *agency* which I define as a knowing where to go pervades. A built-in feeling of *self-efficacy*— defined by the school's mandate as an "I think I can" attitude exists.

Analytic Memo #14
Environmental problem solving

This is a list of problem-solving items that I find in the school environment, that add to the problem-solving nature of the school setting. The children see these and are aware of the importance of keeping a systematic, organized program within a well-run school. [I wonder if this is why they asked me whether I would check their "cubbies" to find out whether they were well-organized enough.]

In Class:

1. Homework buddy system
2. Miss Z's use of small board, large board
3. Space on board
4. Use of rug
5. Bins
6. White table
7. List for desk arrangement
8. Miss Z's name-list for hand-ins
9. Tool-boxes for legos
10. Water fountain/sink
11. Desk arrangement

School in General

1. Hallway distribution
2. Color-coded cloak space
3. St. John's book satchels for gym clothes
4. Use of space
5. Use of color
6. Circulation of children

Zack's a joyful character. He's sort of into a popularity contest, trying to gauge his popularity amongst others. He wears trendy clothes and a modern hair-cut. He's been working very closely with the teachers. The principal has walked in several times concerned about his work habits, eating habits, etc. From what I hear, his father owns a famous resort. The children sort of admire him. He **celebrated** wildly when he figured out something. I also noticed how creatively he observed a picture on the black-board that reminded him of something else.

Joseph is another character. He's sort of a **jester** whom everybody loves. He hangs around, looks at what everybody else's doing, not too worried about catching up. He's got Turret's syndrome. I've caught him shaking on tape once. Other than that, I haven't seen much except that he can't write for extended periods of time and therefore uses the computer.

There are a number of kids that sort of hide behind each other. I haven't heard much from Alana, from Cora or from Adelso. They're sort of quiet, withdrawn. They work well one-on-one and seek Miss Z out a lot.

Dianne's sort of adopted a helping role. I noticed how during the last session she walked over to Seb's group to see if he was getting it right. She's also adopted and incorporated several of Miss Z's classroom techniques for herself. On the last day, in order to keep a control of whoever had signed her yearbook, she asked Miss Z for a class-list so that she could systematically jot down who she needed to respond to...etc. Jerry, picked up on this and borrowed a class-list as well.

What do I make of both groups?

Miss Z is different as she interacts with both groups and then also very different when she interacts with the entire class. She wants the independent learners to help the less independent ones. She also wants to slowly remove herself from the scene so that she can concentrate on help-giving. She usually works very closely with those who seek her out and shoos off the independent learners to fend for themselves. The teaching assistant works systematically with those who've determined they need help in a particular area. She organizes a series of appointments to avoid clutter.

Students are helpful with each other. They seem to cover for each other. Lea's always trying to help Cora, who's usually late and sort of off task much of the time. Myra's always hovering over Elaine and vice-versa. Dianne plays an important **commanding role** in this dyad, as she usually takes over when working with them or sitting with them. Gina is a very **independent worker** who doesn't seek anybody out for any reason in particular. She's just interested in completing her tasks and moving on.

Is **staying on in the school** an important factor? Lea told me she's leaving after this year. This has caused her to **detach** herself. Gina did this towards the winter, after the ice-strom, she was determined she didn't want to live in this city anymore. The school is not an issue, however, she wants to be accepted in a challenging IB program. Lea's had trouble all year along. She's had special tutoring, etc. She's one of the few who requested not to participate in my research because she had a bad self-image. After talking to her and reassuring her, I managed to get her and her parents to sign on. She's sort of detached herself from everybody. Eric's no longer around either. I wonder if he's staying on. This is a very expensive school in the elementary. The high school is half-price. I wonder if children over-hear their parents and don't want to reveal that money is a problem.

Analytic Memo # 15
Date: June 27, 1998
How to put the data together
Making Sense of the Data

Today, June the 27th, 1998, I'm making a first attempt to make sense of all of this data. I have transcribed the eight 3-hour tapes during a rainy week in mid-June (it rained for ten days in a row...believe it or not) I borrowed a VCR from ICC and propped the TV set along with VCR next to my computer in the corridor. I began writing down everything that occurred amongst the 26 students in the classroom. I used third person to refer to the children's interactions amongst themselves and with their teachers. I kept the general classroom description to a minimum concentrating mostly on student activity.

Most of the written transcription consists of description of student interaction narrated in third person. I focus mainly on exactly what the children are physically doing while solving problems or engaged in productive activity. I describe their conversations with others using direct quotations or simply the active voice. For example, I report the following: Dianne is checking over her work. She is starting a new task...in the mean time...Donna, the girl working with her is watching her align her numbers closely...and so on.

After transcribing all of the eight video tapes, I proceeded to proof-read the text and to separate it into a theater-like script. In this way, each piece of dialogue or each description by a different child stands alone, independent of other children's activity. I double-spaced these pieces of dialogue or activity description before moving on to another child's activity or dialogue.

Once I'd done this scripting and dividing with the entire text, I made sure I'd typed it accurately and broke it down squarely so as not to leave anything out. I started a new line of text for each different child. For each new line of text, I identify the event, date and video number coding it in such a manner that when I cut it into strips, I maintain the sequential order of events. I doubled the spaces between each intervention to give me enough cutting space. I let it sit for a while. During this space of time, I gave myself time to do other things and to figure out a way to spread all of this data out. My first step was to free up some wall space, because I was definitely going to hang up something rather than spread it out on the floor. I reflected some more, of course, my years of creating classroom displays and bulletin boards helped. I finally decided to put a long strip of masking tape along one wall.

Then I couldn't quite figure out what to do next, so I waited. I figured I'd hang long vertical strips along the horizontal strip with the sticky part facing me. In this way, I could easily adhere the strips of paper. This worked well.

While working, I decided to use two separate wall spaces, one for group A and one for group B. I extended my corridor wall-space towards the kitchen. Fortunately, I'd moved out the furniture the week before. The family has balked and complained because I've changed things around for them...but they've learned to put up with me just like I put up with them.

Separating the two groups was a wise decision. Then, I decided to separate Miss Z's interventions and to post a strip for her along with each separate group. The teaching assistant, of course, only works with group B, so she's posted with them. I thought I'd make space for myself and realized I don't say or do much that affects the research.

As for the principal, Miss B, I hadn't included her. After watching the many hours of video, I've noticed what a presence she is. I didn't write much about her or film her much because I hadn't asked for her consent. During the time that I was thinking about how to write a farewell and thank-you letter to her, I realized how important she has been throughout this entire venture. I've written down the number of times she appears. I usually didn't film her when in the classroom, I hadn't asked her permission to do that. But I've also included her in my field-notes.

Once I had the masking-tape framework up twice, one for each group, I proceeded to cut student interventions into strips. There are 11 children's vertical strips in group A and 15 children's vertical strips in group B (don't ask me why) I never quite figured out why group A was smaller than group B. It should be an equal division. I then used an orange high-lighter for the child's name and am using a yellow one for highlighting the type of intervention.

In trying to make sense of what I have, I can either look at each child individually or perhaps look at coinciding behaviors. From what I see, and what is very evident, in group A I notice that girls hide their feelings, mask themselves behind **baby-talk** and adopt a more assertive mode if supported by a group or if playing a role. Girls help each other out by propping things up for each other, by sharing in a **joint-venture, playful type of activity**, by physically sharing objects and things. Boys seem to size each other up, to measure their worth and find out who's the dominant one. I can't help but be influenced by a TV report on men harassing each other on the job. A prominent anthropologist interviewed for this program says that it's natural. Men want to establish supremacy and control. Primates do this all the time. Why am I expecting more civilized behavior in a classroom?

However, Edward is a very gentle boy. He's much different from the others, perhaps because he carries his **vulnerability** with him all day (his fanny pack with medication) then, Jeremy's different as well. He carries his epilepsy bracelet like if it were an earned chalice, perhaps entitling him to be a little bit more vulnerable? So, I could say that both Edward and Jules are different, less competitive because they're vulnerable? I wonder about that. How do I account for John, who's quiet, minds his own business and sticks to a task until he's through? He is **competitive**, but not an **initiator of competitiveness**, he's not seeking supremacy. Maybe I need to look into instigators of supremacy in boys. Let me look again.

I've examined group A again, trying to see what some general similarities are. Girls side with each other and look for the teacher for support. Boys size each other up and stick to the stronger boy. They seem to append themselves to the leader. How do I account for Gina, who's a very mature, independent learner and quite a challenge for everybody? Should I say that she's **developmentally at another stage**? She doesn't adopt any of the other girls' ways, she doesn't speak childishly or destroy what she's created or mask herself in the company of others. What is she doing and what do I notice. Is there a newfound strength because she knows she's leaving town and the school? Does she play an important role at home, where she's the oldest child amidst parents who are constantly on the move (her father lives in Singapore and waiting out the school year for his family to join him.) Is it because she's from an upward mobile family who's made it this far because they insist on developing their mental abilities and don't bow down to those abilities of others?

Learning more about the children's personal lives might help a bit. Jules's an only, sickly child of older parents who over-protect him. Edward, is sickly, I don't know if an only child. I don't know enough about the other children because I haven't made it a point to find out.

I could explore this concept of boys and their **declared vulnerability.** Tannen talks a lot about girls voices, so I have enough material there. However, how do I account for the developmental?

Let me examine group B.

Aha, break-through...Miss Z's behavior is much different with group B. Her actions with group A are very much : explaining, helping, listening, eaves-dropping... in group A. With group B she is meeting, gathering, asking, telling, handing out, suggesting, announcing...Here's a technique I didn't think I'd be using...garnered from the Writing Center experience, key-word search based on key-word editing. This helped me determine Miss Z's behavior in both groups. How interesting.

The teaching assistant is more present during group B sessions because it's built in into her schedule, and judging from the population of children (Joseph, Zack, Mark, and Lea, I know she's there to assist them. Perhaps Miss Z modifies her instructions because she knows that the teaching assistant is there? I need to ask her.

I've garnered very different information here. Jordan W. is very diligent and quiet. Somewhat like John in his **stick-to-it-ness,** however, he's systematic and comes up with his very own interpretations of things without wanting to tell the world about them. He sort of mumbles to himself and comes up with very mature solutions without wanting to make them similar to those of others.

Dianne, is very demanding on herself and wants to always finish quickly. I've noticed that once she's got it, she walks around to help others get it. It's sort of wanting to gain adept joiners or something. She does tend to be **bossy.**..she gives others instructions and tells the boys off when they get rowdy.

Donna, on the other hand is quietly **supportive.**..she comes to the rescue..I've found her getting stronger and stronger as she builds up her ground. She's become more vocal as the year has evolved.

Jerry's my physical one. He's a **rhythmic bouncer, stacker, clicker**. He gets up frequently from his chair...giving his mind a chance to work while he performs menial tasks. He likes to arrange his pencils, his materials, a systematic series of dots from which to check off from when calculating. He's hard on himself. He's not happy until he's seen a breakthrough.

Adelso, on the other hand, works very quietly. He doesn't need to size himself with others. He just wants to know whether he's capable or not of completing a task.

Don does lots of **consulting.** He's always curious to know what other are doing. He often intercedes while doing something else. I've seen him mumble something to himself, as if listening in on another's group work and still doing his own.

Bernie's my **narrator**. He's always the one who tells me what's going on. He's kept me informed about the progress of the lego's. He also shares his work with me. I think Miss Z appreciates this because I'm an audience for Bernie. I've seen lots of progress in him. He's got a very friendly disposition. He's not angrily competitive, but willing to share.

I've noticed something interesting about Amalia G. She tells Dianne off, telling her she makes things so complicated. She questions things in a very quiet, mature sort of way. She reminds me of a ballerina, poised and elegant, bearing her back so straight. She sort of mumbles to herself when she doesn't agree.

Vignette #1
The Readers of Zamwana
January 29/ 30 Problem
Teaching Reading - Problem Solving Lesson Taught on Thursday/Friday Jan. 29/30, 1998

The problem reads: In the newly developing country of Zamwana teaching reading is a focal point of the government program. The plan is for each individual who can read to spend one year teaching two others to read. That individual is done, but the two new readers must spend one year, each teaching two others to read.
If 1,000 people can read in Zamwana now, how many people are able to read in ten years.

The page is accompanied with a hand- written message that reads:
Anwer:
Checklist:
Write the answer for the problem in a sentence
Write a clear and detailed explanation of what you did (Reread it so that you are sure it makes sense)
Write if you had any difficulties _____
Write if you had any help _____ Who?
Write your strategy _____
Check your answer to see that your thinking and your calculations are correct.

Bracket 1

To my recollection, this is the first problem-solving exercise, after a series of preparation ones. Prior to this exercise, Miss Z has been preparing the children with shorter exercises ie: the Self-Assessment sheet handed out during the month of November where the children keep a log of their problem solving abilities namely:
Problem Solving: (math puzzles - finding a pattern, writing a rule... magic squares, stick puzzles, I've seen #1 A Magic Card Trick where they stacked up cards and suits and problem of the week November 26 Alexandra's Allowance where they were to figure out how many coin combinations she could make to get $2.25 out of 14 coins.
Miss Z has adhered closely to the problem solving mandate of "I think I can attitude...working towards improvement...remaining calm, finding a strategy, giving a clear and complete explanation, checking the answer, listening to solutions, trying out new strategies, keeping an open mind, keeping track of thinking, sticking with the problem (as per Self Assessment sheet)
In the Alexandra's Allowance problem, they try out two of the many things 1. Writing a strategy 2. Keeping track of what they've done via a checklist ie.
1. Did I write the answer in a sentence?
2. Did I write a complete explanation of what I did?

jotting down the process, and no longer thinking about what's happening in a general sense [note for researcher, transcribing needs to be done in two steps, one for jotting down dialogue and exact events, second time for seeing the event as a whole and maybe a third time to see if there's any important type of event popping up.]

Second Viewing: March 19

At this time, I've carefully jotted down the contents of the poster on the exit to Library door. I find that it adds to supports the problem-solving climate in the class. Perhaps this accounts for many of the behaviors I've seen while they sit in the circle. I know that they talk about these things during their "town meetings" and that Miss Z reminds them to adhere to these, which are the class rules, I suppose. I particularly like the "I think I can" attitude promoted in the "don't give up...able to...successful components.

This bulletin board excerpt reflects this:

Smart People Are
Readers
Problem solvers
Good workers
Don't give up
Good listeners
Able to concentrate
Organized
Efficient
Able to resolve conflicts
Forgiving
Successful

In this second viewing I notice several things that happen and jot them down with an asterisk in my written protocol, which is a simple note-taking device, not following any sort of order... Gina offers an interesting comment "principal, like in marketing" she uses it as a device to build up her numbers from...sort of branching outwards. I also notice that Dianne reduces her figures to lowest terms, taking away zeros so that you're dealing with 10's instead of 1000's for the time being. I've noticed several social interactive aspects which are: boys usually take initiative in the "agency" part, girls take on the note-taking record-keeping role. The boys are usually the decision makers in the outset...examples of this (see dialogue for John, Edward, Wayne and Jules tries to engage Dafne A. politely "do you know...can you show me..." he imitates Miss Z's stance. Jordan T and Gina argue and compete sort of proving each other wrong.

Theorizing transfer

I'm starting to see knowledge transfer, especially with Gina's comment from the marketing world.

Breakthrough:

Gina says that as she was explaining, she realized they'd entirely missed a step. She says she had it in her head and hadn't accounted for it in her calculations. While explaining it she "sort of cleared it up..."

Bracket 3

It seems to me that several things are in place here, the more this dialogue and this *assisted instruction* continues, the better Miss Z is able to put in place the independent skills she seeks. I also notice that during each problem solving activity she carefully determines who will form a pair or a group of four. Sometimes it's a gendered process, sometimes it's because students produce similar thinking patterns, sometimes it's because certain students work well with each other. I have to ask her how and why she decides this. If it's after reading preliminary log entries and seeing connections or it's other factors, specifically since the teaching assistant looks into the process and assists with individualized instruction. From conversations with the teachers, this is a very different batch of students. The help at home is different, students aren't having that many opportunities to work with an adult (parent or tutor) and the skills they've started with differ greatly from those of other fifth graders in the past. It's just a matter of this mix. (To be looked into later, however, I do notice that there are more students who need individualized attention in group B.

Prior Experience

I've noticed that Miss Z creates *build ups* for the problems. Prior to the Zamwana problem, there was the Sale at the Frozen Yogurt Shop problem which required that someone tells something to someone else. They worked on this problem rather informally on January 22 (which I hadn't filmed just yet) here's where I discovered Dianne's "partner dots" and some other interesting forms of children *building theory* etc. This particular problem deals with almost exactly the same concept (I'll expand on this later)

First viewing: February 9, 1998

During this first viewing, I've carefully jotted down initial observations. I use the Research Protocol to assist me as I move into the general activities of the tape. I create a circle with names to know who sat where. I notice that Miss Z insists on repeating each sentence so that all children are aware of the meaning of all the words in the problem. She also insists in their noting down which are the facts they need to know. [I ask myself whether students who are not involved in the oral reading are focused] I notice that everybody is quiet awaiting their turn, not interfering with anybody or proving themselves wrong or right, they're very passive] Miss Z does an interesting thing, when they reach the word "now" she has them repeat it over and over to drill into their heads that knowing how many people can read 'now' is crucial to solving the problem. She repeats... "Say it again...say it again...say it again..." She continues asking them over and over "What is the problem? What are you trying to figure out? What are you looking for?" I carefully jot down all the dialogue amongst the children so that I can use it as an exact transcript. Hence, while I'm transcribing, I'm merely observing the dialogue,

3. Did I write down the strategy that I used?
4. Did I check my answer to be sure that it works?
5. Did I write about any difficulties, who helped and how?

Bracket 2

I've decided to look into the *scaffolding* aspect of this series of activities because
1. I've noticed that with group B, Miss Z modifies her instruction giving group B more of a performance model. Students usually have an opportunity to act out or visualize what they are about to work with. Perhaps it's the composition of this second group (namely the presence of children who need more individualized instruction) or merely because the teaching assistant's schedule fits in well or perhaps because Miss Z's already had a dry-run with group A the day before and has modified her approach. I have to ask her about this.

Scaffolding

A.S. Palinscar (1986) in her article *The Role of Dialogue in Providing Scaffolded Instruction* describes scaffolded instruction for the purposes of her study and explains how for this singular purpose, it relies largely on discussion. Wood, Bruner & Ross (1976) define scaffolding as "a process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts." (p. 90). The scaffold, viewed in this context is a support that is slowly withdrawn as the student becomes more self-reliant. Dialogue is a building block for this type of instruction. Hence, what is occurring in this moment in the class is similar to the following, as I quote from Palinscar (1986):

> "Scaffolded instruction begins with the selection of the learning task (Applebee& Langer, 1983). The task is chosen for the purpose of teaching a skill that is emerging in the learner's repertoire but is not yet mature. The task is evaluated to determine the difficulty it is likely to pose for the learner(s) (Applebee & Langer, 1983; Hess & Holloway, 1983; Hoddap & Goldfield, 1983, Wood et al., 1976)."(p.74)

It seems to me that Miss Z. scaffolds the important steps in problem solving systematically adding one more each time she does a practice run with the students. She chooses to scaffold the actual visualization of the problem with group B because they seem to require it.

Reciprocal Teaching

This is a term Palinscar and Brown (1981) have coined as an instructional format to develop this type of scaffolded instruction with dialogue in a classroom. The dialogue is structured by four strategies (question generation, response, summary, clarification, prediction) it is a system they would like teachers to use.

Vignette# 2
Date: March 9, 1998
Prior to Spring Break

I've now made ten visits to St. John's school. I don't hesitate each time I go anymore or worry about my presence being obtrusive. Miss B, the principal introduces me to visiting parents as her "in-house researcher who takes it all in". She walks in frequently, I'm always discretely in my little corner, not upsetting things, either filming, writing or having kids photograph their work. I keep everything tidily under control so as not to upset the regular flow of classroom events and try not to interrupt or annoy.

I've shared my work with Miss Z and showed my scrap book to Group B. I've also shared what the literature has to say about gender with the teachers. My next move is to share help-seeking/help-giving as the teaching assistant was working on this and I'd interviewed her on it.

I notice that Miss Z is moving away from the scaffolding and allowing students to come up with their own thoughts and solutions more. She is now insisting on their explaining and justifying what they are doing. When she returned their math problem solving note-books, she had lots of them re-visit their workings this week and justify what they'd done.

They've done math problem solving at other times because reports are due and Miss Z wants to get everything together. However, during the Middle Ages part last week I was able to concentrate on gender and during the math catch-up part this week, I'm able to focus on help-seeking/help-giving.

There will be a three week break after next week. Students are going on trips and are excited about this. It's a long break for everybody.

I've gotten lots of material and need to start zooming in on what I'm looking for. The preparation for a presentation has helped me re-locate my thoughts.

Environmental

I continue to notice "environmental problem solving" which enriches this atmosphere. Now it's "spring cleaning" based on the medieval habit of changing the hay on the floor during a change of season. Miss Z always relates whatever goes on in the classroom to what they're studying.

Math Connections

By aligning numbers to what they stood for, Miss Z helped them see connections, having them "experience" seeing a pattern when it's on the blackboard. Once they get this, she takes them further. First, she had them work out a formula and replace numbers for the operations. They could use calculators and came up with lots of adequate answers. As Jerry is working he yells out " I just realized something...burrows to tunnels add up to nines...**an eureka moment.**

Vignette # 3
December 5 & 6, 1997
Student Talk
Problem: Alexandra's Allowance
Recording device: Field notes

1. FN/5/12/97 Jules: " **For 25 cents I will choose 14 coins it's too high. I will keep on guessing (deducting coins) I had 7 25cent coins which added to $1.75 then I added dimes to get 2.25 7 dimes and 7 quarters was too high so I used 4 nickels instead of 2 dimes because a nickel is half a dime.**

[bracket: Learning by doing]

2. FN/5/12/97 Bernie:**"I'll take off the 25 cents from $2.25 because it's easier to work with $2.00."**

This to me [bracket] is estimation, rounding off and economizing for practical purposes. No matter how many times I've tried to tell fourth graders the value of this strategy, they've never used it naturally, only to please me.] I think this reflects students need for halving things evenly. It seems that 2 is easily cut in half, more so than 2.25 the thought processes behind this is wonderful.

Another strategy that was used was having coins add up to quarters. Students are used to making dollars with four quarters. The technique here was to get as many quarter replacements as possible and juggling with the coin/amount possibilities. Hence, this is a "group to make a dollar" technique.

Vignette # 6
Some Insights
February 7, 1998
After "Cooking up" field-notes

Rockers: My usual rockers are Joseph, Jordan T., Jerry, Zack. I wonder what brings on this rocking behavior. I don't notice it in girls.

Adult Base-Touchers: Jules, Cora, Dianne, Mark and Lea are my most frequent adult-base-touchers. They want to know how I feel about them. Jules usually greets me with a hug. Dianne seeks my approval. Cora shares her art-work. Mark likes to look through my equipment. Lea likes to confer with me.

Celebrators: I've discovered that children celebrate when they find success. Dianne clicks rhythmically, Jerry stacks things, Zack cheers and moves off, Mark swears and swears over and over again. John is another celebrator. He started chanting to himself and cheering himself onward in the coins/allowance problem. I think I caught him in flow while he was putting everything together with that particular problem.

Fast-Forwarders: Over and over again I see some children finding a "fast forward" way of solving problems. If they figure out the multiples they immediately say, " Oh, it's easy, multiply 4 x 12 and you get 48, or 9 burrows times 8 tunnels, oh, it's 72". When they need to explain or show somebody else, they realize it's not so simple.

Second Wind: There's a time of exposure to the problem. After realizing it's not so simple, some students are realizing that there's more to it. They start catching this second wind, it's usually after the first half hour.

Being at two places : Jerry can be working on a task of his own and also listening in on what goes on with the reading group. I wonder why this happens. I wonder what drives this type of behavior.

Stackers/organizers: Jerry and Gina are systematic. They seem to like to stack, pile, organize and put everything away conveniently so that they can pursue whatever it is they're doing. I wonder if this is a way of saying, o.k. this is done, that is done, it seems to hold ground, let's move on to something else. Is it a way of efficient house-keeping?

Creativity: I spotted Don doing two things at a time. Somewhere I'd read that creativity is apparent when people can "chew gum and walk at the same time" Dean was figuring out a problem, he had a firm grip on it, therefore, his confidence was high. He was able to create conversation about something totally different while stacking up his coins and counting his numbers. I've seen his artistic bend as he shared his creative "Halmark" cards with me. Perhaps he does have a very creative mind.

I want to test these insights:

1. Creativity
2. Flow
3. The second wind
4. Time
5. Teacher direction
6. Ease with experience