The Role of Language in Planning for Science Instruction:
Case Studies of Four Teachers of the Gifted

by

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Abstract

This exploratory project investigated the perceptions of four elementary teachers of the gifted in regard to the role of language in planning for science instruction. Four case studies emerged from this project, a case study of each of the three volunteer teachers and my self-study.

During one school year, the three volunteers, the school principal, the language consultant, my research advisor and I were involved in this project. The information in the four cases was derived from many sources including a series of seven videotaped science workshops with the three volunteers, ten videotaped discussions between the language consultant and me, nine videotaped individual interviews with the three volunteers, two videotaped interviews with the principal, my research journal and four cumulative teacher portfolios.

Within each case study, I interpreted the transcribed “critical conversations” and other data that were relevant to my research problem. Specifically, I investigated what the teachers perceived regarding (1) their judgements about selecting and defining school science language and concepts, (2) their strategies for teaching and/or assessing school science language and concepts, and (3) the impact of the workshops.
The findings indicate that each teacher noticed (1) that her judgements about selecting and defining school science language and concepts were an important part of planning for instruction, (2) the usefulness of translating back and forth between everyday science language and concepts and school science language and concepts, (3) that the workshops encouraged the exploration of alternative teaching and/or assessment strategies, and (4) that participation in this project coincided with some changes in her teaching practice.
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Introduction

Often generalist elementary teachers have a minimal science background but they are required to organize appropriate science activities for their students. This means that teachers must critically evaluate diverse resources on many different science topics, prepare engaging classroom materials, and plan appropriate sequences of lessons. Each teacher needs to select and apply various strategies in order to encourage the development of scientific processes, skills, and attitudes by students as mandated in the Science K-7 Integrated Resource Package (IRP). A critical process for students to acquire is the ability to communicate their scientific ideas to others. This has been recognized by the Ministry of Education, and so the Science K-7 IRP (1995) states that school science programs should promote the development of scientifically literate students.

When communication is facilitated through language, all the participants need to have a comparable functional understanding of that language. The teacher’s use of school science language affects the teacher’s selection of resources for students, the planning for instructional sequences, the design of experiments, and the format of assignments. It also affects the amount of emphasis that is placed on the development of school science language and the assessment of the students’ understanding of school science language and school science concepts.
School science concepts are the domain-specific science ideas that are mandated in each Prescribed Learning Outcome (P.L.O.) within the K-7 Science curriculum. School science language is generally used to communicate school science concepts. School science language is the expected form of language usage for science content areas as specified in the K-7 Science IRP.

Generally elementary teachers only take one course of instruction on the elementary science curriculum and teaching methods. Thus, they may be concerned about a lack of science content knowledge, functional school science language, and effective methods for facilitating conceptual development in students, in particular for gifted students. They may be unaware that school science language can be confusing to some students, and that misunderstandings about the meaning(s) of words increase the difficulty of learning new science concepts. This applies to both teachers and children in science classrooms (Fensham, Gunstone & White, 1994; Grimmett & Erickson, 1988).

A class of elementary students in British Columbia, at any grade level, is generally non-homogeneous. Elementary classrooms encompass students from multi-cultural and multi-lingual backgrounds with a range of intellectual abilities. Teachers are encouraged to adapt or develop programs to meet the needs of their students. When one considers that the characteristics of the students may include E.S.L. (English as a Second Language), various ability levels, and an inconsistent background knowledge of school science language and concepts, the complexity of teaching science becomes apparent.
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If one is teaching gifted students within a science program that utilizes **subject-based acceleration, curriculum compacting, and curriculum telescoping**, then the situation becomes more challenging, even for experienced science teachers. For example, at the research site all subject areas of the curriculum were compressed to 60% of the mandated hours of weekly engagement. The other 40% of the time was devoted to enrichment classes in various subjects. This means that the students receive fifty minutes of science instruction three times per week. Since the students spend less time in contact with the teacher or the curriculum content, both the teacher and the students need to communicate their science ideas effectively and accurately. The development and precise use of school science language is essential for the communication of school science concepts, experimental observations, and scientific procedures.

This qualitative research project was designed to examine the impact of a series of professional development science workshops on elementary teachers of the gifted. The data generated by the research process were used to produce detailed case studies of the three participant teachers and my self-study. This project explored the teachers’ judgements in regard to selecting, defining, teaching, and assessing relevant school science language and concepts. The workshops encouraged the teachers to express their perceptions of the role of language in the planning of science instruction. The investigation of these practices can inform the processes of both teaching and learning.
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Background to the Research Problem

There is controversy about the relationship between the development of language and the development of concepts in children. Piaget (1972) claims that the development of internal cognitive structures are necessary before linguistic and social factors can affect learning. He insists that a person's cognitive level is paramount when considering what learning can take place, and what type of instruction should be offered, within a particular context (Piaget, 1972).

Vygotsky ([1934] 1986) declares that a person can have an unconscious understanding of a concept, but that it is language which facilitates the purposeful mental construction of ideas and clarifies thought into words. According to Vygotsky, conceptual development includes a continuum of mental processes that proceed from non-complex forms of reasoning (everyday science concepts) to more complex, abstract forms of reasoning (school science concepts).

Everyday science concepts are the culturally affected, socially experienced science ideas that a student has formed about science topics, phenomena, and content domains as they are used and enacted in the world at large. Everyday science language is generally used to communicate everyday science concepts. Everyday science language is the culturally-expected social norm of language usage for science content areas within the community served by a school.
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Lemke (1990) agrees that language is a systematic psychological tool that is useful for communicating ideas; however, he identifies "semantics" as the language process that specifies word meanings and therefore affects conceptual development. According to Lemke, students gradually acquire science concepts at school through the recursive social negotiation of word meanings and semantic relationships (Lemke, 1990).

Perhaps learning and/or teaching science is a complex social interaction in which the articulation of language contributes to the attainment of consensual understandings (Edwards & Mercer, 1987). It may be that language and conceptual development are a co-emergent coalescence of thought, physical action, and experience (Davis, 1996). However, this project was organized according to Vygotsky's and Lemke's views of linguistic-conceptual development.

The Research Problem

Students learn science vocabulary and concepts from the adults around them as well as from the culture at large (Vygotsky, [1934] 1986). Teachers are important mediators in the development of school science language and concepts. Therefore, this project will (1) examine the teachers' judgements about selecting and defining relevant school science language and concepts, (2) explore the teachers' strategies for teaching and assessing school science language and concepts, and (3) investigate the teachers' perceptions of the impact of the workshops.
Rationale

School science language is historically, socially, and culturally entrenched in traditional science instruction, especially in school science textbooks, teacher manuals, and science resources (Lemke, 1990). There is a noticeable style of language in both scientific arguments and in the structure of scientific reasoning. This has caused some researchers to assert that there is a "language of science," and that teachers and learners need to be enculturated into the community of science practitioners by developing proficiency in school science language and processes (Driver, Leach, Millar, & Scott, 1996; Halliday & Martin, 1993; Lemke, 1990).

There is some concern that constructivist theory has not significantly affected teacher development programs (Treagust, Duit, & Fraser, 1996). Similarly, I am concerned that theories about the development of school science language may not have impacted upon programs for elementary teachers. When do teachers usually examine the interaction between teacher language and student learning or consider changes in their teaching strategies? Many teachers examine the relationship between school science language and everyday science language when planning for instruction in order "to determine whether there may be a match/mismatch between curricular expectations and the student’s level of development" (Gruenewald & Pollak, 1984, p. 14). Specifically, planning for science instruction includes the logical development of concepts as well as
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the "introduction of new vocabulary expressing new concepts versus new vocabulary expressing old concepts" (Gruenewald & Pollak, 1984, p. 128).

Personal Perspectives and Context

My attitudes toward science instruction for the gifted arose from teaching Gr. 4 – 10 Science to gifted students for six years. In 1999-2000, I worked as a teaching assistant/instructor for the SCED 320 (Curriculum and Instruction in Elementary Science) course for the Department of Curriculum Studies at U.B.C. That was the first time that I had an opportunity to observe the role that language played in the planning of science instruction within a professional program. While I was instructing the pre-service teachers I began to wonder what perceptions experienced teachers might have about the role of language in planning science instruction for the gifted.

Design of this Research Project

This project’s design was based upon three ideas that emanate from the theory of social constructivism: (1) individuals and communities construct knowledge through their interactions with their environment, (2) language is an important mediator in the social construction of knowledge, and (3) a relationship exists between the development of language and the development of concepts (Richardson, 1997; Staver, 1998).
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This project was exploratory in nature, so the evolving research design emerged from within a general framework. The framework was organized in a sequence of four phases: (1) organizational procedures (May 2000 - Sept. 2000), (2) establishing a community of inquiry (Oct. 2000 - Dec. 2000), (3) planning for science instruction (Jan. 2001 - Apr. 2001), and (4) reconstruction of practice (Apr. 2001 - July 2001). These four phases are described in chapter three.

This project included a series of meetings, presentations, resource visits, science workshops, research-oriented discussions, interviews, and consultations during the 2000 - 2001 year. The workshops involved topics within the B.C. K-7 Science curriculum and included "hands-on" experiments, critical conversations (Feldman, 1998, 1999), concept mapping and the construction of artifacts. I presented the workshops to the three participant teachers (Susan, Amanda, and Janet). There were seven workshops, and each one was approximately one hour long. In addition to the workshops, I also conducted a total of eleven individual interviews (nine with the three volunteer teachers and two with the principal). Each interview was approximately twenty minutes long. Furthermore, I participated in ten consultations with Tammy (the language consultant), and each one was approximately thirty minutes long. The workshops, interviews, and consultations were all videotaped. This project generated four case studies of elementary teachers of the gifted (a case study of each volunteer and my self-study).
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Significance of this Research Project

This project examined some of the processes involved in the planning of science instruction for gifted students, in particular (1) the teachers' judgements about selecting and defining school science language and concepts, and (2) the teachers' strategies for teaching and/or assessing school science language and concepts. It also reported the perceived impact of the workshops, specifically (1) the teachers' judgements about translating back and forth between everyday science language and concepts and school science language and concepts, and (2) the teachers' insights into changes in their teaching practice.

The teachers' judgements about selecting and defining appropriate school science language and concepts are significant because the process involves an evaluation or estimation of the students' prior science knowledge and language skills. Insight into such a process is informative for both researchers and teachers.

The strategies that teachers use to teach and/or assess school science language and concepts are significant because the rote memorization of science language and concepts is not advocated for any students (Lemke, 1990). The recitation of memorized definitions becomes problematic when children are capable of the sophisticated mimicry of adult sentence structures (Vygotsky, [1934] 1986). Many gifted elementary students exhibit a high verbal and/or written fluency in language (Maker, 1995). Therefore, teachers need
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to develop strategies that check for understanding. The rote memorization of scientific words by students can lead to conceptual difficulties because replication of the teacher's scientific definition is often perceived by the students to equate with mastery of the related scientific concept.

The teachers' judgements about translating back and forth between everyday science language and concepts and school science language and concepts are significant because translation enhances the communication of meaning. Although scientific knowledge is organized in a systematic way, Lemke claims that it is not equally accessible to all learners. The reason for the inequity is the lack of adequate bridging and translation between the students' everyday science language and concepts as compared to the teacher's school science language and concepts (Lemke, 1990). If instruction is student-centred, then the teacher should plan to provide the students with opportunities for linguistic and conceptual development.

The teachers' perceptions of changes in their teaching practice are significant because professional development programs should encourage and support self-evaluation and reformulation of practice. When teachers form a community of inquiry, they can examine and validate their past knowledge and generate new knowledge that is intimately connected to each participant and to the context of the investigation (Cochran-Smith & Lytyle, 2001). A perception of change in practice may engender a continued interest in professional development programs as well as applications to classroom situations.
Limitations of this Research Project

The reader must decide whether or not his/her own teaching practice is similar to the reported context of this research project before considering how to apply the findings. To assist the reader in his/her interpretation of the findings the limitations of this project will be discussed next.

The first limitation of this research project is that it was an exploratory study grounded in theory but without an explicit empirical hypothesis. This project investigated only one aspect of linguistic-conceptual development, namely the perceived role of language in the planning of science instruction.

The second limitation of this study is that it focused on four experienced, competent, reflective elementary teachers of gifted children (the three volunteers and myself). There was a pre-determined social structure within which I assumed the roles of mentor and interviewer while the participant teachers assumed the roles of engaged learners and evolving practitioners. I encouraged the establishment of a community of inquiry to explore the research problem.

All three of the volunteers had a common educational background in regard to teaching attitudes, practices, and beliefs concerning the instruction of gifted students. Each volunteer had taken university courses about instruction for the gifted across the curriculum in general,
but not science instruction in particular. In contrast, I am a science specialist who has taken several advanced courses in curriculum and instruction for the gifted. I was familiar with the methods used at the school for accelerating, compacting, and/or telescoping the science curriculum.

The third limitation of this project is that it was both physically and philosophically situated within a specific teaching context. The school is a small, independent elementary school with 100 gifted students. Each student has an individual Student Learning Implementation Plan (S.L.I.P.) which covers all areas of the curriculum. Typically, the students are individually monitored for continuous progress every six weeks. Since the teachers have contact with small groups of students, this facilitates the compilation of an extensive file on each student’s academic, social, physical, and emotional development.

The teachers also have access to information about the students’ performance on I.Q. tests, reports from school psychologists, and documentation of the students’ preferred learning styles. The teachers have extensive knowledge about each student’s abilities and any possible learning difficulties. This knowledge of the students’ abilities affects the teachers’ decisions when planning for instruction. Teachers in other educational settings may not have access to extensive documentation about each one of their students. Thus, caution should be used before generalizing the findings of this study to other independent and/or public schools.
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The fourth limitation of this study is that I only had direct contact with the teachers and administrators at the school, not with the students. I did not directly monitor the teachers' science lessons. Instead, feedback was obtained through the teachers' logbooks, the teachers' anecdotal comments, and the teachers' videotaped discussions during the workshops. Further information was obtained in the individual interviews with each volunteer during phase four (April 2001 - July 2001). Interviews with the principal were carried out to situate the overall research within the context of the social dynamics of the whole school. This study does not focus on student learning, except indirectly as perceived by the teachers. Therefore, one should use caution if generalizing the findings to student learning and achievement in diverse classroom situations.

The fifth limitation of the project is the selection of the data that was used for analysis. The final accumulated data included four logbooks of hand-written reflections, my research journal, my document file, concept maps, artifacts, and approximately eighteen hours of videotape. I used selective sampling from the videotapes to present the evolving perspectives of the teachers and then I compressed the information into four case studies. Although excerpted from a limited set of data, the selected samples of critical conversations were considered typical of the four teachers. Therefore, one should use caution if generalizing the findings of this project to teacher discourse between secondary science teachers.

The sixth limitation of this project was that the materials, resources, and activities were specifically chosen to facilitate the discussion of Gr.4/5 school science language and
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concepts. Therefore, since this project was a narrowly focused exploratory investigation, limited by a small sample size, any generalization of the findings to other elementary teachers of the gifted, or to secondary teachers, should be approached with caution.

Definition of Terms

**Acceleration, Subject-based:**
Rapid movement through, and mastery of, the curriculum content of a single subject area at an earlier age than usually expected.

**Critical Conversations:**
Critical conversations are a sub-set of teacher discourse and are very different from either normal daily conversation or general procedural “teacher talk.” Critical conversations are oral discussions that are pre-meditated, focused on an authentic problem in practice, intentionally research-oriented, analytical and which occur within a context of social professional development over a limited period of time (Feldman, 1998, 1999).

**Curriculum Compacting:**
Curriculum compacting is a process that decreases the amount of time that the student spends within a grade level on the regular curriculum subjects. This encourages students to demonstrate what they already know about the subject content, to decrease the amount of time spent on studying previously-mastered material (Reis, Burns, & Renzulli, 1992).
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Curriculum Telescoping:
Curriculum telescoping decreases the amount of time that students spend on a subject domain by overlapping the required content, procedures and skills from adjacent grade levels. For example, a teacher can overlap the common elements from grades seven and eight science, instruct the students on the compressed content and assess the students accordingly.

Everyday Science Concepts:
Everyday science concepts are the culturally affected, socially experienced main ideas that a student has formed about scientific topics, phenomena, constructs and content domains as they are used or enacted within the world at large. Everyday science concepts rely on the personal sensations, observations, interpretations and manipulations common to the culture within a community.

Everyday Science Language:
Everyday science language is the culturally-expected social norm of language usage about scientific topics within the community served by a school. Everyday science language is the medium of communication which includes the words, terms, phrases, grammar, sentence structure and definitions related to science topics that are common to the community in which a school is physically situated.
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Gifted:
A complex of intelligence(s), aptitudes, talents, skills, expertise, motivation and creativity that characterize an individual with either the potential for, or the demonstration of, productive performance in content subjects, domains of knowledge or cultural disciplines (Feldhusen, 1992).

Reflective Practice:
Reflective practice is a process that can generate oral, written, pictorial and other constructs in a social context of professional teacher development which evolves over time. Reflective practice can result in subsequent changes in teacher beliefs, personal understandings and practices over time (Erickson & MacKinnon, 1991; Schon, 1983). In this study, reflective practice was a component of the workshops and the interviews.

School Science Concepts:
School science concepts are the domain-specific main ideas that are mandated in each Prescribed Learning Outcome (P.L.O.) within the K-7 Science curriculum.

School Science Language:
School science language is the expected form of language usage as specified in the K-7 Science IRP course of studies. School science language includes the words, terms, phrases, grammar, sentence structure and definitions common to the school community at large but not necessarily the cultural community in which a school is physically situated.
Introduction

Teacher development encompasses learning about the act of teaching as well as discovering how to best support student learning. There is a continuing need to carefully examine how teachers construct and apply their knowledge about teaching in order to formulate useful development programs. I envisioned this project as an exploratory program to investigate teachers' perceptions of the role of language in planning for science instruction. Effective teacher development programs should be based upon sound educational theories. This chapter presents the theories which engendered this project.

Situated Cognition

The theory of situated cognition implies that purposeful teaching and learning is directly connected to the context of the generating experience (Chaiklin & Lave, 1993; Duschl & Hamilton, 1992). This theory is relevant to my project because I attempted to create a supportive learning/teaching environment and to establish a “community of inquiry.” Specifically, I planned to organize a cooperative, reflective, practice-oriented group of teachers (a community of inquiry; Lieberman, 1988) consisting of the three participant teachers and myself.

A teaching/learning environment that encourages purposeful authentic activities
should provide many opportunities for physical, social, and language interactions between the participants (Chaiklin & Lave, 1993; Choi & Hannafin, 1995). In this project, planning for science instruction is the ordinary practice of the participants; therefore, it is an authentic educational activity. Such authentic activities support the transfer of knowledge and skills from familiar contexts to new applications in diverse contexts (McLellan, 1996). I encouraged the three teachers to modify and implement some of the activities from the workshops in their classrooms. After completion of the instructional sequence, I interviewed each teacher about the implementation.

Conceptual Classification System for this Project

Since concepts are structured mental representations of meaningful categories, people have created many different hierarchies and taxonomies of concepts (e.g., Chi, 1992; Keil, 1979, 1989). Although this project focuses on school science concepts, the diagram (Figure 2-1) is used to depict the possible interactions between everyday science concepts, school science concepts, and disciplinary science concepts.

School science concepts are taught in schools because they may not be learned without academic training. School science concepts may be intellectually opposed to everyday concepts because the school science concepts utilize a more systematic assessment of the available scientific data (Osborne & Freyberg, 1985). Disciplinary science concepts are the main categories of ideas that are generally used by scientists
within their own academic communities. The degree of interaction between the three types of science concepts depends upon the social, cultural, and technological experiences of the learner.

Figure 2-1 Conceptual Classification System
Chapter 2: Literature Review

Linguistic-conceptual Classification System for this Project

Vygotsky claims that everyday concepts are intrinsically related to everyday materials, language, and situations while scientific concepts (both school science and disciplinary concepts) are related to formal scientific instruction with selected science materials and vocabulary (Vygotsky, [1934] 1986). Similarly, Lemke claims that at least three distinct languages now exist in the domain of science: (1) everyday language, which is the language used within a community, (2) school scientific language, which is linked to the school curriculum, and (3) technical scientific language, which is regularly used only by technological experts (Lemke, 1990). Lemke's technical science language corresponds to my disciplinary science language. These views support the following representation (Figure 2–2), which depicts the possible interactions between the three different dialects of science language and the three different kinds of science concepts.

I have generalized that everyday science concepts are usually communicated through everyday science language, school science concepts are usually communicated through school science language, and disciplinary science concepts are usually communicated through disciplinary science language.
Students often use everyday science language to express their views about science topics. Teachers should be aware that students are using everyday science language, and that misunderstandings can arise due to the teacher's use of school science language. The use of a common language, school science language, can enhance the elicitation
of students' queries, hypotheses, predictions, and assumptions. However, the teacher needs to check that the students comprehend the scientific words that they are using rather than just parroting back memorized definitions (Lemke, 1990). The use of the correct scientific word or definition does not automatically prove mastery of a school science concept, but it does permit purposeful dialogue with the teacher and does support the ongoing process of conceptual development. Mastery of the appropriate science language is only the beginning of scientific understanding because the scientific words are a psychological tool for examining science concepts. Teachers should view the learning and teaching of science as a shared social process that may require the teacher to translate ideas back and forth between everyday language and school science language (Lemke, 1990).

In our North American culture, oral and written language are often considered to be the primary form of communication for science ideas, especially in the elementary grades. In comparison, non-linguistic forms of communication (e.g., graphic, pictorial, mathematical, and symbolic) are often considered to be secondary when making scientific explanations to children (Ogborn, Kress, Martins, & McGillicuddy, 1996). However, concrete materials and non-linguistic activities can support the development of contextual definitions and explanations for science concepts. Part of planning for science instruction is the consideration of alternative strategies for presenting school science vocabulary in stimulating, contextual, and meaningful ways.
These theories are relevant because the teachers were provided with "hands-on" activities to explore contextual definitions for school science concepts. A contextual definition places the defined term within a stated scenario that invites experimentation, observation, and hypothesizing. Contextual definitions are a powerful way to organize the meaning of a science word within a certain physical, social, and/or grammatical context (Bruning, Schraw, & Ronning, 1999). For this reason, contextual definitions may be more accessible, useful, and applicable for elementary students.

Teachers are a part of a community of people who use school science language to make sense of science topics and science phenomena in a particular way. When teachers encourage students to learn school science language, through instruction that provides opportunities for translation and bridging between everyday science concepts and school science concepts, then the students are invited to become a part of the school's scientific community.

Constructivism

Broadly conceived, constructivism is concerned with how the individual thinking processes of learners develop. There are several branches of constructivism including radical constructivism (von Glasersfeld, 1984) and social constructivism (Tobin, 1993). This project emerged from a personal perspective on teaching and learning science that is rooted in social constructivism. The term social constructivism expresses the view that
all cognitive frameworks result from the interaction of the social environment with the physiological processes of the human nervous system. Ideas are communicated between individuals to further the goals of the society. Thus, mental frameworks are individually constructed but are socially mediated (Tobin, 1993). My attitudes toward social constructivism affected the research process because a teacher’s views on the formation of scientific knowledge affects his/her science teaching practices (Fensham, Gunstone, & White, 1994).

Communication is essential for sharing and re-evaluating both individual and group knowledge. When people communicate their science ideas, the form of the communication is influenced by the situational context and may include language, symbols, pictures, artifacts, or actions. The theory of social constructivism values the role of language in the development of concepts. Ideas, and the language which is used to express those ideas, display an interactive evolution over time (Staver, 1998).
A constructivist perspective on learning impacts upon instructors' attitudes, beliefs, and strategies for teaching adults as well as children. When social constructivist attitudes are modelled in development programs, specific patterns of practice commonly emerge in relation to the role of the learner and the role of the instructor. For example, traditional teacher education programs, aligned with the transmission model of teaching, often instruct teachers to lecture about content and then to conduct formal written testing.

In comparison, in a constructivist program the teachers are encouraged to elicit the learners' prior knowledge, use various strategies to support student learning, and assist students to reorganize their own understandings of concepts (Novak, 1988). An important difference between the two models of teaching is the attitude toward the process of learning. The traditional programs entrench the idea that the instructor causes learning to occur, while the constructivist programs present the idea that the instructor is "responsible for sharing meanings with/between learners" (Novak, 1988, p. 311).

A social constructivist teacher development program should give teachers time to reflect upon their ideas, share their professional insights, elaborate upon the views of others, and consider alternative pedagogical perspectives and teaching strategies (Tobin, 1993). I structured the workshops to communicate science ideas according to my constructivist perspective on learning rather than according to a transmission model of instruction. In comparison to the transmission model, constructivist attitudes toward teaching can be typified as including more learner-centred, "hands-on" experiences, more
interpersonal dynamics (action and dialogue), and more inquiry into solving real-world problems (Richardson, 1997). Social constructivism is aligned with teaching techniques like anchored instruction, bridging, translation, scaffolding, and the use of contextual definitions. I tried to establish an environment of inquiry which included concrete manipulatives, practical relevant experiments, open-ended discussion questions, and a non-judgmental atmosphere of group investigation.

If knowledge about one's teaching practice is not merely a collection of facts but an evolving cognitive process, then the social construction of knowledge within a community of practice requires the cooperative, purposeful, reflective communication of ideas between the different inquirers. This type of communication is essential because the shared meanings of words and shared interpretations of ideas can lead to consensual understandings of perceived problems within practice (Brandes & Erickson, 1998; Grimmett & Erickson, 1988). The interactive social process of learning, for teachers as well as children, cannot be separated from the reciprocal actions and language of the learners.

It has been suggested that teacher development should value the opinions and views of practicing teachers, recognize that the communication of ideas occurs through many mediums, and that science teaching involves the orchestration of socially constructed knowledge (Bell & Gilbert, 1996). Within the field of research on professional development, practicing teachers are gaining credibility as researchers because practicing
teachers have authentic experience with specific learners within particular contexts, and they use critical inquiry to solve problems both during the act of teaching and after the act of teaching (Feldman, 1999; McLean, 1995). In this project I encouraged reflection and critical conversations about teaching experiences and organized each subsequent episode based upon feedback from the volunteers as well as from Heidi (my advisor) and Tammy.

Reflective Practice

In the context of this project the term “reflection” was purposefully used to designate a pre-meditated cognitive process of reconstructing practice in order to gain insight into the actions of teaching and personal assumptions about teaching (Grimmett & Erickson, 1988). The workshops were intentionally designed to stimulate teacher awareness of, active inquiry into, and “reflection” upon, the role of language in the planning of science instruction.

Each teacher transforms information in different ways and applies the resultant knowledge to his/her own practice. Some researchers have noticed that several common changes often occur in the expressed actions and words of science teachers both during and after their involvement in a “reflective” teacher development program (Erickson & MacKinnon, 1991; Grimmett & Erickson, 1988). One common change is called “reframing” because over time the teacher revisits, re-interprets, and re-evaluates a specific teaching event. Due to reflection, the teacher draws new inferences from the
remembered experience of a teaching/learning episode and then uses these new inferences to reassess and reframe his/her current teaching practices (Grimmett & Erickson, 1988; Schon, 1983). Reframing is relevant because both the workshops and the interviews in this project were scripted to encourage discussion of teaching experiences related to planning for the instruction of Gr. 4/5 school science language and concepts.

Reframing involves conceptual development within the science teacher and is manifested by changes in the teacher's pedagogical perspective on science teaching practices. A change in pedagogical perspective can affect many dimensions in the process of science teaching, including attitudes towards different methods of teaching science, the roles of the teacher and the students, and perceptions of how students learn (Erickson & MacKinnon, 1991). Reframing can occur within reflective teachers in any subject area, and has also been called a paradigm shift (Kuhn, 1962; Schon, 1991). An example of a paradigm shift would be a change from a transmission to a transaction position on educational practice in a field (Miller & Seller, 1990).

A second common change that often occurs in reflective science teachers is the search for, and accumulation of, "divergent or alternative teaching strategies." Experienced teachers want to learn about alternative techniques which could be applicable within their own practice. Whether or not a teacher experiences a paradigm shift, he/she is often motivated to investigate various new or revised instructional options. If the new teaching strategies are based upon unfamiliar theories, then the teachers are often stimulated to
examine the theoretical framework that supports the new practices (Grimmett & Erickson, 1988).

The quest for divergent teaching strategies demonstrates the teachers’ awareness that the design and implementation of science instruction can affect the students’ learning outcomes. This attitude shows that the teachers respect the individual intellectual abilities and learning styles of their students (Erickson & MacKinnon, 1991). In this project the teachers were invited to explore and discuss many alternative strategies for introducing, applying, and assessing school science language and concepts.

If a researcher actively collaborates with the other participants in an investigation, then his/her reflections are linked to the active role(s) that he/she assumes. In this project I performed three different but overlapping roles: (1) researcher/planner (phase one, May 2000 – Sept. 2000), (2) mentor/participant (phases two and three, Oct. 2000 – April 2001) and (3) researcher/interviewer (phase four, April 2001 – July 2001). A researcher may experience reframing and divergent teaching strategies while engaged in a reflective teacher development project. In addition, he/she may experience “design feedback” from the participating teachers which affects the evolving design of the research process. Such feedback alerts the researcher to deficits in the design of the study and may initiate alternate approaches to mentoring, integration of activities, or reassessment of the connections between the operant theories and teaching practices (McLellan, 1996).
Teacher discourse is a sub-set of reflective practice and includes oral, written, physical, and pictorial constructs used in social interactions between teachers within the context of professional teacher development over a limited period of time. In this project teacher discourse occurred within the framework of a series of activities, experiments, workshop discussions, and interviews over a period of eleven months. Oral language is often the primary route for teachers to communicate their pedagogical reflections to others. Oral discussions, narratives, and dialogue have been a historical data source for many types of quantitative and qualitative research, including those in the field of biography, ethnography, and case study (Creswell, 1998). A characteristic form of oral communication has emerged from the analysis of research on teacher discourse and is called “critical conversations” (conversations that demonstrate critical inquiry; Feldman, 1998, 1999).

Critical conversations arise from teacher dialogues and discussions that are pre-meditated, research-oriented, and which occur frequently over a limited period of time. The episodic oral inquiries shared by teachers, as described by Feldman (1998, 1999), are focused on an authentic problem within the context of their practice. In this project the participant teachers were encouraged to engage in critical conversations about the role of language in the planning of science instruction.
Chapter 2: Literature Review

Although research has shown that reflective practice can be a vital component in teacher development programs, the significance of critical conversations is still questionable. Are critical conversations a valuable derivative of teachers' reflective practice, and if so, why are these particular oral discussions considered to be so illuminating? One answer is that critical conversations occur between teachers within a community of practice and elicit consensus about possible solutions to a practical problem. Thus, critical conversations are grounded in the theory of social constructivism:

...knowledge is actively built up from within by individuals and by communities...language-based social interactions are central to the building of knowledge by individuals and communities...the purpose of cognition and language is to bring coherency to an individual’s world of experience and a community’s knowledge base, respectively. (Staver, 1998, p. 517)

The context of a professional development research project affects the emergence of critical conversations between the participants. If a research project is not based within the teachers' classrooms, then it is useful to simulate the context of the perceived problem within practice (Richardson, 1997). In this project the context of the problem was "planning for science instruction" (an authentic professional process), and the physical context included "hands-on" experiments, construction of artifacts, and concept-mapping (authentic activities).

Since critical conversations are co-produced within the context of an interactive investigation, they may help to unify public knowledge within a domain and reveal the
assumptions upon which past teaching practice was based (Feldman, 1998, 1999). The practical application of past understandings and the formulation of new understandings align with the view of reflective practice presented by Grimmett and Erickson (1988). Therefore, a research design which supports the emergence of critical conversations can encourage teachers to verbalize their prior understandings, to share their new perceptions, and to explain how these new perceptions have affected their practice.
Introduction

This chapter describes the procedures used in this project. A social constructivist approach to professional development led me to organize a series of workshops and interviews, assume the role of mentor, and encourage discussions about the role of language in planning for science instruction. I was committed to extensive time at the site, the documentation of detailed case studies, the task of data analysis and reduction, and the uncertainty of an emergent project. Multiple perspectives on the research problem were elicited, and the cumulative feedback from Susan, Amanda, Janet, Heidi, and Tammy was used to organize each subsequent episode. I speculated that the four cases might evaluate strategies for teaching school science language and concepts and might offer insights into the reconstruction of practice.

Chapter three is presented in three sections. The first section introduces the overall framework of the research sequence or what actions I had planned. The second section describes the data collection methods for the construction of cases or how I planned to acquire meaningful data. The third section discusses the data analysis or how I planned to interpret the emergent data within each case.
The Setting

The site is a small independent elementary school for the gifted that is located within twenty kilometres of a large urban centre. The school is situated in a rural area and has a large playing field and playground. The school has a staff of twelve teachers and an enrolment of one hundred students. There is a maximum of fifteen students per teacher. The students are drawn from many of the nearby suburbs.

The school is multi-denominational and supports multiculturalism, multilingualism, and the Theory of Multiple Intelligences. The school endorses a science program that includes curriculum compacting, curriculum telescoping, and subject-based acceleration. The school requires all potential students to be tested by an educational psychologist before applying for registration. All entrants accepted to the school have achieved at, or above, the 92 percentile on a standardized set of I.Q. and achievement tests that are age-normed.

The seven workshops, in phases two and three of this research project, took place in the science resource room which is a medium-sized room with a sink, tables, a refrigerator, student lockers, a chalkboard, and shelves of science equipment. The interviews in phase four took place in each teacher’s classroom after school.
This project interpreted the expressed perceptions of a group of teachers during the 2000 – 2001 school year. The participant teachers were recruited in the following way. During a presentation, I outlined the time commitment and the participatory requirements. Volunteers were elicited who matched the following requirements:

1. The volunteer is an elementary teacher at the site.
2. The volunteer is willing to participate in “hands-on” experiments and science activities during the series of workshops. The volunteer is willing to participate in a series of interviews in phase four of the research project. Each workshop and interview will be videotaped.
3. The volunteers will all instruct similar grade levels of science.
4. The volunteers are willing to implement modified versions of some of the methods for scientific vocabulary development that will be presented in the workshops.
5. The volunteer is willing to commit to approximately one to two hours per month, for a period of nine months, for the research project.
6. The volunteer is willing to engage in constructing various artifacts. For example, one of the artifacts of the research will be the individual teacher’s logbook of comments.

The volunteers were all experienced generalists who taught all of the subjects in the elementary curriculum except for French, Physical Education, and Music. While recruiting, the only inducement was the offer of an opportunity to be involved in “hands-
Chapter 3: Methodology

on” science activities and research-focused discussions during the inquiry. The
volunteers were willing to be exposed to teaching strategies that were drawn from recent
educational research in science instruction. They viewed this project as an opportunity to
improve, enrich, and/or extend their practice. More detailed information about each
volunteer is included in the introduction to each case in chapter four.

Prior to this research project, I was professionally acquainted with the school’s
Director, the Principal, and two of the volunteer teachers. I had taught Grade 4 – 10
Science to gifted students at the school. Neither Tammy nor I was an employee of the
school at the time that the research was carried out. Tammy had completed a Masters
degree in English Education in the U.B.C. Department of Language Education and during
this project was enrolled in a Ph.D. program in the U.B.C. Department of Language and
Literacy Education.

The Construction of Cases

I consider a case study to be a pre-meditated, richly described, fully-documented
report of a particular event that is theoretically perceived, assessed, and interpreted
(Shulman, 1986; Yin, 1989). In this project, each case is a bounded system which
contains multiple sources of detailed data. I made judgements in my selection of the
research site, the requirements of the participants, the research problem, and the research
methodology. These judgements determined the borders of the bounded system.
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Section One: Framework of the Research Sequence

The sequence for this project included four phases of inquiry: (1) organizational procedures, (2) establishing a community of inquiry, (3) planning for science instruction, and (4) reconstruction of practice.

Phase One

In phase one, I planned and carried out the organizational procedures shown in Table 3-1. I met with the school's administrators twice, the first time to present the initial contact letter and the second time to present the agency consent form. On August 29, 2000, I made my first resource visit. I briefly visited each staff member to ascertain which science topics he/she was planning to instruct. I sorted through materials in both the teachers' resource room and the school's library for appropriate resources. On August 31, 2000, I made a presentation to all of the staff about the purpose of this project. I discussed the time commitment and requested volunteers.

In September 2000, I made a second resource visit to the school and met with those teachers who had expressed interest in this project. The three volunteers signed their consent forms and determined which grade level of science and which topics would be investigated in workshop #1. The principal also signed a consent form and agreed to be interviewed twice during the school year. Heidi, my advisor, reviewed each document before it was used. Tammy offered to observe the workshops, view the videotapes of the interviews in phase four, and engage me in videotaped consultations after each episode.
## Table 3–1 Research Sequence in Phase One: Organizational Procedures

<table>
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<th>description</th>
<th>documentation</th>
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<td></td>
<td></td>
<td></td>
<td>2. initial contact letter</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3. research journal</td>
</tr>
<tr>
<td>June 23, 2000</td>
<td>meeting</td>
<td>meet with Director and Principal</td>
<td>1. document file</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. agency consent form</td>
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<td></td>
<td></td>
<td></td>
<td>3. research journal</td>
</tr>
<tr>
<td>June 27, 2000</td>
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<td>request for ethical review</td>
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<td></td>
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<td></td>
<td>3. research journal</td>
</tr>
<tr>
<td>Aug. 1, 2000</td>
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<td>ethical review approved</td>
<td>1. research journal</td>
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<td>science resources for all teachers</td>
<td>1. research journal</td>
</tr>
<tr>
<td>Aug. 31, 2000</td>
<td>presentation to all staff teachers</td>
<td>purpose of project &amp; request volunteers</td>
<td>1. document file</td>
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<tr>
<td></td>
<td></td>
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<td>2. initial contact letter</td>
</tr>
<tr>
<td></td>
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<td>3. consent form</td>
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<td></td>
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<td>4. research journal</td>
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<td></td>
<td></td>
<td>5. logbook portfolio</td>
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<td>1. research journal</td>
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<td>Sept. 14, 2000</td>
<td>meeting with interested teachers</td>
<td>discuss project &amp; request volunteers</td>
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<td>2. consent form</td>
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<td></td>
<td></td>
<td></td>
<td>3. research journal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. logbook portfolio</td>
</tr>
</tbody>
</table>
Phase Two

In phase two, I planned and carried out the organizational procedures shown in Table 3-2. Although I had the research question in mind, I had no set script for each workshop in phases two and three. Rather, the science topics were chosen by the three participant teachers. Since all of the volunteers were instructing Gr. 4/5 students, they chose topics from the Gr. 4/5 Science curriculum. I negotiated the content of each successive workshop with the volunteers. I selected Gr. 4/5 experiments, models, visual resources, and various “hands-on” activities in response to their requests and interests.

In phase two, there were three workshops and one resource visit. Each workshop encouraged the teachers to use concrete materials, discuss teaching strategies, consider open-ended questions, and reflect about teaching practice. At the end of each workshop the participants gave me feedback on that particular workshop and made suggestions for the next workshop. At the end of workshop #3, the volunteers selected different topics in human biology that they wanted to investigate in phase three. Heidi reviewed my outline for each workshop before I presented it. She viewed each videotaped episode and made suggestions for improving the next episode. Tammy only attended the first four workshops. She viewed the videotapes of the subsequent workshops and interviews. My videotaped debriefing consultations with Tammy for these latter sessions occurred at a later time. Each consultation was approximately thirty minutes long.
### Table 3–2 Research Sequence in Phase Two: Establishing a Community of Inquiry

<table>
<thead>
<tr>
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<th>Type of Action</th>
<th>Description</th>
<th>Documentation</th>
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<td>workshop #1 concepts in Gr. 4/5 Earth/Space Sciences</td>
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<td>2. logbook</td>
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<td></td>
<td></td>
<td></td>
<td>3. portfolio</td>
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<td></td>
<td></td>
<td></td>
<td>4. research journal</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>5. videotape of episode</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7. videotape of consultation</td>
</tr>
<tr>
<td>Oct. 23, 2000</td>
<td>episode two</td>
<td>workshop #2 concepts &amp; language for topic of atmosphere</td>
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<td></td>
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<td>2. logbook</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3. portfolio</td>
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<td>4. research journal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. videotape of episode</td>
</tr>
<tr>
<td></td>
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<td>6. artifacts</td>
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<td></td>
<td></td>
<td>7. videotape of consultation</td>
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<td>Nov. 20, 2000</td>
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<td>workshop #3 concepts &amp; language for topic of water</td>
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<td>4. research journal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. videotape of episode</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>7. videotape of consultation</td>
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<tr>
<td>Dec. 12, 2000</td>
<td>resource visit</td>
<td>science resources for all teachers</td>
<td>1. research journal</td>
</tr>
</tbody>
</table>
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Phase Three

In phase three (Table 3–3) there were four workshops and two resource visits. Each volunteer investigated strategies for introducing, reinforcing, and assessing relevant school science language and concepts. Susan examined human senses, Amanda investigated bones and muscles, and Janet focused on the circulatory and respiratory systems.

In order to stimulate discussion about school science language and concepts, I presented activities which focused on language communication. For example, in workshop #5, I engaged the teachers in a debate about alternative strategies for teaching school science vocabulary. Feedback from that debate resulted in the survey of strategies for teaching Gr. 4/5 Science terms that is shown in Table 3–4. Since planning for instruction includes consideration of assessment methods, I invited the volunteers to discuss various types of assessment procedures. Feedback from the teachers resulted in the assessment survey sheet that is shown in Table 3–5. To encourage preliminary oral appraisal of the research problem, I edited interesting video segments from the first six workshops and presented them in workshop #7.

Heidi reviewed my outline for each workshop before I presented it. She viewed each videotaped episode and made suggestions for the next episode. Tammy viewed the videotapes of the workshops and then engaged in videotaped debriefing consultations with me.
### Table 3-3 Research Sequence in Phase Three: Planning for Science Instruction

<table>
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<tr>
<th>date</th>
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<td>episode four</td>
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<td>Apr. 3, 2001</td>
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<td>April 10, 2001</td>
<td>episode seven</td>
<td>reflections on video segments &amp; preliminary findings</td>
<td>1. document file 2. logbook portfolio 3. research journal 4. episode video 5. artifacts 6. consultation</td>
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</table>
Table 3-4 Strategies for Teaching Gr. 4/5 Science Terms

<table>
<thead>
<tr>
<th>Indicate the strategies that you use:</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ongoing science vocab list posted in the room</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. Students write down science terms &amp; definitions in notebook</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. Science terms are introduced orally during brain-storming</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. Students complete fill-in-the-blank worksheets on definitions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. Students read aloud from a reference. New words are read aloud in context.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. Students match terms to a list of definitions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. Students use science terms to label diagrams</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. Terms are emphasized orally during a related experiment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. Terms are discussed after doing a related experiment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. Students use terms to label a poster or mural</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. Terms are orally reviewed after a video</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. Terms are reviewed through singing or poetry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. Terms are reviewed through dramatic actions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
### Table 3-5 Assessment of the Understanding of Gr. 4/5 Science Terms

<table>
<thead>
<tr>
<th>Indicate the strategies that you use:</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students orally define words correctly. Teacher keeps records</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. Students write down definitions correctly from memory</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. Students make a concept map to explain a word correctly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. Students complete fill-in-the-blank worksheets on definitions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. Students write a research report &amp; use words in context correctly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. Students match terms to a list of definitions correctly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. Students use science terms to label diagrams correctly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. Terms are used to correctly complete a crossword puzzle</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. Terms are used correctly to write up a related experiment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. Students use terms to label a poster or mural correctly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. Students use terms correctly to compose questions/answers after viewing a video</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. Students use words correctly during an oral presentation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. Students use terms correctly during an oral debate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Phase Four

In phase four (Table 3–6) there were eleven interviews and one resource visit. There was a series of progressive individual interviews with each of the three volunteers and two interviews with the principal. In the individual interviews in episodes eight and nine, I tailored my questions for each participant teacher according to their prior queries and feedback. In episode ten, I asked each teacher the same questions about the impact of the workshops. Each interview was approximately twenty minutes long.

After the completion of all of the interviews, I composed a synopsis of the preliminary research findings and gave a copy to each volunteer. They were asked to respond by returning their copies of the synopsis to me, along with their written comments. In this way the volunteers provided professional feedback on my interpretation of the research data. To view each copy of the research synopsis, with the teachers’ written comments, refer to the appendix.

Heidi reviewed my questions for each interview before I engaged in it. She viewed each videotaped episode and made suggestions for the next set of interviews. She also provided feedback on the research synopsis before it was distributed. Tammy viewed the videotapes of the interviews and engaged in videotaped debriefing consultations with me.
### Table 3-6 Research Sequence in Phase Four: Reconstruction of Practice

<table>
<thead>
<tr>
<th>Date</th>
<th>Type of Action</th>
<th>Description</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb. 26, 2001</td>
<td>interview</td>
<td>Principal</td>
<td>1. research journal 2. videotape</td>
</tr>
<tr>
<td>May 8, 2001</td>
<td>episode eight</td>
<td>interview three teachers individually</td>
<td>1. document file 2. logbook portfolio 3. research journal 4. videotape of episode 5. artifacts 6. videotape of consultation</td>
</tr>
<tr>
<td>May 22, 2001</td>
<td>episode nine</td>
<td>interview three teachers individually</td>
<td>1. document file 2. logbook portfolio 3. research journal 4. videotape of episode 5. artifacts 6. videotape of consultation</td>
</tr>
<tr>
<td>June 21, 2001</td>
<td>episode ten</td>
<td>interview three teachers individually</td>
<td>1. document file 2. logbook portfolio 3. research journal 4. videotape of episode 5. artifacts 6. videotape of consultation</td>
</tr>
<tr>
<td>June 22, 2001</td>
<td>resource visit</td>
<td>collect resources</td>
<td>1. research journal</td>
</tr>
<tr>
<td>June 22, 2001</td>
<td>interview</td>
<td>Principal</td>
<td>1. research journal 2. videotape</td>
</tr>
<tr>
<td>July 31, 2001</td>
<td>research synopsis feedback</td>
<td>three individual teachers</td>
<td>1. document file 2. research synopsis</td>
</tr>
</tbody>
</table>
Section Two: Data Generation and Collection for the Cases

In all four phases of this project there were six sources of information: Susan, Amanda, Janet, Heidi, Tammy, and myself. The principal was also a data source in phase four. A summary of the sources of data is shown in Table 3-7.

Table 3-7 Data Generation From Each Source During This Project

<table>
<thead>
<tr>
<th>Source(s)</th>
<th>Workshops or Interviews</th>
<th>Resource Visits</th>
</tr>
</thead>
</table>
| Susan, Amanda & Janet| 1. demographic sheet  
2. teacher requests  
3. individual logbooks  
4. videotapes of episodes  
5. artifacts  
6. research synopsis | 1. teacher requests |
| Val                  | 1. documents  
2. research journal entries  
3. videotaped episodes  
4. videotape of the consultations  
5. artifacts | 1. research journal entries |
| Principal            | 1. videotaped interviews | N/A                     |
| Tammy                | 1. consultant’s logbook  
2. videotape of the consultations | N/A                     |
| Heidi                | 1. written comments on documents  
2. oral comments transferred to Val’s research journal | N/A                     |
Chapter 3: Methodology

Susan, Amanda, and Janet

Each teacher generated six types of data: (1) a demographic information sheet, (2) teacher requests, (3) individual logbooks, (4) videotaped participation in each workshop and interview, (5) artifacts, and (6) their written responses to the research synopsis. Each episode was stored on a separate videotape and each tape was labelled by episode. Each episode produced approximately one hour of videotape. The demographic information, teacher requests, photocopies of the logbook contents, artifacts and copies of the synopsis from each teacher were collected, sorted and placed in individual logbook portfolios in chronological order. The original logbooks were returned to the volunteers. Each volunteer’s responses to the research synopsis are presented in the appendix.

Val

I generated five types of data: (1) my document file, (2) my research journal, (3) my participation in each videotaped episode, (4) my participation in each videotaped consultation, and (5) artifacts. Each type of data contained different information. For example, my document file included the presentation outline and activity sheets for each workshop. My research journal included personal comments and reflections about each workshop, interview and consultation. The videotaped episodes included my critical conversations with the volunteers. The videotaped consultations included my discussions with Tammy about the volunteers’ use of school science language. The artifacts included selected overheads, photocopies of anatomical diagrams, and hand-made models.
Chapter 3: Methodology

All of my documents were collected and filed in chronological order in the document file. Some examples of the workshop activities are presented in the appendix. My artifacts and my reflections on each workshop, interview, and consultation were stored or recorded chronologically in my research journal. Each episode and consultation were stored on a separate videotape and they were labelled chronologically.

The Principal

The Principal generated data in two videotaped interviews. Each interview was approximately twenty minutes long and occurred in the principal's office. I viewed the videotape of each interview and recorded the pertinent information in my research journal.

Tammy

Tammy generated two types of data, the consultant's logbook and her videotaped consultations with me. The consultations occurred after each episode and were approximately one-half hour in duration. Tammy observed the first four workshops but she did not participate in the activities. Subsequently, she viewed videotapes of the later workshops and interviews and then engaged in a videotaped consultation with me. I collected and reviewed the contents of her logbook at the end of phases two, three, and four. I recorded each consultation on a videotape and labelled them chronologically. I viewed the videotape of each consultation and recorded Tammy's feedback in my research journal.
Heidi

Heidi influenced the content and the evolving design of this project in many ways. She reviewed each original document that I composed, for example, the initial contact letter. She wrote comments on each document and I made modifications before each item was presented to the participants. All of the original materials, and the modified drafts, were placed in my document file. We met regularly and discussed both the content and the format for each episode before it was presented. For example, she engaged me in discussions about the differences between everyday language and school science language. Heidi’s oral suggestions were summarized and chronologically recorded in my research journal.

Section Three: The Cycle of Data Analysis for Each Case

My method of data analysis arose from my interpretation of three major theories: social constructivism, reflective practice, and linguistic-conceptual development. I planned to systematically examine examples of “important events” through a cycle of data analysis in order to develop the case studies. The five steps in the cycle were:

1. identify important events in the data,
2. categorize the important events according to the categories of interest,
3. sort the categorized data into each teacher’s case,
4. compress the categorized data within each teacher’s case, and
5. interpret any patterns to guide the ongoing research.
Chapter 3: Methodology

Phase One

I defined "important events" to include several categories of interest. The four categories used in phase two are listed below:

1. critical conversations about selecting and defining school science language and concepts,
2. critical conversations about translating between everyday science language and concepts and school science language and concepts,
3. critical conversations about alternative teaching and/or assessment strategies for school science language and concepts, and
4. critical conversations about changes in teaching practice.

Phases Two, Three and Four

After each episode I applied the five steps in the analytical cycle to the generated data. I looked for evidence related to the four categories of critical conversations in the individual teacher's logbooks, the videotaped episodes, my research journal, Tammy's logbook, and the videotaped consultations. Feedback from the volunteers, Heidi, and Tammy impacted upon my interpretation of the data. After episode three, I re-evaluated the four categories and decided to continue to use them in phases three and four.

I noticed that critical conversations were emerging in the videotaped workshops and consultations. Although I continued to collect many types of data from each person, the
case studies were constructed from only the following resources: (1) the volunteer’s demographic sheets, (2) my research journal, (3) the transcriptions from the videotaped workshops and interviews, (4) the transcriptions from the videotaped consultations, and (5) the volunteer’s written responses to the research synopsis.

Identifying Critical Conversations

I recognize that the identification, categorization, sorting, compression, and interpretation of critical conversations within the data requires some conjecture and judgment on my part. I used the following four steps to identify critical conversations:

1. I listened carefully to the teacher discourse while immersed in the activities and made a mental note of possible critical conversations. Either immediately or later the same day, I recorded indications of possible critical conversations from each episode in my research journal.

2. I watched the videotape of each episode and noted any critical conversations in my research journal.

3. I watched the videotape of each consultation and noted any critical conversations in my research journal.

4. After the preliminary identification of the critical conversations in each workshop and interview, I showed each videotaped episode to Heidi and Tammy. Their oral feedback assisted me to finalize my selection of the critical conversations and I transcribed them from each videotape for further analysis. The transcriptions were placed in my research journal.
Chapter 3: Methodology

The identification of critical conversations is summarized in Table 3-8 below.

**Table 3-8** Identifying Critical Conversations

<table>
<thead>
<tr>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Listen for critical conversations while engaged in the episodes</td>
</tr>
<tr>
<td>2. Listen for critical conversations in the videotape of each episode</td>
</tr>
<tr>
<td>3. Listen for critical conversations in the videotape of each consultation</td>
</tr>
<tr>
<td>4. Select and transcribe the identified critical conversations</td>
</tr>
</tbody>
</table>

The critical conversations were categorized into the four specified categories. They were categorized and sorted at the same time that they were identified. The critical conversations were sorted based upon the dominant speaker in the discussion. The sorting was reviewed at the end of each phase.

**Compression of Critical Conversations**

I used the transcripts of the critical conversations to reveal each teacher’s own interpretations of the research problem. Each case also contained other relevant data that was collected to support the critical conversations and to place them within the context of this project. I selected the supporting information from each teacher’s individual logbook portfolio.
Chapter 3: Methodology

The critical conversations in the four case studies were transcribed from the videotapes of the ten episodes, the two interviews with the principal and the ten consultations. When a lengthy, or recurrent, critical conversation occurred I extracted the main argument and placed it in the appropriate case. My self-study followed the same process; however, more written documentation was used to support the transcripts of the critical conversations.

Criteria of Soundness

The criteria of soundness demonstrate what standards of quality and verification I used in the construction of the cases. The criteria of soundness should demonstrate why the collected cases can be presented as being current, accurate, believable, and well-documented. I used three criteria of soundness for this project: (1) prolonged systematic engagement with and persistent observation of the participants, (2) detailed descriptions, and (3) triangulation (Creswell, 1998). All three criteria must be demonstrated in order for the cases to be considered to be sound.

Prolonged Engagement and Persistent Observation

I was able to observe and interact with the participants over an entire school year. I was persistent and attended to the pertinent details of each workshop, interview, meeting, or consultation. I collected a wide variety of data from the volunteers including their individual logbooks, videotaped records of the workshops and interviews, and artifacts.
Chapter 3: Methodology

To document my self-study, I maintained a document file, my research journal, the videotaped records of my interactions with the teachers and with Tammy, as well as artifacts. I collected feedback from the teachers, Heidi, and Tammy to help me describe the changes in the evolving design of this project.

Detailed Descriptions

Since I had previous experience in planning science instruction for gifted students, I was able to notice, record, assess, and interpret the words and actions of the volunteers. Due to my knowledge of science resources and the elementary science curriculum, I was able to encourage focused discussions of school science concepts and language. The use of multiple types of detailed information facilitated the construction of the cases.

Triangulation

Viewing a research issue from several different perspectives, or triangulation, can provide corroborating information to elucidate a perceived theme in the data (Creswell, 1998). I gave oral feedback to, and received written and oral feedback from, the volunteers at the end of each episode. I discussed the evolving project with Heidi and Tammy on a regular basis. I provided additional feedback to the volunteers through a discussion of the preliminary findings at the end of phase three and through the research synopsis at the end of phase four. Each volunteer wrote comments on her copy of the synopsis and returned it to me. Susan, Amanda, and Janet accepted and supported the findings reported in the research synopsis.
Chapter 4: Four Case Studies

Introduction

This chapter presents four case studies, each of which contains a series of critical conversations and other relevant data. The selected conversations are representative of the teachers' expressed views on the role of language in the planning of science instruction. This chapter is organized into four cases so that the reader may appreciate the development of each teacher's perceptions. Each case study contains transcripts of critical conversations which are relevant to the four categories of interest:

1. judgements about selecting and defining school science language and concepts when planning for instruction,
2. translating between everyday science language and concepts and school science language and concepts,
3. the consideration of alternative teaching and/or assessment strategies for school science language and concepts, and
4. the perception of changes in teaching practice.

Some of the critical conversations are related to more than one category.

Each case begins with a short biography of the teacher. The names of the volunteers were replaced with pseudonyms. Each teacher's critical conversations are organized chronologically within the four categories and each conversation is introduced with a brief contextual summary. The conversations were transcribed in each teacher's own
Chapter 4. Four Case Studies

words. In the case of ambiguous statements I inserted more contextual information within brackets. I wrote brief comments after each excerpted conversation.

I used **bold** lettering to denote a speaker's **oral emphasis** of a word or phrase and *italic* lettering to denote *school science words* within the discussions. Long, divergent conversations were condensed into a logical sequence of ideas. When there were several speakers involved, the conversation was assigned to the major speaker. When a conversation was important to the development of different cases then it appeared in more than one case. My interpretation of the findings from the cases is presented in chapter five.
Chapter 4: Four Case Studies

Susan’s Case Study

Susan has a B.F.A., a B.Ed., and a diploma in Early Childhood Education. She has been an elementary teacher for sixteen years at various schools. She recalls taking only one academic science course at university, a geography course. During the timeframe of this project she was concurrently taking a university course on educational psychology for the teachers of the gifted. This was her first year of employment at the research site.

Selecting and Defining School Science Language and Concepts

Excerpt #1

The following conversation occurred during episode #1. Susan was concurrently teaching the topic of “Water” and shared an anecdote about an event in her class.

SUSAN: I want to teach scientific inquiry... We did one (experiment) on capillary action in celery... they could predict, but what was the conclusion?... what I was trying to get them to realize was that it was an example of capillary action and that the water molecules were moving up the veins... they just said, “It’s capillary action.” (introspectively) Yes, but why? Do you know why it is happening?

VAL: Did you talk about that?

SUSAN: No... they just felt like they did it and so lets move on.

VAL: So, they gave you the scientific word? Did they give you any definition or description of what it is?

SUSAN: No. But, they (apparently) knew what it was. But, I didn’t ask them. I didn’t ask them, “Well now, how does capillary action actually work?” Because that is really difficult to find... I had to do a lot of looking before I could even get some background knowledge for myself that was simple enough, because the books just identify it and they don’t say how it works.
Chapter 4: Four Case Studies

Susan said that she wanted to teach scientific inquiry, which is a complex process. The conversation showed that she was concerned about the communication, investigation, and application of specific science concepts. She appeared to be uncertain how to elicit the students’ prior knowledge. The conversation also indicated that she had difficulty finding suitable teaching resources and appropriate definitions for some school science concepts.

Excerpt #2

The following conversation occurred in episode #8 during an individual interview.

My questions addressed issues that Susan had previously mentioned to me.

VAL: You mentioned in your logbook that when you are using references and teacher resources for planning instruction that you “found that the wording in texts and experiments to be problematic at times.” Maybe we could start there?

SUSAN: A lot of the references...they can’t agree on the terminology...We ran into that today, we’re doing the sense of smell. One book talked about the receptor nerve, one mentioned the sensory nerve and the other (third reference book) had the olfactory nerve... and they were all the same picture. (She sighs) So the kids got confused...even if it is (an overlapping description of) the same thing...So, if you are giving them worksheets, you all have to use the same terms...because when it comes time to test them, they don’t know what to call it.

VAL: Is there only one answer?

SUSAN: No, I accept different answers...but it is so confusing for the kids.

VAL: In your logbook, you asked about the complexity of a definition?

SUSAN: It (the definition’s complexity) is based on the student...so I struggle with that, because if it (the definition) is too complex then they don’t get it (don’t find the definition meaningful). So I look for the simplest book to explain something...then I go to a harder book that talks more complicated...
more difficult science words). They have a hard time equating it, even if the books are explaining the same thing. I'd like...if there were almost standards. Like these are the words and this is how we are going to use them. This is what they need to know (the concepts) and these are the words that we are using. Let's agree on these words, these standards...because it is too confusing for the kids.

Susan indicated that there can be similar school science words which have overlapping meanings. Also, she would prefer that a standardized science vocabulary list accompany the curriculum guide. She noticed that the higher grade level science reference books used more sophisticated science language and that it was difficult to translate the terminology between various resources.

Excerpt #3

The following information is from Susan’s copy of the research synopsis which she completed after the end of term three. The replies are her written comments.

SYNOPSIS: School science language is the expected form of language usage for science content areas as specified in the K-7 Science IRP. (Val’s definition).

SUSAN: I’d like to see a list of “terms” to be studied, be included in the P.L.O.’s. For example: The Gr. 5 P.L.O. states that the students should be able to “describe basic units of matter.” I’m not sure if I interpret the term “basic units” in the same way that the Ministry does.

SYNOPSIS: The teachers recognized the multiple and powerful role of language in that their own awareness of school science language affected their...lesson planning...and the strategies chosen to assess the students’ understanding of terms and concepts.

SUSAN: I also recognized the importance of using very specific wording when writing up (composing) tests. Sometimes children would get confused because we use multiple labels to identify the same thing. For example, the parts of the ear have different labels for the same parts.
Chapter 4: Four Case Studies

Again Susan suggested that a standard list of school science words and definitions be included with each concept in the curriculum's P.L.O.s. She noticed that ambiguous or multiple terms were confusing and has apparently standardized her own vocabulary.

Translating

Excerpt #4

The following conversation occurred during episode #6. Each teacher was given two different overheads of anatomical diagrams for labelling. One of Susan's overheads showed a diagram of the human ear and the other showed a diagram of the human eye. A word list appeared at the bottom of each diagram. Each teacher was asked to select some words that the students might need to be taught.

SUSAN: (referring to the overhead of the human ear) They will know hammer but not in this context.
VAL: There is a point.
SUSAN: They would know what a nerve was but I'm not sure about anvil.
AMANDA: (indicating Susan's overheads) These terms are harder. They (the students) probably have not been exposed to (the parts of) the eye and ear so much.
JANET: I just taught this...about a week ago. They didn't know cornea, lens or iris.
SUSAN: (replying to Janet) I would have thought that they would know lens.
VAL: (to Susan) Do you think that the sheet is appropriate to use?
SUSAN: I think that, the kids that I have, that they would find some of these words too hard...but they could do it...What I found worked (for other topics)...I'd make them use research books (library references) to find out the answers to this. It gave them research skills.

Susan understood that the students might be confused about the meanings of words like
**hammer** and **anvil** when they were used in an anatomical context. She was aware that it might be necessary to translate back and forth between everyday and school science language. She encouraged the students to seek out definitions for words in reference books.

**Alternative Strategies**

Excerpt #5

The following conversation occurred in episode #1. I had asked for feedback on the astronomy experiments that had been presented.

SUSAN: What I got from today...the whole idea of written output...that that is my own expectation. Perhaps I have to justify what I am doing with the children by saying that they have to have something that they write because that is going to make them more directed in what they are doing...Maybe, if they don't write anything down I can do five different experiments rather than just doing one...I could still discuss all of those experiments and we could have a discussion and an analysis, but things would go much faster if they don't have to write everything.

AMANDA: You could write it (the main ideas) out and put it up. You could put it on a chart or an overhead.

SUSAN: What I would do is that I would write it all on the board for them, but I would say...that it was cheating because I was writing it all out for them. But I see that it is a way to pull it all together for them at the end...They copied it down.

VAL: But modelling is a totally acceptable method of teaching.

AMANDA: Maybe you have to decide what is really important. Is it the actual writing it down...or is it the actual process of doing the experiment and discussing? What is the priority of the lesson? For me it is not trying to get everything written down (by the students).

When Susan did demonstrations and experiments she expected the students to
complete a written answer sheet for each activity. She seemed to feel that she did not cover the content fast enough or discuss concepts in much depth. She appeared to be searching for alternative teaching strategies and Amanda suggested some.

Excerpt #6

The following conversation occurred at the end of episode #3. I had presented four different experiments involving either the physical properties of water or water pollution. The teachers had performed some activities within each experiment.

VAL: Other feedback from today?
SUSAN: If you were going to do these (the four experiments) with students, what kind of (a) write-up would you have? Would you do that all orally?...My students are young (accelerated).
VAL: I would have a variety between lessons...and during the year a progression from more oral work to...where by the end of the year they should be doing more writing.
SUSAN: So, like what you did today, the oral discussions with us about them (each experiment)...you could do a similar format with the children?
VAL: Yes, or you could do it on an overhead...put ideas on the blackboard, or do a big (chart) sheet of paper...They don't necessarily have to do a fill-in-the-blank answer sheet.
SUSAN: What I have been doing...I prepare a sheet for them (for each student to fill in) and it is too dry.
AMANDA: Yeah, it almost takes away from doing the science. You are trying to promote a positive attitude toward it...you want to keep that enthusiasm and participation going. You can do the whole period on experiments and discuss it at the end (of the period) or in next class.

Susan continued to search for alternative ways to cover the science content which did not consistently demand substantial written output from each student. She had received
suggestions from her colleagues but she specifically asked me for advice. Apparently, she relied on individual written work from each student rather than on oral discussions or cooperative group products for informal assessment. Although she had been told about other teaching strategies she appeared to have difficulty implementing new techniques.

Changes in Teaching Practice

Excerpt #7

The following conversation occurred in an individual interview in episode #8.

VAL: So when you are planning, how do you choose the words (that) you are going to teach?

SUSAN: Well, the words are probably the least important thing... the words are just labels that are convenient... but are needed as a reference point. I think that we need to teach what it (the sensory nerve) is, what its purpose is, what it does and then put the label on it. If they get the label first, then they think that they know all about it (because they have the word) but they have no idea how it (the sensory nerve) actually works.

VAL: When there are alternative definitions or alternative ways to apply a concept... what decisions do you make when you are planning?

SUSAN: For example, when I went over their tests on the sense of smell... I realized that they don’t have a good grasp of what happens when you smell (something)... I had used reference books, visuals and diagrams... but not much discussion, and I realized that I needed to teach in a different way.

VAL: Yes, go on.

SUSAN: Now, when I am planning something, I think “What other way can I teach it?” Now I am planning to do a dramatization of the ear (the function of the auditory nerve). I will script it out, someone will be the nerve impulse and (he/she) will have to run to the brain with the information. I’ve found that words on a piece of paper don’t really mean anything to them.
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Susan had decided to make changes in her teaching practice and she was willing to implement alternative teaching strategies. She had recognized that student-focused discussions were important for teaching science concepts. She had also noticed that the printed word alone could be meaningless to some students.

Excerpt #8

The following conversation occurred in an individual interview in episode #10.

VAL: In what ways have the science workshops affected your ideas about Gr. 4/5 science language?
SUSAN: I found from the workshops... well not to presume that just because they (the students) use the terminology... that does not mean that they understand the concept. I had to look at how I use terminology. It made me think, "How can I test, in more than one way, that they are applying that concept (correctly)?"

VAL: Can you give me an example?

SUSAN: It takes more questioning. I want to know they are using it (the science word) in a particular context. You have to talk with them.

VAL: In what ways have the science workshops affected your ideas about Gr. 4/5 "hands-on" science?

SUSAN: I had them doing (in term one) a written lab sheet for every experiment... but like Amanda suggested in the workshops, maybe it is better to do more discussion, or do the lab write-up the following day or do the write-up as a group activity. I tried some of those things.

VAL: How did that work for you?

SUSAN: Good. I started to do more "hands-on" for them... learning centres with a procedure card with very simple instructions. They like that a lot... It made me realize, like we (teachers can) get this whole idea in our heads that a science product has to be on a piece of paper. Just talking to Amanda and Janet, getting their advice and encouragement. And more dialogue went on during the week (daily collegiality) and those dialogues might not have happened without the workshops.
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Susan reiterated that she found oral discussions with the students to be important for the communication of science ideas. She appeared to be more comfortable with flexible group activities like learning centres. She implied that the implementation of alternative teaching strategies benefited her students. Also, Susan seemed to be more confident about using alternative forms of assessment in addition to written tests.

Excerpt #9

The following conversation occurred in a private interview with the principal of the school at the end of the school year.

VAL: Have these three teachers become a resource for the other teachers?
PRINCIPAL: I notice that Susan has become a mentor to the two Gr. 1-2 primary teachers for science.
VAL: That’s interesting.
PRINCIPAL: Yes, the other teachers seek them (the three volunteers) out for their science ideas, their creativity and for their science resources...Susan especially for her art ideas...Did you see her three dimensional skin models?

The principal had noticed that Susan was using alternative teaching strategies, especially various “hands-on” items like student-built models. Susan appeared to have increased confidence in her science teaching skills because she became a mentor to the two primary teachers. Susan did not tell me that she had become a mentor.
Amanda’s Case Study

Amanda has a B.Ed. and has been an elementary teacher for four years. She reports that she took first year university courses in biology, geography, and computer sciences. She had previously been employed for ten years as a medical lab technician at different hospitals. She had already completed one special education course on gifted children, and during the timeframe of the project she was completing a second relevant university course. She had worked as a teaching assistant at the research site for one year and as a teacher for four years.

Selecting and Defining School Science Language and Concepts

Excerpt #1

The following conversation occurred during episode #5. Each teacher was given two different overheads of anatomical diagrams for labelling. Amanda’s overheads were diagrams of the skeletal system. A word list was at the bottom of each diagram.

VAL: (to Amanda). Talk to us about your two overheads. Do you think that they are appropriate to use for your students?

AMANDA: From previous experience, I’ve found like with words like “marrow” the kids think that they know (what it is) but they don’t really know what the word means. I bring a marrow bone in, I let them look at it and feel it (the marrow inside the bone)...and when I’m teaching the heart I always bring in a beef heart.

VAL: (referring to Amanda’s overheads) Would you use these? Are they appropriate?

AMANDA: The students that I have this term...I don’t think that they know cranium or femur...or pelvis.
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We were talking about what the skeletal system protects and they don’t have a lot of prior knowledge... I asked them, “What’s another name for skull?” and they couldn’t come up with it.

JANET: (referring to Amanda’s overhead) I don’t think that they will know clavicle.

AMANDA: Actually I am going to have to teach all these terms... I expect them to learn twenty-four different bones... I’ve got a lot more in addition to this (she points at the list)... This is basic knowledge but you need it to do higher level stuff (applications of concepts)... I want them to learn the names and the locations of the bones... and (their) functions in the human body.

Amanda had conducted an oral survey of the students’ prior knowledge of skeletal nomenclature. She indicated that the students often had an everyday definition for a concept like “marrow” but that they did not know the scientific definition. Amanda stated that correctly labelling the bones was beneficial because it supported further academic investigation of the skeletal system. She preferred to use concrete items when presenting scientific terms rather than just printed words or pictures. Amanda considered both the name of the bone and its location to be important in demonstrating a bone’s function.

Excerpt #2

The following conversation occurred in episode #7. I had shown the teachers selected excerpts from the previous videotaped episodes. After commenting on the excerpts the teachers were asked to discuss two focus questions.

VAL: How important is it for your Gr.4/5 students to BE ABLE TO explain or define the related appropriate science terms in a particular content area?... Please explain your ideas.

AMANDA: (referring to the wording of question #1) Explain and define are not the same thing. Define might mean that you are (just) regurgitating a (given) definition. Explaining implies that you are...
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understanding, you are asking (yourself and answering) the why questions.

VAL: So, you would say that explaining is more application?

AMANDA: Yes, at... by the end of the time that we spend on the concept.

VAL: Have the science workshops affected your ideas about Gr. 4/5 science language?

AMANDA: I have taught this before... It made me stop and think about what I was teaching and what sort of vocabulary I was teaching... Is this term really necessary?... Like osteoporosis, I think is (an) important (word and concept) to teach... I had a smaller, more meaningful vocabulary... this term.

The students used it on a regular basis and they talked that science language.

VAL: The students regularly used the science words?

AMANDA: Not at first... at the beginning they didn’t know any vocabulary, but by the end... after we covered the concepts.

Amanda immediately recognized that the first focus question was poorly worded. She pointed out the difference between the words define and explain. She selected and used a smaller scientific vocabulary this term while teaching the skeletal-muscular systems. Amanda encouraged the students to use the scientific nomenclature to communicate their ideas in class and noticed an increased mastery of science language by the students.

Excerpt #3

The following information is from Amanda’s copy of the research synopsis which she completed after the end of the third term.

SYNOPSIS: The teachers recognized that an important relationship exists between the usage and development of Gr. 4/5 school science language and the related concepts.

AMANDA: Language and related concepts need to be understood, versus regurgitated, in order to foster higher level thinking.
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SYNOPSIS: The teachers recognized the multiple and powerful role of language in that their own awareness of school science language affected their... lesson planning.

AMANDA: It is essential to understand and feel comfortable with science language before introducing it to the students.

Translating

Excerpt #4

The following conversation occurred during episode #7. The teachers had just viewed a segment of videotape from episode #5 that showed their interactions with models of the human heart, lungs, and eye.

VAL: What did you notice?... Any comments?

AMANDA: I am going to use a real heart, a beef heart... This term the kids are really into science.

VAL: What about their science vocabulary?

JANET: I find that their scientific vocabulary is weak, so I have been trying to get them to play games to learn the (school science) vocabulary.

AMANDA: Yes, at the beginning (of the unit) they didn’t know any vocabulary. I made up word and action games for my class to help them to learn the (names of the) bones... and the muscles... It’s like Jeopardy. They are (working) in pairs and they have to make up questions and they have to (both) agree on the answer. They write the question on one side of a card and the answer on the other side. They have to show it to me. I check it... When the cards are done we play the game, (orally) in two teams.

VAL: Do they know the differences between the (main) types of muscles?

AMANDA: Yes, they know cardiac, skeletal and smooth muscle... that cardiac is heart muscle... they know voluntary and involuntary muscles, and examples of them... If I name a muscle, they can tell me what type it is, where it is (in the body), and how it moves.
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Amanda encouraged the students to communicate their science ideas in meaningful and appropriate school science language whenever possible. Amanda described a game where the students worked in pairs to develop their understanding of relevant science concepts through appropriate questions and answers. The science ideas were regularly translated back and forth between everyday science language and school science language. Amanda encouraged the students to practice both written and oral language development while investigating the appropriate concepts.

Alternative Strategies

Excerpt #5

The following conversation occurred during episode #7. I presented videotape excerpts from the previous episodes. The teachers had just viewed a segment about the concept maps which they had created. The excerpt had shown the teachers selecting and defining key words from their concept maps.

VAL: So what do you think of “fill-in-the-blank” worksheets?

AMANDA: I don’t think that students should just fill-in-the-blanks (to study definitions). They should use resources or go on the internet to find out what the words mean...I also bring in examples. Like I brought in bones so they can see and feel everything...so now they can take what they know and apply it.

SUSAN: If different students learn in different ways, then we have to have a balance...we can’t just do “hands-on” (activities) only.
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AMANDA: I think that... (she counts off her points on her fingers)... you need to let them see things in visual and written form, so I use notes and diagrams... they need "hands-on" experiments, and they also need to work on projects, a balance of these three things.

Amanda recognized that "fill-in-the-blank" worksheets are often used to teach and/or reinforce school science definitions. She suggested that students should be encouraged to explore definitions through personal research (internet definitions), visuals (diagrams and charts), concrete experiences ("hands-on" experiments) and student-directed projects.

Excerpt #6

The following conversation occurred during an individual interview with Amanda in episode #8. Amanda was asked to comment upon the previous workshop activities.

VAL: We talked about different ways of changing science experiments when you're planning for instruction. Perhaps today you could talk about... what we did in the workshops?

AMANDA: I used the idea of brain-storming, for studying the bones... to get an idea of what they already knew. My kids didn't have much of a knowledge base.

VAL: And how did you do that?

AMANDA: I brought in all kinds of different bones, so that they could take it apart and see, like the periosteum... I was thinking... some kids like a lot of visuals (pictures, diagrams, videos)... I was thinking how they best learned. Like one lesson I might have a writing activity, then one week an experiment or making a model and then some kind of art activity (for the next lesson).

VAL: Why did you pick a particular experiment, activity, or model? What were you looking for?

Amanda: I was looking for the activity that would best illustrate the concept that I was going to teach.
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Amanda reiterated her view that teachers should plan to use a range of alternative teaching strategies for scientific words and concepts. She stated that she tried to provide concrete examples whenever possible so that students could see, touch and talk about the item (e.g., *periosteum*) as opposed to just presenting a written definition. Amanda was aware that each student had preferred learning styles.

Changes in Teaching Practice

Excerpt #7

The following conversation occurred in an individual interview in episode #10.

VAL: In what ways have the science workshops affected your ideas about Gr.4/5 science concepts?

AMANDA: It made me re-evaluate and change to make sure that what I was teaching was meaningful.

VAL: Like what sort of changes?

AMANDA: Every science class...had to be relevant and meaningful to the science concept. There was less paper (student paper work) and more discussion and more “hands-on” activities. This (change) made them really excited about science...The workshops made me think, “How can I be more effective?”...now I feel more relaxed...I’m O.K. I’m a cool science teacher....The workshops made me realize that the most important thing to instil in these kids is an enthusiasm and a love for science.

VAL: Anything else?

AMANDA: I always have an idea about what I want to do. Like in my mind when I’m planning ahead, I will have everything laid out...but the more I teach, I find that the only way to make a science unit really meaningful to the kids is that it has to be based upon their own interests and how they best learn (preferred learning styles)...you have to meet the kids first...pick what experiments will be best (for those students)...otherwise you might have a science unit that doesn’t work.
Amanda related that she planned a general outline of activities before starting a science unit. However, she emphasized that the students' interests and their demonstrated learning styles affected how she selected and crafted the subsequent science lessons. By focusing on constructing "meaningful" lessons for her students, Amanda had eliminated extraneous paperwork in the classroom. She had become more relaxed and enthusiastic about oral discussion. She had validated her belief in the importance of the "hands-on" approach to the science process.

Excerpt #8

The following conversation occurred in a private interview with the principal of the school at the end of the school year.

VAL: Have these three teachers become a resource for the other teachers?

PRINCIPAL: Yes,...Amanda has been helping out the Grade 3 teacher...What I see is a reversal in roles. Rather than those three teachers seeking out other teachers to help other teachers, I see a reversal there...now the new teachers go to those three and ask for help (on) how to do things...the direction of the collaboration has changed.

VAL: That's interesting.

PRINCIPAL: Yes, the other teachers seek them out for their science ideas, their creativity and for their science resources.

Although Amanda did not mention this to me, she became so confident about her teaching skills and strategies that she became a mentor to the Grade 3 teacher.
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Janet’s Case Study

Janet has a B.Sc., a B.Ed., and has been an elementary teacher for three years. She reports that she took first-year university courses in biology, physics, and computer sciences but that she majored in chemistry. She had previously done volunteer work at a hospital. She had already completed one special education course on gifted children and during the timeframe of this project she was completing a second relevant university course. She has worked at the research site for three years as a teacher and is presently the teacher-librarian.

Selecting and Defining School Science Language and Concepts

Excerpt #1

The following conversation occurred during episode #4. Janet had completed a large concept map of her chosen topic, the human respiratory and circulatory system.

VAL: So look at the concept map that you made. Pick a word from your concept map. How would you try to define that word?

JANET: I think...lung capacity. They would not know what that is, and I would define it as “the amount of air that your lungs will hold in one breath...in one inhalation and exhalation”...because we do an experiment with it...the displacement of water experiment where they can see how much air they have in their lungs.

VAL: Any other words that you think you might need to define?

JANET: Well, they need to learn that...the alveoli is the place in the lung where oxygen is exchanged for carbon dioxide...we breathe in oxygen and we breathe out carbon dioxide...and the alveoli is
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porous...for gas exchange...but, I don’t think that they would know what gas exchange ...or porous means either...I might have to teach some of these words.

Janet was confident of her own mastery of school science language but readily identified vocabulary that might need to be taught to the students. She indicated that she planned to use an experiment to introduce both the terminology and the concept of lung capacity. It appeared that Janet was aware of strategies to develop contextual definitions.

Excerpt #2

The following conversation occurred during episode #5. Each teacher was given two different overheads of anatomical diagrams for labelling. One of Janet’s overheads showed a diagram of the human circulatory system and the other overhead showed a diagram of the human respiratory system. Each teacher was asked to select some words that the students might need to be taught.

VAL: (to Janet) Talk to us about your two overheads.
JANET: This is perfect for me, to talk about right now because I know for a fact now that my kids don’t know these terms. Because I already did an introductory brain-storming session with them (they are just starting the topic) and really the only word that they already knew was the lung.

VAL: My goodness.
JANET: They don’t know any of these (she points at the words on her overhead)...They don’t have any prior knowledge... I’ve used this sheet before, in previous years, and I’ve always used it as an introduction, within the first couple of weeks...I use them so (that) the students can visualize where these parts are in the system and it’s important to (be able to) label all of the parts...I think that capillaries would need to be taught and diaphragm would need to be taught.
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VAL: Are the sheets appropriate to use?

JANET: Yeah...when you first introduce a concept, I think that these labelling sheets are a really useful tool and that science models are something (that) I use already. I do the lung model and so that (the use of various models in the workshops) really validates how I teach.

Janet indicated specific terms and concepts that students might need to be taught. She emphasized her own use of diagrams and models for presenting and applying science ideas, like the word and concept of *diaphragm*. Janet made a preliminary appraisal of her students' prior knowledge of vocabulary for the respiratory system.

Excerpt #3

The following information is from Janet’s copy of the research synopsis.

SYNOPSIS: Teachers reported that students felt empowered by their mastery of school science terms.

JANET: Yes, (the) students loved using (the) scientific terms - (and) asked to play our verbal (word translation) “game” often to reinforce skills.

SYNOPSIS: The teachers recognized that “hands-on” experiences were effective for introducing new science terms and for generating contextual definitions.

JANET: (the) contraction/expansion of (the) diaphragm (was) discussed after (the) lung model was built.

SYNOPSIS: The teachers recognized the multiple and powerful role of language in...their selection of teaching resources, lesson planning...

JANET: Much personal influence (is) involved in (lesson) planning. How we interpret the science language through research and past experience highly determines (the) lesson content.

Janet verified that the students felt empowered by their mastery of the science vocabulary. She also recognized that a connection exists between the teacher’s
perception of the role of school science language and the planning of meaningful discussions, “hands-on” activities, and experiments.

Translating

Excerpt #4

The following conversation occurred in an individual interview in episode #10.

VAL: In what ways have the science workshops affected your ideas about Gr. 4/5 science language?
JANET: I think that it (the workshops) made me more aware of how important it is to teach the correct terminology. I think that I focused more on terminology this term because of what you had done in the workshops...So, with the respiratory system, we spent time on the common names and the scientific names. We played games and I tested them on that (understanding of terminology).
VAL: Can you give me an example?
JANET: I do games with the terminology. (She describes in detail an oral word game that she does in class). Like, I might say, “Two point question. What is the common name for the *trachea*?”
VAL: That is interesting.
JANET: We do a lot of oral work...it shows me that they are understanding the whole respiratory system. They learn a lot from each other.

Janet described an oral game that required the students to translate back and forth between everyday science language and school science language. She stated that mastery of the vocabulary assisted in assessing the students’ understanding of the relevant concepts.
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Alternative Strategies

Excerpt #5

The following conversation occurred during episode #7. The researcher had shown the teachers selected excerpts from the previous videotaped episodes. After commenting on the excerpts the teachers were asked to discuss two focus questions.

VAL: How important is it for teachers to consider Gr. 4/5 science terms and the development of the related concepts?

JANET: I find that their scientific vocabulary is weak, so I have been trying to get them to play games to learn the vocabulary... And I use models. I used the touch envelopes (like we did in a previous workshop)... and I used the eyes (models)... My kids are bringing in the materials to build the model of the lung. We are going to do the pulse rates tomorrow. I have never done the graphing before but we are going to try it.

VAL: Anything else?

JANET: Yeah, my kids can say (the science) words... but they are just using reading skills.

VAL: Can you tell us an example?

JANET: It is... maybe these words (she points at her concept map of the respiratory system) ... maybe children see these words and it is like Greek to them... Like today (in her science class) we were looking at some scientific words (points at her concept map up on the wall). They just didn’t get it.

SUSAN: It is worse if you think (erroneously) that they get it. That’s what I found out... as a teacher you think (assume) that they know it (the meaning of the science word), ... but you find out that they don’t understand, they have no application of that knowledge.

VAL: How might that affect the in-class work that you assign?

JANET: (referring to her concept map of the respiratory system) Like, I couldn’t just give them a bunch of words on the blackboard, and say (to the students), “Write those down.” ... and (assume) they
understand them (just) because they can read them. Instead, I would do (some) “hands-on” things so that they could see the words and what they mean. So they could understand it. I have really come away from just making them take down notes... Science terms like \textit{trachea}, I want them to (be able to) explain what it is, what it does and why it is important.

\textbf{VAL:} Go on Janet.

\textbf{JANET:} They should know \textit{breathing rate}, but they should be able to explain, like apply how the \textit{breathing rate} is going to be affected (cause and effect relationship). What happens to the \textit{breathing rate} when you exercise, or when you have asthma? How does your \textit{breathing rate} compare to that of other animals?

Janet stated that she was using several alternative strategies to teach the relevant science words and concepts. She still favoured the use of models but she had also initiated oral word games and planned to collect data on student pulse and breathing rates. She had not done graphing with Gr. 4/5 students before; however, she planned to have the students graph their breathing rates under different conditions.

Excerpt #6

The following conversation occurred during an individual interview with Janet in episode #9.

\textbf{VAL:} You said that your students were going to build the model of the lung?

\textbf{JANET:} Yes, we did that. (She shows me some of the students’ models).

\textbf{VAL:} What were they talking about while they did it?

\textbf{JANET:} We talked mostly about the relaxation and contraction of the diaphragm... we did a worksheet that went along with the model. They had to label the parts on the diagram.
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VAL: (She shows the worksheet to me) O.K., I see. And your students are all doing research projects too?

JANET: Yes, I want three visuals for each project but only two pages (of) written (information). So, we talked about posters, charts, models... or game-boards, but then one student wanted to do a debate.

VAL: That is interesting. Did you set up formal rules for the debate?

JANET: No he did it himself. It was his idea. Look, here are some of the game-boards and you can see the terminology that they used on them. This game-board is about smoking (cigarettes) it has nicotine and Nicoderm (on different squares. If you land on the square then you have to answer the corresponding question. The questions and answers are printed on small file cards.)

Janet was using many alternative strategies to teach and/or assess the students' understanding of science words and concepts. In addition to models and worksheets she had encouraged the students to create research projects. The students' projects included alternative methods of presentation such as charts, posters, game-boards, and a student-directed debate.

Changes in Teaching Practice

Excerpt #7

The following conversation occurred during an individual interview with Janet in episode #10.

VAL: In what ways have the science workshops affected your ideas about Gr. 4/5 science concepts?

JANET: I think that the workshops opened up my eyes to the broadness of the curriculum and (to) all the different (divergent) applications...of concepts. Before I'd always thought of these concepts as very specific and now that I see that they are more broad... and connected.
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VAL: Does that benefit you in any way?

JANET: Definitely. I feel more confident when I teach. I feel that there are so many different strands.

VAL: Does it help you with the planning of lessons?

JANET: Exactly. I found that I was trying lots of new things (alternative strategies)...I think that I did more “hands-on” activities throughout the year and I felt more confident.

VAL: Did you do the graphing of the heart rate and the breath rate?

JANET: The kids did their graphs individually and I marked it. Yeah... I think that the biggest thing that I gained overall (from the workshops) was a willingness to try new things and new ideas.

Janet had increased confidence in her teaching skills and had expanded her repertoire of teaching and assessment strategies. Science concepts were no longer regarded as isolated content areas. She was willing to explore and integrate related concepts and to try new applications.

Excerpt #8

The following conversation occurred during a private interview with the principal prior to episode #5.

VAL: What have you observed about the ways the three teachers talk about science?

PRINCIPAL: I think that it is really important that science have a “hands-on” base and that’s what I see the students doing with these three teachers...like Janet is always coming up with new ideas and different ways to approach it (the curriculum concepts). Janet, I see (that) she goes and finds experiments and presents some of the issues that you have talked about ...Janet has found resources and “hands-on” activities that the students are working on now (term two).

VAL: That’s encouraging... And the other two teachers, Amanda and Susan?
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PRINCIPAL: Yes, but not so much as Janet. Not that I’ve noticed yet.

The principal had noticed that Janet was searching out, applying, and sharing teaching resources and experiments with other teachers. The principal was impressed with the large number of “hands-on” activities that Janet was doing with her students.

Excerpt #9

The following conversation occurred in a private interview with the principal at the end of the school year.

VAL: Can you give me some general feedback about science, especially this term (term three), as compared to the first two terms?

PRINCIPAL: I see much more “hands-on” science this term, more group activities, more collaboration between teachers, between students, and between classes...I saw the (lung) experiment that Janet did in her class. I saw the lung models. The other teachers wanted to do the same experiments with their classes too (at various grade levels)...I think that those three teachers are very empowered...and (there is) enthusiasm coming from the students, it has been internalized (by the students)...Now I see other teachers (in the school) coming to look at what those three teachers have done, especially what Janet has done.

VAL: Have these three teachers become a resource for the other teachers?

PRINCIPAL: Yes. I notice that Susan...and Amanda are mentors...Janet has been giving everyone help with library and science resources.

The principal perceived some changes in the teaching practices of the participant teachers, especially during the third term. She noticed that all three of the teachers, but particularly Janet, engaged their students in a wide variety of “hands-on” activities and experiments. Each of the volunteers became a mentor to other teachers.
Val’s Self-study

I have a B.Sc. (Pharm.), a B.Ed., and have been an intermediate teacher for ten years. For six of those years I taught Gr. 4 - 10 Science to students at the research site. During the 1999 – 2000 academic year I presented Science Education 320, Curriculum and Instruction in Elementary Science, to pre-service teachers at U.B.C.

I was immersed in this project as an organizer, mentor, facilitator, and interviewer. As demonstrated in the volunteer’s cases, I elicited critical conversations related to the four categories of interest. My self-study contains representative critical conversations that I had with the three volunteers and Tammy. It also includes entries from my research journal. The following excerpts are presented chronologically in order to reveal the progressive development of each category. Some excerpts are related to more than one category.

Selecting and Defining School Science Language and Concepts

Excerpt #1

This conversation occurred during consultation #1, immediately following episode #1.

TAMMY: Interesting comment... (from Susan) that the students seem to be using (school science) phrases but are not understanding the concept...in anecdote (from Susan) the students said that they knew what it (capillary action) was but they weren’t asked how (they knew it).
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VAL: (referring to Susan’s anecdote) ... If you have one child that says, “Oh, that’s capillary action and the rest of the class just shuts up. Where do you go from there? Is that the end of the lesson? Once the “science word” is out and has been said where does the lesson go from there? You can’t go back and pretend...that nobody heard that....I think that there are teachers that have difficulty with where to go (with the concept) once the “science word” has come up.

TAMMY: And the teacher didn’t ask them to explain or go further, that was just it. Then she said the texts identify things but don’t explain.

VAL: Assumptions have been made that ideas, especially science ideas, are far too hard for children to understand. Therefore, the ideas have been simplified and simplified...to the point where they are no longer visibly connected to the concept that they are trying to describe...and therefore (such simplifications) are more misleading than helpful in some ways...like Vygotsky says that if a person understands a concept then they should be able to describe it in words and apply it in a practical way.

I am interested in the development of contextual definitions for science concepts, especially when they arise from “hands-on” activities. If a concept is simplified to the point that it just becomes a label (the science word) then some students and teachers may equate knowledge of the word with knowledge of the concept. Labelling a concept should not be the endpoint of a lesson but rather a springboard to further investigations.

Excerpt #2

The following conversation occurred in consultation #2, immediately following episode #2. In the workshop the teachers had participated in an experiment about the rotation of the Earth and they had also observed a lava lamp.

VAL: Today, I noticed that when they were doing the “hands-on” activities they were using simple everyday language...but, when they were looking at the lava lamp, they were talking about heat
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sources, electricity, light, reflection, shadows, the *Kinetic Molecular Theory*, and convection.

TAMMY: That fits really well with what you said last time.

VAL: Yes, the teachers seem to use more everyday language during activities and more school science language in the discussion after the activities... When they are doing the “hands-on” they are focused on doing the steps (procedure) correctly and communicating clearly...today, when they were looking at the lava lamp, and their hands didn’t have to be busy...they could just talk.

TAMMY: When you asked them to answer questions about their observations, the language that they used was much more reflective. They reflected on what they had seen.

During the “hands-on” activities the use of everyday language seemed to be more prevalent among the teachers. Although experiments and other exploratory activities could be used to generate contextual definitions for science concepts it appeared that the school science language emerged when the teachers engaged in the post-experimental discussions.

Excerpt #3

The following conversation occurred in consultation #9 after episode #9.

VAL: Susan has her students going around the school working on surveys (interviewing people). So, we are definitely getting away from “fill-in-the blank” worksheets.

TAMMY: The teachers have gotten away from labelling, like Amanda said (her) students need to know the types of joints or muscles, where it is and how it works, (and) that is into using developed science language...I am impressed that there are more than just isolated (science) words, there is more useful applied science language (expressed by the teachers).

VAL: Amanda said that she was impressed that the students became comfortable with talking (in) the science language.
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TAMMY: At first I thought she was just focussed on labelling but then (in the later episodes) she showed that she expects the students to express their understandings in oral and written language.

Tammy and I noticed a progression from the teachers’ use of science words in isolation (in the earlier workshops) to their use in full sentences and detailed applications of concepts in the later episodes. The science words were no longer being used for labelling but to describe a fuller understanding of a concept.

Translating

Excerpt #4

The following conversation occurred during episode #2. The researcher had engaged the teachers in two different activities, one of which was the observation of a lava lamp in a darkened room.

VAL: When you were looking at the lava lamp...I listened to what you said...Why do you think that the particles are moving?

JANET: A source of light...and temperature...things are really moving in the lava lamp because of the temperature.

AMANDA: I was thinking that the heat...it’s because of the temperature. It’s moving them (the particles) up more... In it (the lava lamp) the hottest temperature is at the bottom, represented where the little things (particles) are moving around so much. (She motions with both of her hands in circular motions).

JANET: The higher the temperature, the more the particles are moving from side to side.

VAL: I heard people using words to describe that.

JANET: Convection.
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SUSAN: They get to the top and then they come down the sides. It’s just like the atmospheric convection, the convection of the Earth.

VAL: And would your students talk about that, about convection? Have you heard them talk about that?

JANET: I don’t think that it’s in their vocabulary. I think that they would have to be taught that.

SUSAN: In a book that I had about water...they had an activity (called) the underwater volcano which dealt specifically with that, about convection. They were trying to show the idea of energy moving from one source to another source...the basic idea of convection.

JANET: Well that is what it is.

VAL: Have you heard your students use the word convection?

SUSAN: No, not unless it was introduced (by the teacher).

AMANDA: The lava lamp represents the whole cycle of the water cycle. You have evaporation where the water evaporates and goes up...and (then) it cools and comes back down as precipitation, comes back down to the Earth...and then it heats up again, and goes back up. (She motions with both hands, her two hands rise together, separate and fall down in circular motions. She repeats the action again).

VAL: Have you heard your students use the word convection?

AMANDA: No, that’s not a word that they would know.

JANET: They have to be taught that.

VAL: Once you introduce the word and concept (of) convection, can they give you examples?

JANET: Yeah, convection oven ...fireplace.

Janet indicated that the students had an everyday science vocabulary but that they needed to be taught school science words and concepts like convection. She pointed this out and the other volunteers agreed. Susan gave an example of an activity that could assist the students to develop their own contextual definition for the term convection. Amanda made an analogy between the convection that occurred within the lava lamp and the
convection that occurs in the water cycle. This conversation revealed how the teachers translated between everyday language (heat, temperature, little things moving around) and school science language (convection). This conversation also revealed that translating between science languages can occur when defining and/or applying a concept.

Alternative Strategies

Excerpt #5

The following information was condensed from entries in my research journal. These entries occurred after workshop #3 and before workshop #4.

I told Heidi that the teachers enjoyed doing four experiments in workshop #3 but that there was little time for discussion. Heidi reminded me that the videotapes will only show what the teachers say and do... since I am interested in how teachers plan for the teaching of scientific language I need to encourage more discussion of science concepts. The teachers may like experiments but I should consider various other presentation strategies that could promote opportunities for teacher discourse. (26.11.00)

I have collected background materials, besides experiments, that I could use for mini-lectures in the next four workshops. These include Bloom’s Taxonomy, scientific literacy reading comprehension questions, survey sheets about the student’s expected ability levels, student learning styles and teaching and assessment strategies for school science language. (15.01.01)

The entries show that feedback from Heidi alerted me to the fact that I needed to use alternative strategies to encourage discussions about science concepts. When the teachers were physically involved in detailed experiments there was a decrease in the
time spent discussing concepts or teaching strategies. I reacted by searching for presentation materials that were more focused on scientific literacy. Therefore, workshop #4 contained 50% "hands-on" activities and 50% discussion whereas workshops #1-#3 contained 80% "hands-on" activities and 20% discussion.

Excerpt #6

The following conversation occurred in consultation #6 after episode #6.

VAL: Today did you hear (conversations) about changes in strategies?

TAMMY: They seem to be thinking about different strategies and approaches to teaching... your presence seems to be stimulating them to re-examine their own practices.

VAL: Now they are planning (for instruction) in term three... planning to use these ideas so they are more self-critical... They are starting to think "How will I use this with my kids?"... I want to see what happens when they start to teach these topics in term three... they will have to think about how they are going to do assessment of this (science concepts and language).

TAMMY: Janet observes and comments but she doesn’t say what she is thinking about or how she plans to teach.

VAL: Yes, the others seem to think out loud (but) Janet doesn’t seem to do that as much. Once she is teaching the topic maybe she will be able to verbalize it better... I am trying to follow their lead.

TAMMY: Amanda said, “You are reaffirming that what we are doing is O.K.”... she seems to feel validated.

VAL: She and Susan are so reflective but I want to elicit more from Janet... to get more conversations... Heidi suggested that I show them excerpts from the (previous) six workshops in episode #7, then (post) some discussion questions.
In order to promote equitable reflection upon the first six episodes the format was changed for workshop #7. Instead of 50% “hands-on” activities and 50% discussion, the format became 50% oral reactions to the videotape excerpts and 50% discussion of the focus questions. I had originally planned that phase four would only be interviews (episodes #8 - #10) so the change in the format of episode #7 provided a vehicle to shift discussions from procedural considerations to applied teaching and assessment strategies.

Excerpt #7

The following conversation occurred in consultation #7 after episode #7.

VAL: This was the first time that they had seen the videotape excerpts.

TAMMY: They had to think (about) what to add to what they had already said.

VAL: Today Amanda and Janet did talk more about how they make decisions about planning to teach science.

TAMMY: There was deeper insight...they revisited these topics...Amanda noticed the ambiguous words right away, define does not mean explain...teachers sometimes interchange words that are not equivalent. Amanda picked up on that right away...the words have to fit into a greater language system. It is crucial to realize that define can just be labelling...explain means (that) you can tell and understand how it works, understand what the process is or how it fits into a greater system.

VAL: It will be interesting to see how she plans to assess student understanding of the science words that they use in third term and what applications she expects from them.

My change in presentation format successfully generated more reflective discussion among the volunteers. As Tammy stated, seeing the videotape excerpts stimulated the teachers to enlarge upon ideas that they had previously mentioned.
Chapter 4: Four Case Studies

Changes in Teaching Practice

Excerpt #8

The following information was condensed from a series of entries in my research journal. (22.08.00 -23.09.00)

In my presentation to all the teachers on Aug. 31st I want to emphasize that my approach to the science workshops is to be a facilitator, a mentor, and to encourage the teachers to examine the role of language in planning for science instruction. How do they plan to communicate their ideas?..The teachers may have been taught about theories like constructivism but how have they interpreted such theories? (22.08.00)

The teachers felt that a two hour workshop would be too long at the end of the day, so we agreed on one hour workshops. They felt that two workshops per month would be too much time pressure so we agreed on a maximum of one workshop per month. I hope to start the workshops in September. (31.08.00)

Seven teachers are interested in the workshops but there is a problem with planning. They need to decide which days they want me to present. I am willing to do a workshop for the primary teachers on one day and for the intermediate teachers on a different day. (10.09.00)

Today I met with the seven teachers but only three of them are eager to schedule the first workshop. The others feel that there are too many demands upon their time. (14.09.00).

Three intermediate teachers have agreed to begin the project. They are all teaching Gr. 4/5 Science, however, one teacher is interested in the topic of weather, one in the topic of water and one in the topic of natural resources. I asked them to suggest some general concept that would integrate the three topics. The first three workshops would connect to that general concept. They could not decide so I suggested the atmosphere of the Earth. (23.09.00)
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These excerpts show my transition from a theoretical approach to this project to a more practical approach to the logistical problems of organizing the workshops with busy teachers. On September 23rd I realized that only three teachers were committed to this project and that those teachers felt overwhelmed by their many responsibilities. Thus, I decided which overarching concept would be examined in the first three workshops, namely the Earth’s atmosphere. I felt pressured to get started with the workshops and to establish a relationship with the teachers.

Excerpt #9

This conversation occurred at the end of episode #2 after I requested oral feedback.

AMANDA: I want to see a wider variety of experiments…I enjoy the post experiment discussions. I find it is interesting and helpful to hear other people’s views and frustrations regarding teaching science.

SUSAN: I thought it was interesting to compare the spinning ball and the lava lamp…both involved a light source, reflection, some circular motion or pattern and gravity…making the concept maps of the atmosphere and then looking at them again, I saw how jotting down some ideas can generate more ideas.

VAL: How about if I bring in four experiments next time? We will finish looking at the concept of atmosphere and related concepts like density.

JANET: Yes, my time is so precious. I want to see and try things that I really can use…I wanted to say that you made me feel more comfortable and secure to explore thoughts and ideas and not be afraid to be wrong.

VAL: I hope that you all feel that we can explore ideas…remember after workshop #3 that I need to know the exact topics that you are teaching in term three. Are you all teaching human biology?
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I used feedback from the volunteers to help direct the composition of each subsequent episode. The teachers appeared to find the activities to be interesting and worthwhile. Collegiality was increasing and I felt that we were forming a community of inquiry.

Excerpt #10

The following information was condensed from a series of entries in my research journal (26.11.00 – 05.02.01).

I discussed the project with Heidi today. I mentioned that 1. the teachers use little school science language during “hands-on” activities. 2. More science vocabulary was used in the post-experiment discussions. 3. They have accepted me as a peer/mentor and are also acting as mentors to each other. 4. They enjoy the “hands-on” experiments but that does not generate much oral reflection...Heidi said that during the “hands-on” activities the teachers may be focused on performing the procedures or creating a final product so there is not much being said. The discussions after the activities promote exploration of the concept that was investigated. (26.11.00)

I have viewed the videotapes of the first three workshops twice and have started to transcribe some of the interesting segments. I read and photocopied the logbooks from the teachers and Tammy. (12.12.00)

Presented workshop #4 today and I think that I have found a good balance between introducing mini-experiments and mini-lectures. Each teacher created a concept map of her chosen topic and those words were used to introduce investigation into definitions. We discussed the Ministry’s definition of scientific literacy and Bloom’s taxonomy. Then we did three brief mini-experiments. There was a lot more discourse about concepts and much more use of scientific language. (05.02.01)
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The scientific literacy materials were introduced during a mini-lecture at the beginning of episode #4. Thus, the workshop format changed from being about 80% “hands-on” activities and 20% discussion (as in workshops #1 - #3) to being about 50% “hands-on” activities and 50% discussion. Rather than a detailed experiment I presented three mini-experiments in workshop #4 and the teachers responded enthusiastically to the new format. As mentioned in the previous section, workshop #7 was 50% response to videotape excerpts and 50% discussion of two focus questions. Workshops #8 - #10 were 100% oral interviews. Thus, over the timeframe of this project my presentation format changed from being 20% discussion to being 100% discussion.
Chapter 5: Findings and Discussion

Introduction

This chapter begins with the interpretative framework that was used to analyze the four case studies. This is followed by a discussion of the categorized findings derived from the cases. I was an active participant in the ongoing critical conversations and often sought to immediately clarify the teacher’s expressed views. Thus, some of my emergent interpretations were revealed within the conversations. Although I drew some inferences from the transcribed conversations, I diligently attempted to document the teachers’ perspectives. The chronological format of each case study and the detailed descriptions enhance the context of the presented data, enrich the analysis, and provide an opportunity for judging its credibility. By offering the reader an analysis of the four categories of interest across the four cases, some corroboration is provided with respect to the validity of the research findings. The chapter concludes with some implications for further research.

Interpretative Framework

My discernment of the first two categories of interest within the data was chiefly influenced by Vygotsky’s and Lemke’s views on linguistic-conceptual development. The first category is judgements about selecting and defining school science language and concepts, and the second category is translating between everyday science language and concepts and school science language and concepts.
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Vygotsky claims that everyday concepts arise from socio-linguistic interactions that are not a part of formal scientific instruction, while scientific concepts (both school science and disciplinary science concepts) are related to formal scientific instruction with selected science materials and science language (Vygotsky, [1934 ] 1986). Lemke claims that three distinct languages exist in the domain of science (everyday, school science and disciplinary) and that teachers should be able to translate ideas back and forth between everyday and school science language (Lemke, 1990). I have generalized that everyday science concepts are usually communicated through everyday science language, school science concepts are usually communicated through school science language and disciplinary science concepts are usually communicated through disciplinary science language. I accept that translating between the languages is a part of planning for instruction.

Vygotsky, Lemke, and others (e.g., Smith, Carey, & Wiser, 1985) are concerned about the mimicry of scientific ideas, especially the regurgitation of memorized definitions, by children. An important part of instruction is planning opportunities for the development of both concrete (e.g., Ogborn et al., 1996) and linguistic (e.g., Lemke, 1990) contextual definitions for concepts. Whereas dictionary definitions may entrench a relationship between a new word (or concept) and previously known words (or concepts), contextual definitions place the new word (or concept) within a specific social, experimental and/or grammatical setting (Bruning et al., 1999).
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My discernment of the last two categories of interest within the data was influenced by various researchers. The third category is the consideration of alternative teaching and/or assessment strategies for school science language and concepts. The fourth category is the perception of changes in teaching practice.

The planning of instructional strategies should incorporate the evaluation of student comprehension. In order to demonstrate mastery of a concept, the student must be able to verbally define and practically apply the concept (Vygotsky, [1934 ] 1986). Lemke suggests that teachers should plan various teaching and assessment strategies such as debates, oral and written presentations, and lab reports (Lemke, 1990). The planning of appropriate “hands-on” activities and the use of relevant language can facilitate the communication of concepts and assist in the assessment of student actions (Driver et al., 1996). Many teachers seek out divergent teaching strategies in order to enrich or improve their teaching practice. Reflection upon past practice can stimulate conceptual development within the teacher and can result in an altered pedagogical perspective on teaching practices (Erickson & MacKinnon, 1991).
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Findings and Discussion

The findings within the four categories are interpreted and discussed within each separate case and then I state a generalization across the four cases.

Selecting and Defining School Science Language and Concepts

Susan

The transcripts within Susan’s case appear to indicate her search for a consistent method for selecting and defining school science language and concepts. Susan said that she used a variety of teacher resources across grade levels to identify and explain the relevant science concepts. However, she worried about the complexity of a definition because the divergent resources offered multiple and overlapping definitions richly expressed through extensive vocabulary. This led her to speculate about standardizing both the concepts and the relevant vocabulary within the curriculum. In her copy of the research synopsis she wrote “I’d like to see a list of terms to be studied, be included in the P.L.O. s.”

I got the impression that Susan found multiple definitions for science concepts to be confusing both to herself and to her students. I inferred from Susan’s statements that she initially lacked confidence in her judgements about selecting and defining school science
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language and concepts. However, after participating in the workshops she stated that she
had decided to carefully control her usage of school science vocabulary. Thus, she
apparently standardized her own selection and definition of the relevant concepts and
language.

Amanda

The transcripts within Amanda’s case seem to reveal that she has an established
procedure for selecting and defining school science concepts and language. She stated
that she was concerned about the students’ lack of knowledge about the human skeletal
system and skeletal nomenclature. It appears that she surveyed the students’ background
knowledge at the beginning of the term in order to judge which science concepts and
words to teach. Amanda mentioned various concrete materials that could be used to
assist in exploring contextual definitions, like a beef heart. She indicated that defining
school science language is only labelling. For instance, Amanda emphasized that
“language and related concepts need to be understood, versus regurgitated, in order to
foster higher level thinking.” She stated that the students should not only know the
names of the bones and muscles but also their locations and functions within the human
body. She regularly engaged her students in experiments and discussions.

I got the impression that Amanda’s procedure for selecting and defining school
science language and concepts had three steps: 1. survey the students’ prior knowledge,
2. engage the students with concrete materials to assist in formulating contextual
definitions, and 3. provide opportunities to apply the new concepts and language. It might be inferred from Amanda's statements that she was confident in her judgements about selecting and defining school science language and concepts.

Janet

The transcripts within Janet's case seem to indicate that she has the same established procedure for selecting and defining school science concepts and language as Amanda does. For example, Janet said that she had done an introductory brain-storming session with her students at the beginning of third term. She related her surprise at discovering their lack of prior knowledge about the parts of the respiratory system. Janet used her preliminary appraisal of her students' background knowledge to judge which science concepts and vocabulary to teach.

Janet mentioned various concrete materials that could be used to assist in exploring contextual definitions, in particular student-built models. Janet indicated that school science language should not only be used for labelling. For instance, she stated "The kids want to be able to speak the proper science language... (and) asked to play our verbal (word translation) 'game' often to reinforce skills." I got the impression that Janet's procedure has the same three steps: 1. survey the students' prior knowledge, 2. engage the students with concrete materials to assist in formulating contextual definitions, and 3. provide opportunities to apply the new concepts and language. I inferred from Janet's statements that she was confident in her judgements about selecting and defining school
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science concepts and language.

Val

The transcripts within my self-study indicate that I was concerned about how teachers select and define school science language and concepts. I was concerned because verbal knowledge of a science word does not equate with knowledge of the named concept. For example, I said to Tammy, “I think that there are teachers that have difficulty with where to go once the ‘science word’ has come up.” My view is that school science language should not only be used for labelling but also for exploring, investigating and debating science ideas. I noticed that during “hands-on” activities the teachers often used everyday procedural language while the post-experimental discussions seemed to encourage the use of school science language.

I presented various concrete materials that could be used to assist in exploring contextual definitions. I was concerned that school science words should not be isolated and memorized from worksheets but rather linked to an experiment, a student-built model or group discussion. It seems that I am confident in my judgements about selecting and defining school science concepts and language.

Generalization

Apparently, each teacher perceived that her judgements about selecting and defining school science language and concepts were an important part of planning for instruction.
Translating Between Everyday Science Language and Concepts and
School Science Language and Concepts

Susan

The transcripts within Susan’s case indicated that she had planned to engage the students in some translation activities. She related that she usually directed the students to search for definitions and information in reference books. Since she apparently decided to standardize her own science vocabulary, I assume that she also established a standardized translation back and forth between the two languages. Susan’s approach to translation seems to be teacher-directed and I was uncertain if she had used any other techniques to encourage translation by the students.

Amanda

The transcripts within Amanda’s case indicated that she developed and regularly used oral and written games to engage the students in translation. For example, in one game she directed the students to write questions and answers on blank cards. She checked the accuracy of the cards before they were used in the oral game. She stated that learning the scientific nomenclature assisted the students to discuss and explain relevant concepts. I got the impression that Amanda modeled translation during classroom activities and supported both written and oral language development. I inferred from Amanda’s statements that her translation activities were student-centred.
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Janet

The transcripts within Janet’s case indicated that she also developed games to encourage translation. Janet stated that she had organized oral word games to practice translation because she had been concerned about her students’ weak scientific vocabulary. I got the impression that Janet valued translation as a skill because she tested her students on their understanding of the relevant terminology. It might be inferred from Janet’s statements that she modelled translation, especially orally, and that she monitored the students’ ongoing mastery of school science vocabulary.

Val

Although I presented only one transcript related to translation in my case, it was characteristic of the way in which I elicited examples of translation in the discourse. Rather than lecture to the teachers about Lemke’s views on translation I scripted each episode to support the development of selected science concepts like convection. The translations between the languages arose out of the interactions between the pre-selected concrete materials, the teachers, and myself. Thus, the translations were generated within each episode and I encouraged their usage through my open-ended questions.

Generalization

Apparently, each teacher perceived the value of translating back and forth between everyday science language and concepts and school science language and concepts to some degree. Each teacher seemed to model and encourage translation in her own way.
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Alternative Teaching and/or Assessment Strategies
for School Science Language and Concepts

Susan

The transcripts within Susan’s case indicated her interest in exploring alternative teaching and/or assessment strategies. Susan seemed to be seeking alternatives to written worksheets for every activity and experiment. She asked the other teachers and myself about techniques for structuring oral discussions and group observation charts. In Susan’s copy of the research synopsis she commented, “Being able to discuss strategies with fellow teachers and (the) facilitator was beneficial.” I got the impression that prior to the workshops Susan had primarily used written worksheets and written tests for assessment. However, she became interested in alternative strategies like learning centres and dramatizations. It might be inferred from Susan’s statements that she was dissatisfied with her established practice and was willing to evaluate and implement alternative strategies.

Amanda

The transcripts within Amanda’s case indicated an interest in exploring alternative teaching and/or assessment strategies. Amanda stated that she used multiple techniques including labelling diagrams, “hands-on” experiments, models, presentations, and projects. She discussed many opportunities for using concrete materials with the students, like a fresh bone to introduce the concept of “marrow.” Amanda indicated that
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she planned to use multiple media in her lessons to support her students’ diverse learning styles. I got the impression that Amanda was confident about using various teaching and/or assessment strategies. It might be inferred from Amanda’s statements that the students’ expressed prior knowledge affected her choice of teaching strategy.

Janet

The transcripts within Janet’s case indicated an interest in exploring alternative teaching and/or assessment strategies. She stated that she encouraged group work and that students could choose between various activities that were all related to one concept. Janet stated that she used worksheets, oral word games, student-built models, “hands-on” experiments, diagrams, and presentations. In reference to the students’ projects she said, “I want three visuals for each project but only two pages (of) written (information). So, we talked about posters, charts, models…or game-boards, but then one student wanted to do a debate.” I got the impression that Janet was comfortable with some teaching strategies, like the use of models, but was experimenting with others, like graphing and debates. It might be inferred from Janet’s statements that she is sensitive to the students’ diverse learning styles and that she offers flexible opportunities for assessment.

Val

Although I prepared and presented lists of possible teaching and/or assessment strategies in some of the workshops, I used them to elicit anecdotal responses from the volunteers. In order to encourage critical conversations, I shifted my presentation
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techniques from a focus on experiments to a focus on scientific literacy.

Generalization

Apparently each teacher explored alternative teaching and/or assessment strategies. Participation in the project seemed to affect each teacher's repertoire of instructional techniques to some degree.

Changes in Teaching Practice

Susan

The information presented in Susan's case appears to indicate that there were some changes in her teaching practice. It seemed that she reflected on specific aspects within her practice, in particular her previous reliance on the completion of written worksheets. For example, Susan said "When I went over their tests on the sense of smell... I realized that I needed to teach in a different way." She stated that she was stimulated to implement other teaching strategies and assessment formats such as learning centres, oral questioning, and group discussions. In regard to the workshops, Susan said that she benefited from Amanda's and Janet's advice, and that there was increased collegiality during the school week. The principal stated that Susan had become a mentor to the two primary teachers.

I got the impression that both Susan and the principal perceived changes in Susan's
teaching practice. It is beyond the scope of this project to consider whether the perceived change in Susan’s repertoire of strategies could be generalized to other science content areas or grade levels. Her attitude toward the role of written output in lesson planning, as opposed to oral discussions and ‘hands-on’ activities, appears to have changed. If this analysis is correct, then it might be inferred that participation in the workshops encouraged and supported her re-evaluation of her teaching practice to some extent.

Amanda

The information presented in Amanda’s case appears to indicate that there were some changes in her teaching practice. Amanda said that she focused more on the students’ own interests and preferred learning styles rather than on covering all of the content knowledge. In reference to the workshops, Amanda said that she chose to use a smaller and more meaningful vocabulary during the third term and encouraged the students to regularly talk in school science language. The principal stated that Amanda became a mentor to the Grade 3 teacher.

I got the impression that both Amanda and the principal perceived changes in Amanda’s teaching practice. It is beyond the scope of this project to consider whether Amanda’s perception of her evolving teaching strategies could be generalized to other science content areas grade levels. Her attitude toward the role of student-centred science concepts and language in lesson planning, as opposed to content-centred lessons, appears to have changed. If this analysis is correct, then it might be inferred
that participation in the workshops encouraged and sustained her re-evaluation of her teaching practice to some extent.

Janet

The information presented in Janet’s case appears to indicate that some changes occurred in her teaching practice. Janet said that the use of language was important to lesson planning and assessment. She explained how she used “hands-on” experiments, oral discussions, and student-built models to help students express their understandings of concepts. She said that she had decreased the amount of note-taking and had increased her use of group activities, oral presentations, and student projects. In reference to the workshops she said, “I think that it made me more aware of how important it is to teach the correct terminology.” The principal stated that Janet selected and distributed teacher resources and experiments to all of the staff. According to the principal, Janet also presented some of her teaching activities and the students’ products to other teachers.

I got the impression that both Janet and the principal perceived changes in Janet’s teaching practice. It is beyond the scope of this project to consider whether Janet’s perception of her evolving teaching strategies could be generalized to other science content areas or grade levels. Her attitude toward the role of science language in planning to teach and assess the development of science concepts appears to have changed. If this analysis is correct, then it might be inferred that participation in the workshops fostered her re-evaluation of her teaching practice to some extent.
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Val

In my self-study, I noticed that two different strands of changes took place in my teaching practice. The first strand was evidenced by my negotiations with the volunteers regarding the presentation of curriculum content that was meaningful to them. The interactions with, and feedback from, the volunteers affected my selection of relevant experiments, concrete materials, and diagrams for the workshops. The second strand was evidenced by my search for effective presentation techniques. Feedback from the volunteers, Heidi, and Tammy stimulated me to alter my presentation strategies and the content. The information in my case reveals that the format for the first three workshops was about 80% “hands-on” activities and 20% discussion. The format gradually shifted until it was 100% discussion in the last three episodes. The content changed from being focused on discussing experiments to being focused on discussing teaching and/or assessment strategies for school science language and concepts.

Generalization

Apparently, each teacher noticed some changes in her teaching practice over the timeframe of this project. It is beyond the scope of this project to consider whether the volunteers’ perceived changes in practice were due solely to this project or to other outside factors and influences.
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Implications for Further Research

In my judgement, the professional development program that is described in this project is useful for promoting oral reflection upon practice by experienced teachers. However, several questions arise which have important implications for further research:

1. How might the findings be influenced by recruiting a larger group of teachers from both genders?

2. How might the findings be affected by conducting the project in longer individual episodes or over a longer period of time?

3. Should I have structured the project to include observation of the teachers in their classrooms?

4. What might be a logical subsequent research project?

The findings of this project, together with the above questions, encourage me to suggest a long-term project to continue the investigation of the role of language in the planning of science instruction. The proposed program might involve six stages, (stage A to stage F) spaced over approximately two school years.

Stage A: The initial stage might be organizational procedures, similar to phase one in my research project. However, stage A might occur at a research site during a May – Dec. timeframe. That might encourage the enlistment of a larger number of teachers who might be willing to participate for a longer time.
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Stage B: The second stage might be the establishment of a community of inquiry, similar to phase two in the current research project. However, stage B might occur during a Jan. – Mar. timeframe.

Stage C: The third stage might be observation of the teachers in their classrooms while they taught a selected science topic during term three (Apr. – June). This initial observation phase would provide a baseline for comparison to the subsequent second observation stage in the next school year.

Stage D: The fourth stage might be an examination of the role of language in the planning of science instruction, similar to phase three in the current research project. Stage D might occur during Sept. – Dec. of the second school year.

Stage E: The fifth stage might be the observation of the teachers in their classrooms while they taught the topic that they planned for in stage D. This fifth stage might occur during Jan. – Mar. of the second school year.

Stage F: The last stage might include comparisons between the two sets of classroom observations, a series of individual interviews and a research synopsis. The final stage might occur during Apr. – June of the second school year.

Such a two-year research program might present several organizational problems but it might also provide deeper insights into the role of language in the planning of science instruction.
References


Appendix: Susan’s Responses to the Research Synopsis

Gr. 4/5 School Science Language and School Science Concepts:
Case Studies of Teachers of the Gifted

Purpose of this Project

This project was designed as a professional development program for elementary teachers of the gifted and it occurred within the framework of a series of Gr. 4/5 “hands-on” science workshops and interviews. In the context of “planning for instruction,” this project examined the use of Gr. 4/5 school science language by the three participating teachers and the researcher. It also examined the teachers’ judgements about selecting, defining, teaching and/or assessing school science language and school science concepts.

Introduction

When communication is facilitated through a language, all participants need to have a comparable functional understanding of that language. School science language is the expected form of language usage for science content areas as specified in the K-7 Science IRP. In contrast, everyday science language is the culturally expected social norm of language usage for science topics within the general community. For example, the Gr. 5 PLO states that students should be able to describe basic units of matter. I'm not sure if I interpret the term "basic units" in the same way that the Ministry does.

School science concepts are the domain-specific science ideas that are mandated in each Prescribed Learning Outcome (P.L.O.) within the K-7 Science curriculum. School science concepts may not be learned without academic training and are generally communicated through school science language and activities. Teachers are important mediators in the development of school science language and concepts. This project intended to document the teachers’ perceptions of the role of language in planning science instruction for gifted children.

I'd like to see a list of terms to be studied be included in the P.L.O.'s.
Appendix: Susan’s Responses to the Research Synopsis

This project also explored the teachers’ views on the relationship between the development of school science language and the development of school science concepts. This project included seven science workshops and three sets of individual interviews related to planning for instruction.

Synopsis of the Preliminary Findings:

<table>
<thead>
<tr>
<th>FINDINGS</th>
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<tbody>
<tr>
<td>The teachers felt empowered by their participation in this project, in</td>
<td>← being able to discuss strategies with fellow teachers and facilitators was beneficial</td>
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<tr>
<td>respect to their usage of school science language and its relationship</td>
<td>I don’t think that we should ever be particularly dependent on worksheets.</td>
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<td>to the planning of student activities. They reported an increase in</td>
<td>I think that a lot of these activities are already in place given the nature of the school</td>
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<td>confidence and were more willing to take risks. They became more</td>
<td>This comment was made in relation to using worksheets/wordsearches etc. to teach terms.</td>
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<td>selective in their use of student activities, with a decreased emphasis</td>
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<td>on the completion of worksheets and an increased emphasis on</td>
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<td>experiments, oral debates, group discussions, model-building,</td>
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<td>game-board construction, game show quizzes and various student</td>
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<td>presentations.</td>
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<td>The teachers recognized that an important relationship exists between</td>
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<td>the usage and development of Gr. 4/5 school science language and the</td>
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<td>related concepts. They became increasingly aware of their own</td>
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<td>selection of appropriate terms and the necessity of probing</td>
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<td>students for evidence of the understanding of a science concept,</td>
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<td>rather than accepting the regurgitation of memorized terms. Teachers</td>
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<td>reported that the students felt empowered by their mastery of school</td>
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<td>science terms.</td>
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<td>The teachers recognized that “hands-on” experiences were effective</td>
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<td>for introducing new science terms and for generating contextual</td>
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<td>definitions. During activities, everyday procedural language was</td>
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<td>often used but post-activity discussions promoted more complex</td>
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<td>definitions of science terms and divergent applications for those</td>
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<td>terms.</td>
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## Appendix: Susan’s Responses to the Research Synopsis

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<td>I also recognized the importance of using very specific wording when writing up tests. Sometimes children would get confused because to identify the same thing labels we use multiple labels for the same parts.</td>
</tr>
<tr>
<td>The teachers reported that they listened more carefully to what their students said and that they gave the students more time to discuss ideas in pairs and groups. Also the teachers became more receptive to divergent science observations and personal interpretations of events.</td>
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<td>The teachers reported that participation in an activity or experiment increased the likelihood that they would modify and incorporate it into their lessons. The teachers reported that they had increased their repertoire of science experiments and activities, especially those which helped develop the use of science terms and concepts.</td>
<td>Yes I found this to be quite true. The opportunity to do an experiment beforehand also made one more sensitive to problems that might arise.</td>
</tr>
<tr>
<td>The teachers reported that tactile experiences evoked generalized memories and associations that might not have occurred otherwise. Touching an item can stimulate various responses such as nausea, aversion, relaxation, curiosity, reflection or empathy (e.g., chicken bones and hand-pump).</td>
<td></td>
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<td>The teachers stated that their increased confidence meant that science concepts were no longer regarded as isolated areas of content, rather teachers utilized the interests of students and thematic inquiry strategies to explore, expand and integrate related science concepts. The teachers became more concerned about student engagement than the rate at which the content was covered.</td>
<td>I think I’m always aware of covering content. I don’t think one should be sacrificed over the other.</td>
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Purpose of this Project

This project was designed as a professional development program for elementary teachers of the gifted and it occurred within the framework of a series of Gr. 4/5 “hands-on” science workshops and interviews. In the context of “planning for instruction,” this project examined the use of Gr. 4/5 school science language by the three participating teachers and the researcher. It also examined the teachers’ judgements about selecting, defining, teaching and/or assessing school science language and school science concepts.

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This project also explored the teachers' views on the relationship between the development of school science language and the development of school science concepts. This project included seven science workshops and three sets of individual interviews related to planning for instruction.

**Synopsis of the Preliminary Findings:**

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<td>Definitely!! Makes science fun for the students.</td>
</tr>
<tr>
<td>The teachers recognized that an important relationship exists between the usage and development of Gr. 4/5 school science language and the related concepts. They became increasingly aware of their own selection of appropriate terms and the necessity of probing students for evidence of the understanding of a science concept, rather than accepting the regurgitation of memorized terms. Teachers reported that the students felt empowered by their mastery of school science terms.</td>
<td>Language &amp; related concepts needs to be understood (vs regurgitated) in order to foster higher level thinking.</td>
</tr>
<tr>
<td>The teachers recognized that &quot;hands-on&quot; experiences were effective for introducing new science terms and for generating contextual definitions. During activities, everyday procedural language was often used but post-activity discussions promoted more complex definitions of science terms and divergent applications for those terms.</td>
<td>Definitely!!</td>
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<td>It is essential to understand and feel comfortable with science language before introducing it to the students.</td>
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<td>The teachers reported that they listened more carefully to what their students said and that they gave the students more time to discuss ideas in pairs and groups. Also the teachers became more receptive to divergent science observations and personal interpretations of events.</td>
<td>Units/experiments/activities should be based on student interest. Establishing meaning to explore further.</td>
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<td>The teachers reported that participation in an activity or experiment increased the likelihood that they would modify and incorporate it into their lessons. The teachers reported that they had increased their repertoire of science experiments and activities, especially those which helped develop the use of science terms and concepts.</td>
<td>Participating in the activity/experiment made me more confident in my ability to share it with my students.</td>
</tr>
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<td>The teachers reported that tactile experiences evoked generalized memories and associations that might not have occurred otherwise. Touching an item can stimulate various responses such as nausea, aversion, relaxation, curiosity, reflection or empathy (e.g., chicken bones and hand-pump).</td>
<td>These tactile experiences placed us in the role of a student. They made us more aware of what our students experience in regards to touching an item, etc.</td>
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<td>The teachers stated that their increased confidence meant that science concepts were no longer regarded as isolated areas of content, rather teachers utilized the interests of students and thematic inquiry strategies to explore, expand and integrate related science concepts. The teachers became more concerned about student engagement than the rate at which the content was covered.</td>
<td>Science should be an experience, rather than simply trying to teach us explore. Minimy expectations as outlined in the PRs.</td>
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Appendix: Janet’s Responses to the Research Synopsis

Gr. 4/5 School Science Language and School Science Concepts:
Case Studies of Teachers of the Gifted

Purpose of this Project

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This project also explored the teachers’ views on the relationship between the development of school science language and the development of school science concepts. This project included seven science workshops and three sets of individual interviews related to planning for instruction.

Synopsis of the Preliminary Findings:

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<td>Yes, definitely more hands-on been used. As students seemed more engaged, they asked more complex questions about the science content. Instead of memorizing terms, students felt empowered by their mastery of school science terms.</td>
</tr>
<tr>
<td>The teachers recognized that an important relationship exists between the usage and development of Gr. 4/5 school science language and the related concepts. They became increasingly aware of their own selection of appropriate terms and the necessity of probing students for evidence of the understanding of a science concept, rather than accepting the regurgitation of memorized terms. Teachers reported that the students felt empowered by their mastery of school science terms.</td>
<td>The “hands-on” experiences were effective for introducing new science terms and for generating contextual definitions. During activities, everyday procedural language was often used but post-activity discussions promoted more complex definitions of science terms and divergent applications for those terms.</td>
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### FINDINGS

| The teachers recognized the multiple and powerful role of language in that their own awareness of school science language affected their selection of teaching resources, lesson planning, the design of experiments, the format for student assignments, the amount of emphasis placed on the development of science vocabulary, both verbal and written interactions with the students and the strategies chosen to assess the students' understanding of terms and concepts. |
| The teachers reported that they listened more carefully to what their students said and that they gave the students more time to discuss ideas in pairs and groups. Also, the teachers became more receptive to divergent science observations and personal interpretations of events. |
| The teachers reported that participation in an activity or experiment increased the likelihood that they would modify and incorporate it into their lessons. The teachers reported that they had increased their repertoire of science experiments and activities, especially those which helped develop the use of science terms and concepts. |
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Episode #4 - Feb. 5, 2001

Activity P3-J: What did I touch!

This activity can be integrated with different science topics. For example, consider the following P.L.O.'s:
1. Relate the structure and behavior of local organisms to their survival in local environments, Gr. 4.
2. Describe the changing requirements of organisms as they grow, Gr. 4.
3. Identify the basic structure and function of the organs in the sensory system, Gr. 5.
4. Compare and contrast the sensory systems of humans with those of animals, Gr. 5.
5. Describe technologies that allow humans to extend their natural abilities, Applications of Science, Gr. 5.

Materials: large manila envelopes
thin disposable plastic gloves
6 squares of different materials or fibres
masking tape

Additional Materials:
thick industrial plastic gloves
small household items like keys, crayons, erasers, etc.
small natural items like feathers, leaves, bark, etc.

Procedure: 1. Place a hand inside the plastic glove that is taped inside of the envelope.
2. Move your hand inside the envelope. No peeking.
3. Describe the different materials that you can touch.
4. Predict what the materials are. Record your predictions.
5. Open the envelope. Compare your predictions with the results.
6. Discuss how humans can identify items without seeing them.

Extensions: 1. Use thick industrial plastic gloves instead of thin ones.
2. Use other materials inside the envelopes.
3. Chill your hand for one minute in cold water. Dry your hand and then place it inside an envelope without using a glove.
4. Perform the experiment in a dark room.

Questions: 1. What words or phrases do children generally use when they talk about their skin?
2. How is the function (purpose, use) of the glove similar to (and different from) human skin?
3. How is the form (structure, composition) of the glove similar to (and different from) human skin?
4. Why is the skin of a shark, a snake, or an elephant different from human skin?
5. Is our skin alive? How can we tell?
6. How can technology assist astronauts and deep-sea divers to touch and hold things even though they must wear thick pressurized suits?
Appendix: Examples of Workshop Activities

Episode #4 - Feb. 5, 2001

Activity P3-K: Herakles and the egg!

This activity can be integrated with different science topics. For example, consider the following P.L.O.'s:

1. Describe the basic structure and function of the skeletal system, Gr. 4.
2. Identify common elements and molecules, Gr. 5.
3. Relate the life processes of an organism to its use of nutrients, Gr. 4.
4. Identify relevant variables in an experiment, Gr. 5 Applications of Science.

Materials: basin or cooking tray paper towels fresh eggs (small) masking tape glass jar plastic drinking glass cotton balls metric weights lab coats or plastic garbage bags

Additional Materials: glass pickling jars with lids various liquids like vinegar, glycerin, corn syrup, lemon juice and saturated salt solution microscopes duck or goose eggs

Procedure Part I:

1. Protect clothing with a lab coat or a plastic garbage bag.
2. Hold a fresh egg in one hand over the cooking tray.
3. Hold the egg at the two pointed ends using only the fleshy part of the thumb and the index finger of one hand. Hold egg vertically.
4. Squeeze your thumb and index finger against the ends of the egg.
5. Observe what happens.
6. Suggest reasons to explain your results.

Procedure Part II:

1. Construct an egg-cup (egg holder) out of cotton balls and masking tape.
2. Place egg-cup inside the glass jar, at the bottom of the jar.
3. Place an egg into the egg-cup so that the egg is supported vertically.
4. Place a plastic drinking glass on top of the egg so that the glass is touching the top point of the egg.
5. Predict how many grams of weight will need to be added to the drinking glass before the eggshell cracks.
6. Carefully add metric weights gently into the drinking glass.
7. Observe what happens. How much weight does it take to break the eggshell?
8. Repeat steps 3 to 7 in Part II with five new eggs, successively.
9. Discuss the range that is observed in the results.
10. What factors can affect the range in the results?
Appendix: Examples of Workshop Activities

Extensions: 1. Examine the different parts of the eggshell with a magnifying glass.
2. Predict what will happen to an egg that is left for two weeks in various different
   liquids (while sealed inside of a jar that is completely filled with the liquid).
3. Use extra large eggs instead of small size eggs.
4. Use duck or goose eggs instead of chicken eggs.

Questions: 1. Compare and contrast an eggshell to a human skull. What are the similarities and
differences?
2. Is the eggshell alive? Are our skulls alive? How can we tell?
3. Compare and contrast the contents of a raw fresh egg to the contents of the human
   skull. What are the similarities and differences?
4. How can these activities help us to determine the chemical composition of eggshells
   and of bones?
5. How could the materials/activity be modified for your classroom?
6. What words or phrases do children generally use when talking about eggshells,
skulls and other bones?
Appendix: Examples of Workshop Activities

Episode #4 - Feb. 5, 2001

Activity P3-L: Biological Transportation Pipelines.

This activity can be integrated with different science topics. For example, consider the following P.L.O.'s:

1. Describe the basic structure and function of the organs of the circulatory and respiratory systems, Gr. 5.
2. Describe how technology has affected human health, Gr. 5.
3. Compare and contrast the muscular systems of humans and various animals, Gr. 4.
4. Predict the results of an experiment, Applications of Science, Gr. 4.

Materials: rubber air pump
turkey basting pump
eye droppers
red food colouring
glass beakers
pipettes
capillary tubes
stethoscopes
stop watches

Additional Materials: bicycle pump
air mattress pump
aquarium pump

Procedure Part I:

1. Fill three beakers with 250 mls of water. Add one drop of food colouring to the water in each beaker.
2. Predict which method of transport will be the fastest/slowest:
   a) using the turkey basting pump to move the liquid out of the beaker and transfer it to another empty beaker,
   b) using an eye dropper to transport the water,
   c) using a pipette, or
   d) using a capillary tube. Explain your predictions.
3. Begin the transport of the water. Continue with each type of transport for one minute.
4. After one minute, measure the amounts of water that were transported by the four different methods.
5. Which method transported the most water, the least? Discuss the reasons why you think that you got these results.
6. Discuss the relevant variables in this experiment.

Procedure Part II:

1. Use the rubber air pump to transport the water from one container to another.
2. Describe how the pump is similar to (and different from) the human heart.
3. Chart the responses to step #2 above.
4. Use a stethoscope to listen to the pulse at your throat, your chest and your wrist.
5. Describe what you notice about your pulse at different places. Is your pulse the same or is it different? Does your pulse sound louder or quieter?
Appendix: Examples of Workshop Activities

Extensions:
1. Use the different pumps to fill up basketballs with air. Time how long it takes.
2. Use Part I to represent different parts of the respiratory system.

Questions:  
1. What kinds of materials do we usually transport through pipelines? 
2. What could the turkey basting pump, eye dropper, pipette and capillary tubes represent in the circulatory system? In the respiratory system?  
3. What are the relevant variables in Part I?  
4. How could Part I and Part II be related to blood pressure?  
5. How is the rubber pump a good (and bad) model of the human heart?  
6. What words do children generally use when talking about the heart and blood vessels?  
7. What is the function of the valves inside the human heart?  
8. What words do children generally use when talking about the lungs and the respiratory tract?  
9. How is Part I related to high blood pressure, asthma and emphysema?  
10. Do all mammals have the same kind of heart?