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Talking and Learning
in
Elementary School
Science Lessons

By

Sandra Guilbert

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **TALKING AND LEARNING IN ELEMENTARY SCHOOL SCIENCE LESSONS** submitted by **SANDRA GUILBERT** in partial fulfillment of the requirements for the degree of Master of Education.

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ABSTRACT

This study was based on the premise that language is the ordinary means by which we make sense of our world. The specific hypothesis addressed was that talking collaboratively in small groups is an important method for achieving conceptual change in science lessons. To examine language being used to construct meaning, small group talk during five lessons or sets of science lessons in two grade three classes and two grade six classes was recorded. This talk was transcribed and analyzed for evidence of children learning to language and learning through language. The lessons which fostered talking-to-learn, defined as talking to build understanding, shared a number of characteristics; the children worked together collaboratively and the tasks tended to be open ended, involved the children and made sense to them. Under these conditions the students used language for a variety of purposes and engaged in conversations displaying more complex thinking, rather than simply reporting observations.

Listening closely to the children's conversations during these lessons also revealed a number of areas of concern if science lessons are to be minds-on as well as hands-on. Students appeared to make few connections between newly presented ideas and previous understanding or between school learning and their life outside school. As well, several of the groups did not function collaboratively. There was also a limited amount of evidence of students being actively engaged in meaning-making; instead, activity rather than thinking predominated.

Kid-listening can reveal the degree to which students are involved in a lesson, their meaning-making and how a lesson helps them (or does not help them) develop a skill or come to a better or fuller understanding or appreciation of a concept or phenomena. An enhanced understanding of the "workings" of a lesson, allows teachers to plan lessons that better direct students' attention toward intended outcomes.

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CHAPTER ONE

INTRODUCTION

Language is the ordinary means by which we make sense of our world. Talk, the form of language most accessible to us from childhood through old age, is of primary importance in learning to formulate and communicate these meanings. Such beliefs led members of the London Association of Teachers of English to state, "We have begun to look at language in school, not as a subject to be taught and tested, but as an approach to teaching" (Barnes, Britton & Rosen, 1969, p. 119). They adopted, as well, the slogan, "Present talking is future thinking." Two other statements in particular frame this study: "To bring knowledge into being is a formulating process and language is its ordinary means" (Department of Education and Science, 1975, p. 50) and "If we consider language as a means of learning, we regard the learner as an active participant in the making of meaning" (Barnes, 1976, p. 31).

The predominant image in this thesis is that of the active learner talking him or herself into understanding. This image corresponds, as well, to the learner described in constructivist theory. At the time the above statements were written, the term constructivism was reserved for specific theories, notably Piaget's theory of the construction of knowledge and Kelly's theory of personal constructs. As research on learning provided increasing documentation that knowledge is actively constructed by each learner, not passively received, constructivism became the term of choice in referring to this theory. It should be noted that when the word constructivism gained prominence in the literature on learning, a number of influential works on learning, which espoused this theory without using this nomenclature, provided important additional documentation of active learning. For example, reading Barnes (1976) in 1993, one is struck by his constructivist theme, outlining the necessity of actively involving learners in the formulation of knowledge if that knowledge is to be of any value. However, the word constructivism is never mentioned by Barnes.

Patterns of active learning have been detected "across the curriculum," and described, for example, in writings on language learning, mathematics learning and science learning. Whole language learning and minds-on science are both examples of instruction aimed at involving the learner in the learning process. Both "accommodate a view of the child learner as an active, constructive and generative architect of her own language and her own understanding" (Wood, 1988, p. 116). It is the tight fabric of evidence woven from the strands of research in all the curricular areas that makes the theory of constructivism so compelling.

Based, as it is, on constructivist theory and grounded in the belief that language, with an emphasis on talk, is our primary means of formulating knowledge, this study sought a means of examining the language of learners actively engaged in constructing meaning. A personal concern with the transmission approach to science education being offered to my own elementary school-age children had previously piqued my curiosity about science education in the 1980's. I knew that a number of science curriculum innovations had been developed in the late 1960's and early 1970's, yet I saw no manifestation of these advances. Thus, interested in both language and science concept development, I created this study to provide documentation of how children use their language to make sense in science lessons, focusing on students languaging to learn and learning to language. Such a study necessitated locating classrooms where children were offered the chance to make sense of instructional materials; that is, classrooms where children were placed in small groups to experiment and discuss their findings collaboratively.

In this study, language is viewed as a means of learning for both the students and the teacher. Language provides a window through which teachers can view student understandings, allowing teachers to compare what is being learned with what they intended the students to learn. By listening closely to students, teachers have a chance to make curricular adjustments while the students are involved in learning, rather than relying on evidence from post-instructional assessment to reveal who succeeded and who failed to learn the targeted concepts or facts. Listening can also reveal whether or not students really understand a concept and its implications, while tests may only indicate if a student has been able to successfully memorize a concept statement. This thesis is grounded on the belief that talking and thinking and learning are inextricably bound together. The arguments for this belief are presented in the following chapters.

Chapter Two, Review of the Literature, discusses the writings and theories underlying the study, dividing this discussion into four sections for the reader's convenience. However, the evidence presented in each of these sections is felt to substantiate the overarching theory of constructivism.

Chapter Three describes the methodology used in the study, giving details of the research design, data collection and data analysis.

Chapter Four, The Lessons and the Talk, discusses in some detail the context of each of the five lessons or sets of lessons selected for this study and the resultant talk.

The students' purposes for the talk and the extent to which it was talking-to-learn are discussed.

Chapter Five, Implications for Science Education, addresses the topic of what these conversations reveal about the lessons and the science learning which occurred, seeking to answer the question, were these lessons hands-on and minds-on science?

Oracy, a term coined by Wilkinson in 1965 to refer to talking and listening (a parallel term to literacy which is reading and writing) is the topic of this thesis. The particular focus is on students talking to learn and teachers listening to learn.

Purpose of the Study

The literature indicates (MacLure, Phillips & Wilkinson, 1988; Johnson, 1988; Scanlon, Murphy, Whitelegg & Hodgson, 1992) that while increasing emphasis has been placed on the value of students collaboratively exploring ideas, "there is still much to be learned ... about what talk-for-learning actually looks like, the conditions under which it flourishes and the criteria that we apply when we make judgements about the educational value of children's talk" (MacLure, 1988, p. 3).

This study was undertaken to provide additional documentation in examining talking-to-learn in small groups, focusing here on such talk in elementary school science lessons. Two specific questions were posed:

- What do children talk about during small-group work in science lessons?
- What is the purpose of that talk?

The practical intent for studies such as this one is to help teachers understand the role of talking-to-learn in their classrooms. As stated by the National Oracy Project (NOP), the aim is one of promoting "recognition of the value of oral work in school and an increase in its use as a means of improving learning" (NOP, 1990, p. 2).

As the talk that occurs is highly dependent on context, the contexts created by the teachers through their comments, instructions and worksheets have also been documented, making it possible to more clearly define conditions which enhance children's collaborative exploration of ideas.

Significance of the Study

In science education there has been a movement away from a text-book-based transmission teaching approach towards one stressing student involvement in learning science content and processes through hands-on activities. Hands-on alone, however, has been found to be inadequate. This has led to the addition of the descriptor "minds-on"; science education is now aiming to be hands-on and minds-on. Data are currently being gathered by numerous investigators to describe what minds-on science looks like and how it can be introduced and pursued in elementary school classrooms.

Our understanding of how children learn continues to expand, with increasing evidence supporting the importance of the role language plays in the construction of meaning, and the active role the learner must play if significant meaning is to be constructed.

The significance of this study lies in the extent to which these data contribute to an understanding of how children respond to the tasks assigned to them and how they use their language to make sense of those tasks. It is hoped that the data and discussion will provide insights into teacher actions and classroom conditions which contribute positively to students developing understandings which are "more complex, powerful and abstract " than the ones held previous to the lesson (Cobb, 1988, p. 89).

Personally, this research strongly verified my belief that teachers must listen closely to the meanings that the students are making rather than assuming that students will incorporate into their understanding the "common knowledge" (Edwards & Mercer, 1987) the teacher intends to establish. Talk can be used as a window into student understanding and it is the understandings that students are actually constructing that teachers must attend to, not just to lesson plans and teaching methods which meet effective teaching criteria.

CHAPTER TWO

REVIEW OF THE LITERATURE

In this chapter the published research and thought which have informed this study are outlined. The main theme, the role of language in the construction of meaning, is subdivided into sections; in these I explore the literature relating to thought, language and learning; constructivism; and talking-to-learn. The final section reviews current issues in science education, science being the subject area chosen for this study of talking and learning in elementary schools.

Thought and Language and Learning

"To bring knowledge into being is a formulating process and language is its ordinary means." This quotation from the Bullock Report, *A Language for Life,* (DES, 1975, p. 50) focused attention in the education establishment on the relationship between knowledge and language. Bruner (1986) described the theories of "three modern titans of development theory" (p.156): Freud, Piaget, and Vygotsky. The theories of a slightly different triad, Piaget, Vygotsky and Bruner, will be briefly described in this section in order to provide a background for the above quotation and for the educational implications of the theories addressing the role of language in the development of knowledge and understanding.

Jean Piaget concentrated his studies on the problems of genetic epistemology; that is, on an explanation of the origin and development of human knowledge which he defined as the growth in logical thinking. Trained as a biologist, biological presuppositions formed the foundation and means of explaining many of the theories he proposed, theories that were substantiated by his extensive study of children's ideas.

Piaget (1976) stated that, "Knowledge, at its origin, neither arises from objects nor from the subject, but from interactions ... between the subject and those objects" (p. 13). Knowledge is constructed as a result of interactions as the subject progresses in her/his ability to "know objects adequately" (p. 13). These two concepts, subject-object interactions and construction of knowledge, are the central concepts of Piaget's theory. Piaget explained that a new construct is "grafted onto previous schemes and therefore amounts to assimilation of new elements to already constructed structures" (p. 17). If all that children did was assimilate the new elements, however, they would not progress in understanding and this would be non-adaptive. Stemming from his knowledge of biological adaptation, Piaget believed that organisms must also be able to accommodate new elements; that is, they must be able to modify, not simply expand, their knowledge structures. He commented that a progressive equilibrium between assimilation and accommodation is a fundamental process in cognitive development.

Piaget's research led him to advance a theory of stages in the development of rational thought, each stage representing a different equilibrium between assimilation and accommodation. It is through interactions with objects that children increase their knowledge. These interactions, in Piagetian terminology, range from the most basic sensorimotor actions "to the most sophisticated intellectual operations which are interiorized actions carried out mentally" (p. 12). The stages define the types of concepts which the child is capable of dealing with profitably, that is, with understanding. The implications of the stage theory for education are obviously quite considerable. As Wood (1988) observed, "The effects and effectiveness of teaching are fundamentally constrained" (p. 38) by the child's developmental stage in this view of knowledge growth. Actually, although his theories have had a major impact on education, and particularly on elementary school science education, Piaget himself wrote very little about the educational implications of his work.

Actions, for Piaget, formed the base on which understanding and thought were constructed. Language was but a system of symbols used to represent the world and was not believed to have a formative effect on the structure of knowledge; language was only a medium within which thought could take place (Wood, 1988). However, especially as children talk to each other, language was conceded to possibly facilitate the emergence of thought, particularly if it aided in decentering, decentration being the ability of "the subject to take the points of view of other subjects or objects themselves" (Piaget, 1976, p. 21). For Piaget, the role of education was that of a provider of action opportunities which should be commensurate with the abilities of students to assimilate and accommodate these experiences. There is little emphasis on language in Piaget's theories.

In contrast, Lev Vygotsky postulated a much more central position for language in the development of thought. Indeed, he stated as an indisputable fact that "Thought development is determined by language, i.e., by the linguistic tools of thought and by the sociocultural experiences of the child" (Vygotsky, 1986, p. 94). He also believed that "Real concepts are impossible without words, and thinking in concepts does not exist beyond verbal thinking" (p. 107). This is very different from Piaget's belief that language at best only facilitates the emergence of thinking. Vygotsky concludes *Thought and Language*: "A word is a microcosm of human consciousness." (p. 256). As Bruner (1986) explained, Vygotsky saw language as a means of sorting out thoughts and saw thought as a mode of organizing perception and action.

Both Vygotsky and Piaget stressed the importance of activity in learning. That is, both believed that interactions, not passive receptions, are involved in learning acts. Vygotsky, though, incorporated language as an essential ingredient in learning activities. As stated in the introduction to the 1986 edition of *Thought and Language*, "In Vygotsky's theory, activity as a general explanatory principle finds its concretization in the specific, culturally bound types of semiotic mediation" (Kozulin, 1986, p. xlviii).

"A quiet revolution has taken place in developmental psychology in the last decade," wrote Bruner and Haste (1987, p. 1). The result of this revolution is an increasing appreciation for the role of society and culture in the development of higher mental processes. While Vygotsky has not been the only theorist to advance an argument for the social origins of cognition, the publication of his writings in the West advanced that theory to a prominent position. As stated by Vygotsky (1978), "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, *between* people (interpsychological) and then *inside* the child (intrapsychological). This applies to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relations between human individuals" (p. 57). According to Wertsch (1985), this statement expresses Vygotsky's belief in "social reality as playing a primary role in determining the nature of internal intrapsychological functioning" (p. 63). These ideas form the basis of the theory of the social construction of knowledge or "the social formation of mind" (Wertsch, 1985). Further, Vygotsky saw speech as the primary means by which the child internalizes the external, or social, forms which are necessary for the development of higher mental functions.

Vygotsky went on to describe "the place at which a child's empirically rich but disorganized spontaneous concepts 'meet' the systematicity and logic of adult reasoning" (Kozulin, 1986, p. xxxv): the zone of proximal development. Vygotsky saw the possibilities of instruction by an adult or more able peer as leading, rather than being limited by, development. "Instruction usually precedes development. The child acquires certain habits and skills in a given area before he learns to apply them consciously and deliberately" (Vygotsky, 1986, p. 184). Instruction obviously plays a much greater role in this theory of cognitive development than it does in Piaget's theory.

The third person in the triad of theorists of cognitive development is Jerome Bruner, a psychologist with an early research focus on adult reasoning. Concluding that no one method was used in reasoning, that people adopt different processes which vary in effectiveness, Bruner's continuing studies refocused on the development of these different processes (Wood, 1988). Concomitantly, Bruner became acquainted with Luria, an early colleague of Vygotsky, and other Russian investigators of the psychology of learning, resulting in an invitation to write an introduction to Vygotsky's *Thought and Language* when it was first published in English in 1962. Bruner has stated that he liked Vygotsky's "way of interpreting thought and speech as instruments for the planning and carrying out of activity" (Bruner, 1986, p. 72). Like Piaget and Vygotsky, Bruner views abstract thinking as an outgrowth of actions; like Vygotsky, he believes that language plays an important role in cognitive growth.

Bruner's interest in education is reflected in a number of his works: *The Process of Education* (1960), *Toward a Theory of Instruction* (1966) and *The Relevance of Education* (1971). Bruner also became interested in how children acquire language, recognizing "the significance of language in mental development" (Bruner & Haste, 1987, p. 2). Bruner remarked that the observations of many developmental psychologists had moved the field to "give much more weight to interactions with others, and to the use of language, in the growth of concepts and the developing structure of mind" (p. 8). He felt the Piagetian model "where a lone child struggles single-handedly to strike some equilibrium between assimilating the world to himself or himself to the world" (Bruner, 1985, p. 25) was of limited use in describing cognitive growth.

The relationship between language and cognitive development was not being discussed exclusively by developmental psychologists. In 1966, the London Association for the Teaching of English (LATE), a group of practicing teachers associated with faculty from the University of London Institute of Education (including James Britton, Nancy Martin and Harold Rosen), began a serious dialogue on the role of language in classrooms. In these discussions they found themselves looking beyond the teaching of English in the classroom to a consideration of the role of language in learning and in thinking. Their analyses of talk in classrooms were presented to the 1968 LATE conference, followed by a Discussion Document, "A Language Policy Across the Curriculum," which was circulated to schools for discussion and suggestions. This document stated, "Language is the means by which we learn, understand and communicate; therefore, language development is the direct concern of every teacher." This emphasis on language and learning, not just the teaching of language, is the core concept of language across the curriculum (LAC).

In 1969, Harold Rosen (Barnes et al, 1969) wrote, "We have begun to look at language in school, not as a subject to be taught and tested, but as an approach to learning," (p. 119). The climate, according to Britton (Mallett & Newsome, 1977), was "exhilarating" and the results, I believe, have contributed to a paradigm shift in education, shifting the focus from transmission teaching to an appreciation of the active learner using language to construct meaning. This dialogue on language and active learning gained official recognition in the Bullock Report, *A Language for Life*, published in 1975 by the British Department of Education and Science (DES). This sizable study of the state of English teaching in British schools included a number of statements reflecting the discussions begun by LATE: "It is the role that language plays in *generating* knowledge ... that typifies human behavior" (p. 47), and the often quoted, "To bring knowledge into being is a formulating process and language is its ordinary means" (p. 50). Among the concluding recommendations was the statement, "Each school should have an organized policy for language across the curriculum, establishing every teacher's involvement in language and reading development throughout the years of schooling" (p. 514).

A co-author of *Language, the Learner and the School* (Barnes et al, 1969) and of the Bullock Report (DES, 1975), James Britton published *Language and Learning* in 1970, a book which was, and continues to be, a profoundly important work with an intended audience of "anybody who for any reason wants to listen with more understanding to children and adolescents and who has for any reason a concern for what becomes of them" (p. 7). In readable form, Britton provided a synthesis of writings by philosophers, psychologists, linguists and educators, drawing together their varied thinking on the subject of language and learning. Quoting, explaining and expanding their meanings by reference to language, spoken and written, used by children and adolescents, Britton examined language as "a means of organizing and consolidating our accumulated experience...[and] interacting with people and objects to create experience" (p. 278-9). He believed that "before a child can 'make something' of experience, in the sense of turning it to his advantage, he must 'make something' of it in the sense of reducing the flux to order: and there can be no doubt whatever that language is a principal agent in achieving this in all normal cases" (p. 69). Britton's influence has extended beyond that of an often cited author into classrooms themselves because of his involvement with educators at the university and classroom level. A teacher for many years, Britton was a founding member of LATE, of the National Association of Teachers of English (NATE) when it was formed, and worked in and maintained contact with language educators in North America, Australia and New Zealand. As Emig (1987) wrote, Britton's influence has been due to "an attitude, a set of beliefs about what educational research is, about who does it, in what kinds of human arrangements, about the language in which it discovers its meaning, and, indeed, about why we do it, to what ends. Central here are the roles of teachers in such inquiries" (p. 268). Britton (1987) suggested that the 1980's should be 'the decade of the classroom teacher,' observing that "every lesson should be for the teacher an inquiry, some further discovery, a quiet form of research, and that time to reflect, draw inferences and plan further inquiry is also essential" (p. 14).

The issues raised by the language across the curriculum movement and the Bullock report resulted in a considerable amount of writing over the next few years. This literature focused on the role of language in learning, particularly spoken and written language, asking how often students were given the opportunity "to explain, interpret, describe, define, give an opinion, infer, speculate, predict, paraphrase, summarize, compare or contrast, give an opinion, or inquire .... [or to] talk or write in order to develop their own understanding, to inform others, to record or report, to reflect, evaluate, persuade, or entertain?" (Fillion, 1983, p. 704). In the same vein, Mayher and Lester (1983) wrote, "Unless the curriculum is reconceptualized to give children's language production equal weight with the process of language reception, most students will never be given the opportunity to actively engage the material they are learning" (p. 719).

Marland (1977), another member of the Bullock committee, offering a fuller explanation of language across the curriculum and its implementation in secondary schools, stated, "Only through language can we hypothesize, and the ability to hypothesize is the central ability of developed thought" (p. 18). Clive Carre (1980), addressing a Canadian Council of Teachers of English Annual Conference, reminded the participants that teachers need to be aware of what students are actually understanding, that "Words and ideas given to a student who is unable to make connections with previously acquired knowledge are relatively meaningless and cannot be used or transferred" (p. 49). Ten years later, Dillon (1990) noted that "the notion of language across the curriculum ... has not really caught on or displaced a more traditional language arts focus in North America" (p. 7). It seems to have been Dillon's perception that a meaningful discussion about language and learning and the issues these ideas raise about active participation by both teachers and students in a joint construction of knowledge had yet to be developed here within the circle that really counts - the teachers in the classrooms.

Constructivism

Constructivism is, quite simply, a theory of learning with a central tenet stating that knowledge is actively constructed by each learner, not merely passively received. While this may sound unremarkable, it has vast implications for educational systems based on a transmission view of learning. As von Glaserfeld (1991) wrote, "For constructivists, *knowledge* refers to a commodity that is radically different from the objective representation of an observer-independent world. ... Instead, *knowledge* refers to conceptual structures that epistemic agents, given the range of present experience within their tradition of thought and language, consider viable" (p. 119).

Piaget stressed the construction of knowledge as a cornerstone of his theory of cognitive development. For Piaget, it is the viability of a concept for a subject that is of importance, not its absolute match to an objective reality. This means that knowledge is constructed by individuals based on their expectations (formed by previous experience) and their present interactions. If understandings continue to fit the subject's perceptions, equilibrium is maintained, equilibrium being an important component of survival in evolutionary theory.

The other two members of the triad of cognitive development theorists described in the previous section, Vygotsky and Bruner, have also espoused a constructivist viewpoint, although not exactly as Piaget described it. Bruner (1986) has stated, "I am by long persuasion ... a constructivist, and just as I believe that we construct or constitute the world, I believe too that Self is a construction, a result of action and symbolization" (p. 130). Vygotsky, writing about the process of concept formation, stated that "it is a functional use of the word, or any other sign, as means of focusing one's attention, selecting distinctive features and analyzing and synthesizing them, that plays a central role in concept formation" (Vygotsky, 1986, p. 106). Directing mental processes is an active process; focusing, analyzing and synthesizing are certainly not passive endeavors. As Vygotsky (1986) wrote, "The development of nonspontaneous concepts... are not simply acquired by rote but evolve with the aid of strenuous mental activity on the part of the child" (p. 157).

Another name associated with constructivism is that of George Kelly, although he, strictly speaking, wrote of constructs or construction systems. "Man," he wrote, "looks at his world through transparent patterns or templates which he creates and then attempts to fit over the realities of which the world is composed....Let us give the name *constructs* to these patterns that are tentatively tried on for size" (Kelly, 1963, p. 8-9). While Kelly defined a psychological, not a cognitive development, theory, it is a theory which views individuals as active construers of their own reality, attempting to construct a system for predicting and controlling events in their lives. Kelly's was a theory of personality and his descriptions of learning were illustrated with examples drawn from experimental psychology. Substituting the word teacher for experimenter, the following statement could describe the view of many present educators: "When a subject [substitute student] fails to meet the experimenter's [teacher's] expectations, it may be inappropriate to say that he has not learned; rather one might say that what the subject learned was not what the experimenter expected him to learn. ... Let the experimenter find out what the subject is thinking about, rather than asking the subject to find out what the experimenter is thinking about" (p. 77). Again, humans are portrayed as constructing, not simply receiving, understandings of their world.

Wood (1988) noted that "any theory of what teaching entails will have to accommodate a view of the child learner as an active, constructive and generative architect of her own language and her own understanding" (p. 115-116). This is the theme being voiced not only in lengthy, densely reasoned books and articles for academics, but, increasingly, in books and journals for teachers. For example, in 1990, the *Arithmetic Teacher* devoted the "Research into Practice" column for that year to articles describing different examples of constructivism in action in classrooms. The language across the curriculum movement from its inception has stressed the necessity of active participation by learners if real learning is to occur. As Barnes (1976) stated, "the school's manifest purpose [is] the pupils' participation in the enactment of knowledge (p. 18). David Dillon, editor of *Language Arts* from 1983 to 1990, took a language for learning stance, writing (1990) that "language across the curriculum implies that we focus on what meaning learners make and how that meaning is made" (p. 7). Brophy (1992) has gone "beyond 'effective teaching'" (p. 4) to a consideration of the role of the student in learning, recognizing that "students develop new knowledge through a process of *active construction*" (p. 5).

Britton (1969) wrote, "We teach and teach and they learn and learn" (p. 81), noting, however, the lack of a direct relationship between the two. In 1991, von Glaserfeld stated that "Telling' is not enough.... Yet many who are involved in educational activities continue to act as though it were reasonable to believe that the verbal reiteration of facts and principles must eventually generate the desired understanding on the part of students" (p. 127). Constructivism is about how learners build understanding. It is about the learning happening in classrooms, the development of concepts that are "more complex, powerful, and abstract" than the ones held originally by the students (Cobb, 1988). It is reasoned that only the information and experiences that help students make better sense of their world as they perceive it are likely to lead to real understanding, an understanding which must be actively constructed by the learner.

A word often heard in discussions of learning as sense-making is that of metacognition, the knowledge and control an individual has over her/his thinking and learning strategies (Baker & Brown, 1984). In reading, this allows a person to realize when text is not making sense and to make the needed corrections; in mathematics, it warns a person that an answer does not make sense, that corrections are needed; in science, metacognition "empowers the learner to undertake the constructivist processes of recognition, evaluation and revision of personal views" (Baird, Fensham, Gunstone & White, 1991, p. 164). Related to metacognition is the increased emphasis on providing reflective time during lessons. When learning is seen to be more than additive, more than an accumulation of data, but is defined instead as the active construction of knowledge, then a person needs time for "figuring it out." Students need time to assimilate or accommodate new experiences and data to their present understandings, asking and answering such questions as: Do these new ideas make sense? Are they useful? How can I use these ideas to more satisfactorily explain my world? The answers will determine if a lesson results in what Barnes (1976) referred to as *action knowledge*, knowledge which becomes incorporated into a person's world view, or remains *school knowledge*, knowledge presented and partly grasped, but not incorporated "into the inner map on which [a student's] actions are based" (p. 80). Or, as defined by Edwards and Mercer (1987), whether knowledge is *ritual*, knowing how to do something "without any grasp of what it [the activity] was all really about" (p. 99) or *principled*, "oriented towards an understanding of how procedures work" (p. 97), that is, "an understanding [of] the issues and concepts and their relationship to the activities" (p. 99).

A number of classroom practices have been advocated for their efficacy in promoting active knowledge construction. One of these is cooperative group learning. There is an extensive literature on this subject, some containing emphases which would not be considered constructivist in nature, but, rather, aim at promoting better retention of facts. This being so, it is necessary to describe the focus of each of the different types of peer-based instruction in order to differentiate the type of group learning considered important for building understanding.

Using Phelps and Damon's (1989) terms of differentiation, peer-based instruction can be divided into three different approaches: peer tutoring, cooperative learning and peer collaboration. These differ in the ways that students are encouraged to interact, in the compositions of the learning groups and in the curriculum material upon which they focus. These authors contrast the three approaches with respect to the degree that each encourages peer interactions that are equal (equality) and discourse that is mutual (mutuality). Peer tutoring is an approach that assumes one learner is more advanced and is capable of assisting another learner; as such, it is judged relatively low in equality. However, discourse between peers is capable of developing into a dialogue high on interaction (mutuality). Cooperative learning is a broader sub-category, incorporating a number of different team-learning approaches which differ significantly in their emphases on rewards and competition. When the composition of the groups includes students randomly selected by gender and intellectual ability, team learning will often be high in equality. However, a number of different approaches to group work has been advocated, varying from highly interactive group work to group work where tasks are divided up and each part is assigned to an individual within the group. This, of course, leads to wide variations in mutuality.

The third approach, collaborative group learning, is also based on groups of students of different abilities working together on a task. The collaborative approach encourages joint action and discussion, the sharing of ideas and views in order to build understandings that are broader than those probable for just one student. Given these emphases, collaborative group learning is considered to be high on both equality and mutuality.

Slavin (1987) divided the cooperative learning strategies being described in the literature into two groups, those with a developmental perspective and those with a motivational perspective. The developmental perspective assumed that "interaction of children around appropriate tasks increases their mastery of critical concepts or skills" (p. 1162). In contrast, "motivationalists are more concerned with the reward or goal structures under which group members operate" (p. 1162). It is often difficult to compare the results of the research conducted from the two different perspectives as quite different tasks are assigned, ranging from concept formation to the learning of a set of facts. As these tasks require a variety of assessment types, comparisons can be meaningless. Assumptions of motivation also differ markedly, from the belief that students require rewards and competition to make significant learning gains, to the belief that students intrinsically seek meaning and competence and tasks which are perceived as meaningful are rewarding in themselves. The debate about the relative worth of these different approaches seems to be based on an attempt to find one learning strategy that is superior to all others. Rather, teaching and learning are much more complicated than that and different pedagogical strategies are required depending on the topic and the approach to that topic the teacher wishes to take (Shulman, 1986).

This background provides a means of defining collaborative group work from a constructivist perspective. In Phelps and Damon's (1989) terms, it should feature equality and mutuality. Using Slavin's (1987) divisions, it fits into the developmental perspective, although I dispute his claim that collaborative group work as defined here would be aimed at the mastery of skills. This approach is chosen when lessons involve conceptual change, when teachers wish students to "make knowledge their own, not by repeating what they heard, but by exploring ideas through intense conversations with others with whom they quite often disagree. These discussions afford the participants the opportunity to think and rethink, formulate and reformulate their ideas, using what they know, what they think and what they hear, until they reach some sense of completeness about their own thoughts and understanding" (Sharan, 1988, p. 2), this being a form of learning engaged in by Jewish scholars for the past 2000 years. Collaborative group work provides for the articulation of ideas and presentation of differing opinions, leading to individual reconstruction of knowledge, by weaving together previous understandings and new insights gained from this experience and from the explanations given by others.

When "in one and the same situation, different cognitive approaches to the same problem are socially produced" (Doise, 1990, p. 50), socio-cognitive conflict is said to exist. Interested in Piaget's claims that confrontation between differing views is necessary to promote both individual and societal cognitive development, Doise and his colleagues have conducted a series of experiments over the last fifteen years studying the effects of socio-cognitive conflict. Among their conclusions are the proposals that: "Social interaction becomes a source of cognitive progress by virtue of the socio-cognitive conflict it engenders; it is the simultaneous confrontation of different individual perspectives or centrations that gives rise to their integration within a new structure;" and "It is through coordination of their own actions with others that children are led to construct new cognitive coordinations they are not capable of individually" (Doise, 1990, p. 62). The latter statement would appear to tie this research into Vygotsky's concept of the zone of proximal development (Vygotsky, 1978) with peers scaffolding one another within this zone. Thus, Doise's work, undertaken to study Piaget's concept of socio-cognitive conflict, validated Vygotsky's concept of the zone of proximal development as well.

It is such intermeshing of powerful theories of learning that has advanced constructivism to the prominent position it presently occupies in the field of cognitive development and learning theory. It remains to be seen, however, whether constructivist theory will be translated into curricula used in classrooms to actively engage students in the construction of knowledge.

Talking to Learn

Talk in classrooms was the initial focus of LATE when they began their deliberations about language and learning. The result of this interest was their slogan, "Present talking is future thinking." Their observations had convinced them that classrooms were dominated by teacher talk. If using language aids in the development of language, who was getting the linguistic practice? Britton (1969), considering teaching and learning, wrote, "We want children, as a result of our teaching, to *understand;* to be wise as well as well-informed, able to solve fresh problems rather than have learnt the answers to old ones; indeed, not only able to answer questions but also able to ask them" (p. 81) and, "I believe also that the movement in words from what might *describe* a particular event to a generalization that might *explain* that event is a journey that each must be capable of taking for himself - *and that it is by means of taking it in speech that we learn to take it in thought*" (p.114).

In 1976 *From Communication to Curriculum* was published (Barnes) with the stated purpose of exploring the relationship between communication and learning. Barnes argued strongly for student involvement in learning, asking "What part do the learners play in the formulation of knowledge? Where does speech come into this?" (p. 18). In later chapters, he answered that "pupil's talk ... is a major means by which learners explore the relationship between what they already know, and new observations or interpretations which they meet" and "all knowledge has to be actively incorporated into the way he interprets the world, or it will be of little value' (p. 81). He stressed that "language... is the major means by which we consciously organize experience and act upon it" (p. 84). Furthermore, "When placed in the speaker's position we have to have insight into principles in order to construct step-by-step sequence. It is this grasp of principle, of underlying structures, which makes the difference between rote learning and understanding" (p. 114). As Barnes stated, "My main thesis in this book is that the learner should take more part in the formulation of knowledge" (p. 191) and, "The more a learner controls his own language strategies, and the more he is enabled to think aloud, the more he can take responsibility for formulating explanatory hypotheses and evaluating them" (p. 29).

The Schools Council in Great Britain had also become interested in language development in the primary schools and commissioned a report on this topic. The report, published as *The Language of Primary School Children* (Rosen & Rosen, 1973) considered all aspects of language in the classroom, starting with talk. Members of LATE, continuing to be intrigued with talk and its relationship with learning, published "a book of talk, and to a less extent a book about talk" (Martin et al, 1976, p. 9) entitled *Understanding Children Talking.* All of these works stressed that informal talk in small groups is an important part of learning. Bullock (DES, 1975), too, supported a significant role for oracy in the curriculum.

The arguments for talking-to-learn are based on both the theories of thought-language-learning connections and of constructivism. The acceptance of these explanations of learning does establish every teacher's involvement in language development, a recommendation of the Bullock Report (DES, 1975). Barnes (1976) wrote, "If we consider language as a means of learning, we regard the learner as an active participant in the making of meaning." Using Halliday's (1982) terminology, talking-to-learn is justified by both its ability to aid in learning through language and in learning about language. The following discussion will focus on describing talk in the classroom in these terms. A third aspect, teachers using this talk as a means of monitoring children's ideas, will also be considered.

"Oh, I'm just thinking out loud," is a statement that gives much pleasure to proponents of talking-to-learn, reinforcing their belief that talk allows a person the chance to come to a realization of what s/he understands or believes, out loud where the statements can be heard, considered and, possibly, corrected. "I hear *myself* as I speak; my own subjective meanings are made objectively and continuously available to me and *ipso facto* become "more real" to me" (Berger and Luckman, 1967, p. 36). In addition, in conversations participants not only state their own ideas, but hear what others think, undoubtedly somewhat different as each person has constructed his/her understandings from different personal experiences. "The joint and mutual use of language gives us a huge step in the direction of understanding other minds" (Bruner, 1986, p. 62). The realization that other viewpoints exist introduces cognitive conflict which Piaget saw as important. In Piagetian theory this realization aids the child in decentering, in becoming more aware of a range of options. It is this language function that Piaget stated to be indispensable for cognitive development (Piaget, 1969). Thus, in conversation, we clarify our own views to ourselves and others and listen to the views of the other participants; we share our understandings. From this can evolve an understanding that is broader and more inclusive than that which would have been possible for any one of the participants to synthesize. As Torbe & Medway (1981) stated, "They do together, with mutual support, what none of them could have done individually" (p. 48).

However, students are not only learning through language, but are also learning about language in these conversations. They are learning to communicate: to state and justify opinions, chosing relevant data for doing so, and also to listen and give consideration to the opinions of others. Students are given an opportunity to negotiate meaning, using persuasion, questioning, argumentation and consensus-building to reach a more comprehensive understanding of the topic. In this talk, students do not merely add new knowledge to old, but their understandings change (Dudley-Marling & Searle, 1991). Conversations which foster such development in the classroom seldom happen spontaneously; they are carefully planned. Jones (1988) suggested that three elements are important for the success of learning-talk: "The task should be of interest to the pupils; the task should be an open one, where a number of responses ... are possible; and there should be as far as possible a purposeful and understood 'outcome' from the talk" (p. 103).

Smith (1987) reported that an investigation of talking in primary mathematics classes convinced the participating teachers that almost all the children they observed needed to articulate their thinking, that talking aloud appeared to serve an important learning function for these children. Alton-Lee & Haberfield (1982) observed a positive relationship between talking (to oneself or to peers) and the occurrence of concept learning in a unit on conservation.

Through talk, teachers and learners can establish a common 'way of seeing' an image or event which has similar meanings for each of them (Sutton, 1992). This is of importance for the construction of public knowledge which Sutton has defined as an overlap of private understandings. Edwards & Mercer's (1987) research, "based on the belief that all education is essentially about the development of shared understanding" (p. 1), concluded, "The experiences and activities of the classroom are made meaningful by the sense made of those things by classroom talk" (p. 169). In their study they observed and audio and video-recorded classroom lessons, looking for examples of teachers and students building shared understandings through discourse and joint action. Their conclusions were not encouraging: "Sucess and failure are conceived largely in terms of inherent properties of pupils, rather than as outcomes of the communicative process of education itself" (p. 130); and "A successful education process is one which transfers competence to the learners. It is almost as if formal education for most pupils is designed to prevent that from happening" (p.159). It appears that too often in schools there is a lack of real communication between teachers and students. Teachers assume students are receiving the verbal messages being sent, but in a teacher-monologue classroom context, minus the built-in checks on communication used in normal conversation, unobserved breakdowns in communication often occur. Moffet (1968) suggested, "We have to distinguish between the capacity to produce a given discourse and the capacity to receive and understand it" (p. 31).

As was mentioned earlier, children talking to learn are engaged in a process which allows teachers a means of monitoring meaning making. Ideas are being discussed - or maybe they aren't; both being powerful indicators of what learning is occurring The teacher is offered a chance to hear what the students understand the assignment to be, what their initial understandings are and if and how they are able to construct understandings and ways of thinking that will help them better understand and participate in their society. In listening carefully to the meanings being constructed in these student discussions, teachers can identify: insights and explanations of use to other students, common misconceptions, useful and meaningful extensions to the topic, and strengths and weaknesses in the assignment itself.

Such listening may be a very difficult task to undertake in a busy classroom. For this reason, a number of researchers (Barnes & Todd, 1977; Harker & Green, 1985; Jones, 1988) have advocated that teachers audio-record some of the small group discussions held in their classes. This enables teachers to listen to children talking to learn when they have a chance to focus closely on the discussion. These researchers do not suggest that every discussion be recorded and listened to, but that such an exercise can provide valuable information about lessons and learning in our classrooms.

As Langer (1960) suggested, "From the first dawning recognition that words *express* something, talk is a dominant interest, an irresistable desire" (p. 42-3). This interest can be channeled in schools to help children use language to learn and learn to language more successfully. "The primacy of the spoken word in human intercourse cannot be too strongly emphasised. Important though the written word is, most communication takes place in speech; and those who do not listen with attention and cannot speak with clarity, articulateness and confidence are at a disadvantage in almost every aspect of their personal, social and working lives" (DES, 1982). Jones (1988) also stressed this point; "If schools neglect talk they will not only deny young people a vital means of learning but they will be failing to equip them for life" (p. 29). When students engage in talking-to-learn, they are concurrently languaging to learn and learning to language; it is present talking affecting both future thinking and future language ability.

Hands-on and Minds-on Science

A realization that the science being taught in schools was not meeting the needs of society led to major science curriculum development projects in both Britain and the United States in the 1960's and 1970's. In Britain, the impetus for change came, in part, through statements and reports issued by science teachers and Her Majesty's Inspectors calling for a more child-centered, investigational approach to science education. Primary science education was influenced, too, by Piaget's views that children learn through interactions with concrete materials and are constrained in understanding science concepts if they are at a pre-operational stage of development. In the United States, Americans were shaken by the Soviet launching of Sputnik in 1957. To regain supremacy in science, numerous science curriculum development projects were undertaken, funded by the United States government. In both countries the resulting science curricula were more process skill oriented than traditional content-led science teaching. Reflecting these initiatives, the Alberta Elementary Science Curriculum Guide (1983) recommended that the following process skills be emphasized: observing, classifying, measuring, communicating, inferring, predicting, controlling variables, interpreting data, defining operationally, hypothesizing, formulating models and designing experiments.

The shift from a text-book based to a more active, hands-on approach to science education in the elementary schools has been a slow one. For the large number of teachers who do not feel qualified to teach science (Manning, 1981; Loucks-Horsley et al, 1990; Tilgner, 1990), text books assume the responsibility for "carefully explaining the concepts it includes" (Renner, Abraham, Grzybowski and Marik, 1990), providing a traditional structure and a set of facts that teachers can refer to when they must teach science. The text exists; the children just need to read it and remember what they have read, an approach to science which is not unfamiliar to teachers and parents as it is similar to their own schooling. A text-book approach also requires little extra space and equipment.

Despite these obstacles, the continuing curricular emphasis on a hands-on approach to science education in the last 20 years has effected a gradual shift toward hands-on activities in elementary school science. However, hands-on experience has not in itself led to increased science literacy (Strauss, 1990; Jenkins, 1992).

Instead, hands-on science too often become a series of activities done because they were hands-on; teachers were aware that science lessons should be hands-on, but often did not place the activities in a context leading to the development of science understanding (Millar & Driver, 1987; Loucks-Horsley et al, 1991; Rowell, 1991). That children were actively engaged with materials was thought to be adequate, especially as much of the curricular emphasis was being placed on the development of science process skills rather than on science content (Alberta Education, 1983; DES, 1985; Millar, 1989). As well, activities were often too restrictive, what Wasserman & Ivany (1988) refer to as science rather than sciencing, carrying on "pseudo investigations to 'find' what has already been found. If a student has done an 'experiment' that doesn't provide the expected results, she is admonished to try it again until it does" (p. 5). Driver (1983) considered much of this illustrative or confirmatory science to be placing an additional intellectual demand on pupils as it required them to attempt to relate observed phenomena to theoretical models. Driver (1983) has also suggested that the slogan "I do and I understand" which is often used to justify hands-on science activities, should be restated as "I do and I am even more confused" (p. 9) in many classrooms. Woolnough and Allsop (1985), too, expressed concern about the restrictiveness of much of the practical work being done in school science, as it "is often closed, convergent and dull" (p. 3). In addition, Woolnough &

Allsop (1985) cited a growing body of research which suggested that attempting to teach theory through hands-on activities was not only inefficient, but could be harmful if it distracted students' attention away from the real goal of the lesson - the development of meaning.

At the same time that these concerns about hands-on science were growing, the body of research and literature addressing constructivism was steadily increasing. Wittrock (1974) described the paradigm shift in educational psychology "toward cognitivism, toward reinstating the learner, and his cognitive states, and information processing strategies, as a primary determiner of learning with understanding and long-term memory" (p. 87). Accepting that learners construct their own understandings, an increasing number of researchers in science education began asking students to describe their beliefs about a wide array of science topics (Osborne & Gilbert, 1980; Bell, 1981; Gunstone & White, 1981). The message from all these studies was quite consistent: "Children do have firmly held views about many science topics prior to being taught science at school" (Osborne & Wittrock, 1983, p. 489-490) and their "ideas are parts of conceptual structures which provide a sensible and coherent understanding of the world from the child's point of view" (p. 490). Furthermore, "children in classroom often unknowingly misinterpret what they are taught so that the new information is not in conflict with their earlier ideas" (p. 491). Learners were seen to be "building mental representatives of the world around them that are used to interpret new situations and to guide action in them" (Driver, 1989, p. 481-482).

In addition to this research, considerable attention has been given to the role of dialogue, student-student and teacher-student, in the creation of knowledge. As expressed by Roper and Stringer (1987), "To talk is to learn... And like science, which is concerned with forming order out of chaos, talk helps to shape our ideas, to determine what we think" (p. 32). Harlen and Jelly (1989) concurred, writing, "Science work is inevitably noisy work because we want children to talk freely among themselves since this is necessary to shape their ideas" (p. 34). Thus, through talk, students not only clarify their own ideas, but become aware that others, peers as well as scientists, may place a different interpretation on an event. Easley (1990) wrote, "What is important to conceptual progress is increasing openness to alternative conceptions and sharing ideas" (p. 67). Again, as discussed in the section on Talking to Learn, conversation is vital in establishing a common way of seeing (Sutton, 1992) and discussing experience, this being necessary if "common knowledge" (Edwards & Mercer, 1987) is to be established in classrooms.

Other issues have surfaced as a result of the acceptance of the constructivist approach to learning. As Wheatley (1991) indicated, the principle of constructivism "which says we have no 'God's eye' view of a 'real' world and thus can know the world only through our experiences, is troublesome for many" (p. 10). There need not be a dichotomy, however, between science defined as a body of consensually agreed upon knowledge (Millar, 1989) or as public knowledge, "a temporary structure of critically appraised theories with their 'facts' and defined terms" (Sutton, 1992) and science education which aims to enable "learners to make better sense of their world by helping them restructure their ideas in useful and usable ways" (Osborne & Freyberg, 1985, p. 88). That is, science can be seen as "the construction of exemplary models that encompass increasingly wider ranges of phenomena" (Novak, 1988, p. 77). To return to Piagetian theory, subjects progress in their ability to know objects more adequately; that is, in ways congruent with public knowledge.

However, "the teacher's role will no longer be to dispense 'truth' but rather to help and guide the student in the conceptual reorganization of certain areas of experience" (von Glaserfeld, 1988). A number of teaching models, with a very considerable amount of overlap, has been created to implement a constructivist approach to learning (Nussbaum & Novick, 1982; Osborne & Freyberg, 1985; Driver & Oldham, 1986). The Children's Learning in Science Program at the University of Leeds identified eight features that characterize a constructivist teaching model. They are:

1. The teacher starts a topic by eliciting learners' existing ideas.

2. The teacher provides practical experiences which relate to and extend the learner's knowledge.

3. In addition to practical experiences, the teacher provides separate opportunities for thinking.

4. The teacher emphasizes collaborative learning methods.

5. The teacher helps students learn how to learn.

6. The teacher provides a classroom environment which encourages the full exploration of ideas and their critical review, but where premature judgment is avoided.

7. The teacher accommodates learners' prior ideas to his or her teaching.

8. The teacher recognizes, and intervenes to overcome, critical conceptual hurdles to help the learners restructure their knowledge. (Constable & Long, 1991)

Other authors have described science lessons in terms of three phases: an initial exploratory phase, a discussion phase and a more focused investigatory phase. These have been called play, debrief, and replay by Wasserman and Ivany (1988); △ , ○, and □ phases by Hawkins (1965); setting up the problem, preliminary exploration and investigation by Harlen & Jelly (1989); and exploration, explanation, and application by Karplus (1977).

Strategies for use with these models have also been advanced. These include the use of concept mapping (Fensham, Gerrard & West, 1981; Novak, 1988), multiple-choice questions (Gunstone, 1984; Treagust, 1986), and/or discrepant events (Rowell & Dawson, 1979; Friedl, 1991) to stimulate student thinking. As well, students have been introduced to activities to increase their metacognitive abilities (Mitchell & Baird, 1985).

As the quotation by von Glaserfeld (1988) indicates, an important objective of education based on the constructivist theory of learning is that of conceptual reorganization. In science education the discussion is focused on conceptual change - what it means and how it can best be implemented. "Realigning, reorganizing, or replacing existing conceptions to accommodate new ideas" (Smith et al, 1993, p. 112) has been suggested as a definition of conceptual change. Discussions of conceptual change appear to always occur within the framework of constructivism, conceptual change being the end and constructivism the means.

There is, at present, active dialogue in the field of conceptual change. A common definition of the word concept has yet to be achieved. A concept, according to Alberta Education (1990) is "an idea or meaning represented by a word, term, or other symbol that stands for a class or group of things" (p. B.1); Novak (1988) defined it as "a perceived regularity in events or objects designated by a label" (p. 82); and Pines (1985) described a concept as "a package of meaning" (p. 109). There is also no real agreement about "the weight to be given to children's ideas about science compared with the accepted scientific view" (Millar, 1989, p. 590). That is, to what extent should school science accept the children's understandings about science or aggressively attempt to shift their ideas toward ones more closely reflecting those of scientists? In addition, Millar (1989) questioned the need for a constructivist teaching model, arguing that constructivism can better contribute to "improving the sequencing and pacing of science curriculum and less in terms of changing teaching styles and approaches" (p. 590). Moreover, studies indicate that the conceptual change that most teachers will have to make to shift from their present practices to a constructivist approach is "a complex and problematic process" (Neale et al, 1990, p. 110).

As well, teaching to effect conceptual change places additional demands on teachers. Teachers are to provide tasks which are "potentially interesting and challenging" (Tobin et al, 1990, p. 8), ensure the activities are relevant to the students (Pope & Gilbert, 1983), elicit children's existing beliefs (Osborne & Freyberg, 1985), point out discrepancies or inadequacies (Smith et al, 1993), propose alternative frameworks (Glasson and Lalik, 1993) and "recognize, and intervene to overcome, critical conceptual hurdles to help the learners restructure their knowledge" (Constable & Long, 1991, p. 408). These are very heavy demands to place on teachers who currently do not feel qualified to teach science.

Given these areas of disagreement, it would appear the field of science education needs to return to principles on which there is broad consensus, working from these toward a theory of instruction. I would suggest that there is considerable agreement about how students learn, criteria for content selection, and the role of teachers in science education. Briefly, it is widely accepted that learning involves an active subject interacting with objects and ideas, and making connections between these interactions, prior understandings and public knowledge. This is seldom accomplished without effort and requires both time and support. Language and communication, as outlined in the preceding sections, are also acknowledged as playing a central role in concept formation.

Content should be knowable, usable and enable students to better understand their world (Harlen, 1985; Osborne & Freyberg, 1985; Kirkham, 1989). To achieve this, the teacher's role will be one of providing both experiences, and time and structure for making sense of those experiences. Teachers will need to help students make connections between their prior understandings and the new concepts. S/he will monitor the learning that is occurring and make adjustments in order to help "initiate students into the 'ways of seeing' which have been established and found to be fruitful by the scientific community" (Driver, 1989, p. 482). This, of course, occurs in steps, as students progress in their ability "to know objects adequately" (Piaget, 1976, p. 13).

In the end we want students to have what Barnes (1976) referred to as action knowledge, "pupils' *assimilation of knowledge to their own purposes*" (p. 82), not merely school knowledge; that is, knowledge presented to students which they perceive to be applicable only to exercises and examination questions in school. When minds-on science is adopted, classrooms will become places of "intense exploration, argument construction and dialogue among pupils similar to that which occurs as scientists go about doing science" (Trumbull, 1992, p. 8). Minds-on science focuses on students and the meanings they are constructing; it is their minds that are of concern.

CHAPTER THREE

METHODOLOGY

This chapter includes a description of the research design, the participants in the study and the data collection and analysis.

Research Design

Site and participant selection

The data for this study were collected in three different classrooms in three different schools in a large Canadian city.

The study was originally designed as a collaborative action research project, with the researcher working collaboratively with a teacher to develop the science lessons and to analyze the children's conversations during these lessons. School pressures made such a collaboration impossible for the teacher, but the time spent in her classroom provided an insight into the classroom factors essential for such a study of talk to succeed. Some of these factors will be discussed in the following discussion of methodology. Of major importance to the continuation of this study was the clarification of two requirements: the lessons had to be hands-on science, and the teacher needed to be committed to children working collaboratively in small groups during these lessons.

To locate classrooms meeting these requirements, I made inquiries among teachers and consultants in the immediate school districts, asking for names of teachers who conducted small group, hands-on science lessons. In School District One, the name of one teacher was suggested by several teachers and confirmed by the science consultant for the district. The science consultant for School District Two recommended a number of teachers he had worked with regularly, teachers who enthusiastically pursued small group, hands-on science.

The selection process was random, yet subjective. I contacted the teacher widely recommended in School District One and two teachers from School District Two who taught in schools not more than a 20 minute drive from my house. All three teachers agreed to take part in this study. A description of the teachers, their schools and their students follows. All names have been changed to provide the anonymity promised to the participants in the study.

The schools, the teachers and the students

Elm School is an attractive, modern school less than ten years old, located in a rapidly expanding area of the city. The 450 students come from a broad range of socioeconomic backgrounds, from families that live in a nearby "country club" area of large, expensive houses, to families that live in the government subsidized housing located near the school.

Linda, the teacher widely recommended in School District One, was teaching part-time, sharing her time between science teacher duties and mother duties. A teacher for over fifteen years, she had started teaching with an early childhood education specialty. She had become interested in teaching science and enrolled in numerous in-service courses in science education. Based on her interest and background in science teaching, she was offered a job as a district science consultant. Linda had worked for six years in this capacity, developing and piloting lesson plans and demonstrating science instruction to teachers in their classrooms. She returned to the classroom, specializing in teaching science. She stated that she felt two activities in particular contributed to the science learning of her grade six students: group work in which students share ideas and talk about what they are doing; and independent research requiring them to locate information and then present it, this combination "making them more aware of what the subject is about."

Linda taught science to both grade six classes in the school, teaching these lessons in their regular classrooms. These classrooms were arranged traditionally with the desks in rows facing the blackboard. For these lessons, though, the students worked in groups wherever in the room they felt comfortable, many working in groups sitting on the floor. There were 21 students (9 boys and 12 girls) in one class and 20 students (8 boys and 12 girls) in the second class. Both classes were heterogeneous in terms of students' scholastic ability, ethnic mix and socioeconomic class. The students appeared generally to get along quite well, although some exceptions will be noted in the conversations. The exceptions, however, were based predominantly on individual personalities, not on race, socioeconomic level or scholastic ability.

Robin School, located in the same area of town as Elm School, is only two years older and has a similar-sized school population. Again, it is an attractive, modern school in appearance. The school boundaries, however, incorporate an area containing more modest housing then those for Elm School. There are some single family residences, but four-plex multi-family dwellings predominate, a sizable number of these being government subsidized housing for lower income families.

Sheila has been a classroom teacher for six years, teaching at the Division One level. She confessed that she had originally hated to teach science, but found the district science consultants and in-service courses stimulating. Subsequently, she had joined a group of elementary school teachers arranged by a district science consultant to discuss, over the course of a school year, issues related to science teaching in elementary school classrooms. By the time she agreed to participate in this study, hands-on science had become one of her favourite subjects because she found the children to be such enthusiastic learners.

Her classroom was inviting with both children's work and teacher-prepared materials on display. The desks were arranged in pairs all facing the front of the room and the children frequently worked together as partners. At the time of this study, Sheila was teaching a combination grade two/three class. There were 25 students in the class, 16 girls and 9 boys; three boys and six girls being in grade three. The range of scholastic ability was wide, spanning low grade two ability to high grade three, but this did not appear to cause many difficulties during the observed science lessons. The class included a racial and socioeconomic mix of children who worked together with only the normal differences of opinion.

McDonald School is an older school, built in 1910 and located in the inner-city area. The school is well-maintained with murals painted in the hallways and large and airy classrooms. The surrounding neighbourhood consists of luxury high-rise apartments, older single-family dwellings, new condominiums and lower-income multi-family dwellings. The ethnic and socioeconomic backgrounds of the students in the school were as varied as the diversity of housing stock might suggest. With a school population of 250 students, McDonald School is considered a medium-sized school.

Susan had been a teacher for seven years, all at McDonald School. This was her second year teaching at the grade three level; she had previously taught grades one and two. She had an early childhood education background at university and remained actively involved in expanding her expertise in pedagogical content knowledge (Shulman, 1986) by taking both in-service and university courses. Interested in improving her teaching of science, she had attended a number of district in-service courses and had been a member of the same group of teachers exploring science teaching in elementary schools as Sheila. Susan's teaching reflected her belief that hands-on experience, whether it be in mathematics, social studies or science, is of utmost importance to children's learning.

There were 18 grade three students in her class at the time of the study, a nearly equal number of girls and boys. Three of the students were in the English as a Second

Language program and a number of other students were first generation Canadians. Again, this group was heterogeneous in terms of ethnic mix, scholastic ability and family income level. The children appeared to work together amiably and were accustomed to working in groups; their desks were clustered in groups of four in the classroom and they worked in small groups rather than individually much of the school day. This set of lessons was held in the science room with groups of three students assigned to six different tables.

Before initiating the study, I visited each of the classes, explaining the project and the fact that I was interested in the talk that occurred in their groups during their science lessons. The children accepted this explanation with few questions other than when could they listen to themselves on the tapes. I distributed permission forms which were to be signed by the student and a parent or guardian, informing the students that no-one had to participate and that no real names would be used. Instead, I would refer to them as Girl or Boy A or B or use a made-up name. The students were all interested in participating, even though I did not plan to play their conversations back to them.

Role of the researcher

As this study focused on talk occurring in small-groups during hands-on science, the tape recorder played a major role in the collection of data.

I initially attempted to take detailed field notes of student interactions with other students and with the materials while the group being audio-recorded was engaged in their science lesson. It was immediately apparent that the presence of not only a tape recorder, but a note-taker as well, had disastrous consequences; the children did not want to say or do anything. Consequently, I took notes as the lessons were introduced and concluded, jotted down occasional observations during the course of the lesson, and collected samples of student assignments.

It was also apparent that the teachers could use help during these lessons. Attempting to repay the kindness of these teachers, who allowed me to carry on my research in their classrooms, I worked with the students as I saw necessary, lighting peanuts and candles, watching that the children did not burn themselves, clarifying instructions and answering questions. While these activities allowed me less time to take field notes, they did give me a chance to observe the different ways groups handled the assignments.

If a label is necessary, the researcher functioned as an observer- participant during most of the science lessons.

Research schedule

Data collection occurred sporadically from September through May of one school year and was interrupted by a sabbatical leave I took with my family from January to mid-April.

After agreeing to participate in the study, each of the teachers suggested that as only certain of their science lessons would meet the needs of the study, they would contact me when they planned a series of hands-on, small group science lessons.

Soon after I contacted her in November, Susan planned to undertake a Mystery Solids unit of study, blocking out two school days in which to do it. She invited me to record these lessons. While she was willing to have me in the classroom during the lessons, she made it very clear that the collaborative mathematics study she had participated in with a graduate student the year before had been very time consuming, and she currently had no extra time nor desire to engage in anything that demanding.

Linda planned a series of lessons on Static Electricity for mid-December which she felt would be suitably hands-on. As she taught only part-time and worked in two different classrooms, the amount of time which I could spend with these students was restricted.

When I first talked to Sheila, she was just starting the Mystery Solids unit. Having no time to send home and collect permission forms from the students, I only visited the classroom, observing and working with the students while they pursued their investigations.

Returning from our sabbatical leave, I contacted the teachers again. Susan did not have time available for further research to be conducted in her classroom, but Linda and Sheila gave me the dates and times of their upcoming hands-on science lessons and invited me to take part in and audio-record these lessons. Thus, the Solar House, Peanut Power and Mealworm lessons were recorded during the month of May. Generally, I was present in the classrooms only during science lessons.

In all, there are nearly nine hours of recorded conversation, and an additional hour of teacher introduction and whole class discussion recorded in November, December, and May.

Data Collection

Audio-recording

After choosing to do a study of talking-to-learn, the best way to record such talk became a major concern. There was a technical decision: what equipment would best meet the needs of this study? As well, I wanted to capture talk which would reflect normal classroom small group talk as closely as possible.

Barnes and Todd (1977) had recorded their small group conversations in a room separate from the classroom, increasing the clarity of the recording and making it easier to accurately transcribe the talk. This approach, however, was rejected for both logistical and "normalcy" reasons. Logistically, finding a quiet, unoccupied room is difficult in many schools; several of the lessons involved materials to be collected from a central supply area; other lessons involved fire and the students needed to be supervised. In addition, for the sake of normalcy, the students needed to remain in their usual environment, surrounded by peers pursuing similar experiments. Thus, clarity and ease of transcription were sacrificed for validity.

I asked personnel in a university technology center for advice about audio- tape recorders and microphones. Almost any good quality audio-tape recorder was felt to be sufficient. It was suggested that if several students wore lapel microphones, the signals might interfere with each other, so this type of recording equipment was rejected. A PZM conference microphone was suggested as this type of microphone can pick up sound from all angles, as well as being effective with a moving sound source. With this in mind, but not owning such a microphone, I took my own tape recorder and small (8 centimeter long) traditional microphone to class and placed this equipment as unobtrusively as possible. The microphone had to be placed in front of the students, however, in order to pick up their conversation. Looking very much like a microphone, this resulted in self-conscious statements or silly noises from the students. This certainly did not meet the normalcy rule.

I next borrowed a conference microphone to test its impact on conversation. This microphone looks like a flat black 12 centimeter square steel plate with a small black protuberance on the top. The cord is five meters long, allowing the tape recorder to be placed at some distance from the recording site. The students were engaged in joint book research the day I came to record with this new microphone. It was obviously much less obtrusive and the sound quality on the tape was quite good, but a new difficulty surfaced. It was clear that if the students were not actively engaged in some type of hands-on activity, any microphone at all would affect the quality of the conversation; the children were too aware of being recorded to be able to proceed naturally.

When the conference microphone was used to record the talk of a group involved in an experiment of interest to them, the tapes reveal only an occasional comment that would indicate that the students were aware of being recorded. Typically, when there was less interest in an investigation, there was a heightened awareness of being recorded, the extreme being a group that spent nearly ten per cent of its time making up and reviewing pseudonyms for the group members so their real names would not appear on the tape.

Recording in the natural classroom setting did have disadvantages. Individuals' voices were at times masked by background conversations, and voices from adjoining groups were sometimes difficult to differentiate from those in the group being recorded. For certain experiments, too, students worked with their materials at a distance, not facing the microphone (which was placed in the center of their circle if they were working on the floor or in a central location if they were sitting at desks or tables). It is also very difficult to differentiate between the voices of individual children of this age, even between the voices of boys and girls; only the occasional student has a highly distinctive voice. I played a tape a back to one group, asking them to help me assign the right name to each speech turn. They, too, were often unsure if a voice was their own or that of a class mate. This being so, much of the transcribed talk is not accredited to any particular student.

When it was possible, one or two extra audio-tape recorders and conference microphones were borrowed, allowing several groups to be recorded simultaneously.

Field notes

Since the focus of this study was on the talk, field notes were intended to provide the context of the lesson and any information that might be of use in understanding the recorded conversations. As indicated above, because I worked with the teacher as a classroom helper, and because the children's conversations had been constrained when it was obvious to them that I was taking notes about their group, I took few field notes while the students were pursuing their small group investigations. However, notes were taken during the introduction and conclusion of the class, noting any special contexts (school assemblies, changes in weather, special events) and recording any instructions or notes written on the chalk board.

Other data

The third type of data to be collected were the worksheets the students used during these lessons.

Transcriptions

The initial transcriptions were made using the tape recorder used to record the conversations, as this equipment provided accurate voice reproduction. That is, the recorded voices sounded reasonably similar to those of the participating children, making it possible to assign names to the voices more often than when using a transcribing recorder. Tapes were played and replayed as many times as necessary to transcribe the words accurately. If a word, phrase or sentence simply could not be understood, a blank space was left. Extended off-task chatter (longer than 30 seconds) was not transcribed in its entirety. Instead, the initial statements were transcribed and the total length of the interchange noted. In total, it required nearly six hours to transcribe one hour of classroom talk.

The symbols used to aid in the reading of the talk are located in Appendix A.

After all the lessons had been transcribed and typed, I listened to the tapes again, this time using a transcribing recorder, to check on the accuracy of the transcriptions and to fill in as many of the blanks as possible. A transcribing recorder allows one to vary the speed of the tape, making it possible to better understand certain passages. However, as indicated, the voice tone reproduction is not as good, making it very difficult to differentiate between children's voices.

In addition, an independent verification of the accuracy of the transcriptions was done. Three tapes, randomly chosen to represent a variety of lessons (Mystery Solids, Static Electricity, and Mealworms), were given to an independent reviewer with the request that she randomly select two five minute segments from each of these three tapes and verify, or make corrections to, the transcriptions. The changes were minimal; six additions or corrections to children's utterances and one more lengthy addition to a teacher's exchange were made. A typical addition was changing, "Rub it ? " to "Rub it really hard." None of the corrections affected any of the classifications made for those utterances.

Analysis of the data

Following the recording and transcription of the children's small group talk, a means of evaluating the raw data, of answering the question "What is happening?" (Erickson, 1984), needed to be defined. I had initially considered choosing aspects from several different classification models; models under consideration included Halliday's (1977) language functions (instrumental, regulatory, personal, heuristic, imaginative and representational); Cazden's (1989) descriptions of peer discourse cognitive benefits (discourse as catalyst, as peer "scaffolding", as relationship with an audience, and as exploratory talk); the British Science Teacher Action Research (STAR) Project's targeted scientific processes (language for observing, interpreting, hypothesizing, planning, measuring, recording, raising questions and critically reflecting); and Tough's (1976) classifications of the uses of language (self-maintaining, directing, reporting, towards logical reasoning, predicting, projecting, and imagining). However, in attempting to develop a hybrid classification system, the possibility of being arbitrary and/or too exclusive or inclusive arose. Instead, two specific analytical tools were chosen: Tough's (1977) classification of the uses of language, and the talking-to-learn guidelines from the British National Curriculum document *Language in the National Curriculum* (LINC) (1991). These were selected for their usefulness in directing attention to different aspects of the conversations; to evidence of the purposes for which the students used their talk and to indications of students talking-to-learn.

In addition to this focus on language, the question of "What science are the students learning?" was ever present. As Erickson (1984) indicated, "We can assume that all students are learning something. The basic issue is that many students...do not appear to be learning what the teacher and the school claim to be teaching" (p. 138). Multiple readings of the transcripts indicated that, indeed, student learning was often at variance with teacher intent.

Each of these analyses, the Tough (1977) classification of uses of language, the LINC (1991) talking-to-learn guidelines, and the "analytic detective work" (Erickson, 1984) to detect science learning are described below.

Tough's classification of the uses of language

With an interest "in the way in which language functioned to express and construct different kinds of meanings that would reflect the child's awareness, appreciation and interpretation of the physical and social world around them" (Tough, 1977, p. 39), Joan Tough and her colleagues created a classification system to enable them to pursue a functional analysis of children's language.

In classifying language, four functions, "the means by which a purpose is achieved" (p. 44) were distinguished: the directive function, the interpretive function, the projective and the relational function. Each of these functions was subdivided into uses of language and these uses further differentiated by strategies, the different devices used to effect this use. This keying system allows for finer judgments of the uses of language to be made incrementally, decreasing the complexity of the choices at each stage. An explanation of each of the functions and its related uses and strategies follows.

The **Directive Function** is "concerned with directing action and operations" (p. 45), "with the organization and implementation of physical actions and operations" (p. 47). Language use may be self-directing or other directing. Self-directing language strategies are used for monitoring actions, focusing control and forward planning. Other-directing language strategies are listed as: demonstrating, instructing, forward planning and anticipating collaborative action (self and other).

The **Interpretive Function** is "concerned with communicating the meaning of events and situations" (p. 45) and is divided into two language uses; first, reporting on present and past events and, secondly, reasoning, which reflects "the awareness of different levels of complexity in the structure the child is able to place on his experience" (p. 52). Nine strategies were identified for reporting: labeling, elaboration of detail, association and comparison, recognizing incongruity, awareness of sequence, recognition of associated actions or events, absence of conditions, recognition of a central meaning and reflecting on the meaning of experiences. Two strategies were associated with reasoning: recognizing dependent and causal relationships and the recognition of a principle or determining conditions.

The **Projective Function** is "concerned with the organization of meaning for events that have not yet occurred and which may never take place" (p.55), "drawing upon the imagination and using elements of known experience to *project* and explore situations in which one is not at the time actually, and may not ever be, taking part" (p. 45). This function is subdivided into three uses: predicting, empathetic and imaginating. Three to five strategies are associated with each of these uses, but as very few examples of the Projective Function were identified in these lessons, these strategies had no relevance for this study.

The **Relational Function** is the fourth and final function delineated by Tough. This function describes the role of language "in establishing and maintaining relationships between people" (p. 45). Language may be used here for two purposes, self-maintaining and interactional. Tough outlined the strategies children use in attempts at self-maintenance as: referring to needs (both physical and psychological), protection of self-interest, justification, criticism and threats. In an interactional use of language, strategies include those that are self-emphasizing or other-recognizing.

This framework is succinctly outlined on pages 68 and 69 in Tough's (1977) book. Tough wrote, "It does not seem likely that the classification is exhaustive or would be entirely appropriate for the analysis of adult's language, but it provided a set of descriptions of language in use that could be used objectively and which offered a basis for comparing the language used by different children" (p. 67). It was precisely because this classification offered an objective description of language use and multiple decision points, maximizing reproducible choices, that Tough's (1977) classification of the uses of language was chosen for this study.

Using Tough's framework, explanations and examples, I went through the transcripts utterance by utterance, interpreting the function or functions of each, putting a check by those I was unsure of (example: "Look at here" - Directive or justification?) and leaving all ambiguous utterances such as, "Hey, J., you have...," or "I think..." unmarked. I also made a list of sample statements placed in each category and the reason for their inclusion which aided in standardizing the categorization. Masking the first categorization, I repeated this process. Correlation was high.

Being particularly interested in the Interpretive Function, I repeated the above process for all those utterances judged to be Interpretative. That is, I asked if a statement appeared to be labeling an object or identifying an event, (It's white, or It's burning); or if it was used to associate or compare objects or events, or to exemplify any of the other Interpretive strategies.

The categorizing marks (checks) were then tallied and the tallies for each category were converted to percentages of the total number of utterances. As such categorization is not an exact science, the percentage figures were arbitrarily rounded to the nearest five percent. For example, I felt that rounding the following figures for a Mystery Solids lesson, 61% **Directive**, 28% **Interpretive** and 11% **Relational**, to 60%, 30% and 10% respectively, realistically reflected the trends in language use during this lesson.

LINC talking-to-learn guidelines

In Britain, the role of oracy (talking and listening) in knowledge formulation has been recognized for years, as evidenced by the 1967 LATE slogan, "Present talking is future thinking," the emphasis placed on oral language learning in the Bullock Report (DES, 1975), and the 1988 National Curriculum Council mandate to establish a National Oracy Project (NOP). This three year project involved developing ties with interested local education authorities and helping them to establish initiatives intended to develop talking and listening in classrooms and curriculum planning. This recognition that "oracy matters" (MacLure et al, 1988) is reflected in the British National Curriculum which states as an attainment target one, "The development of pupil's understanding of the spoken word and the capacity to express themselves effectively in a variety of speaking and listening activities, matching style and response to audience and purpose" (LINC, 1991, p. 1).

To help prepare teachers to implement the National Curriculum, an extensive package of materials was developed. These materials were intended to guide teacher discussion of issues and to further their understandings of the rationale for the targeted learning. A portion of the LINC discussion materials focused on talking and learning, stating, "At the same time as helping pupils to develop their talk repertoire, schools will wish to employ that repertoire as a means of learning" (p. 11). "The Talk Repertoire" document continues:

> If the primary purpose of the talk is to learn, we should value talk that gives children opportunities to:
>
> - hypothesise, predict, and speculate
> - relate new ideas to their previous understanding and experiences
> - express and justify feeling, opinions and viewpoints
> - consider the feelings, opinions, and viewpoints of others
> - organise, interpret and represent ideas and information
> - question, explore, and think aloud (p. 11)

This concise statement of valuable classroom talk was chosen as a means of evaluating the extent that the recorded talk displayed characteristics of talking-to-learn.

With the guidance of these LINC talking-to-learn guidelines, I again read through the transcripts line by line. Unlike the Tough classification, however, much of the talk was not categorized as it did not seem to exemplify any of these categories. Fearing that my initial interpretation may have been too narrow, I did a second classification using unmarked transcripts. The match between classification one and two was very close, with the exception of additions being made to the category talk used to *organize, interpret and represent ideas and information.*

Two other categories, *consider the feelings, opinions, and viewpoints of others* and *question, explore and think aloud*, were of particular concern. I found it extremely difficult to decide whether individual utterances should be classified as exploratory; the same was true for consideration of others. It was apparent that the teachers had established classroom environments where the students felt free to express their ideas in their own words and where collaborative group work was encouraged. In the three classes I observed, the children were expected to *question, explore and think aloud*; successful group work of this kind demands a tentative, exploratory approach. While the groups differed in the consideration shown for others, the three teachers did expect students to be considerate to each other. Fearing that a judgment of exploratory talk or talk exemplifying consideration for others might very well be arbitrary, or that it might include so many exemplars as to make it meaningless, I decided not to attempt a categorization of these types of talking-to-learn.

The numbers of classification exemplars were then tabulated for each transcript and the tables cross compared to note any wide variations which might require further analysis. The data were judged to display consistency within and between transcripts.

Multiple readings: What are the students learning?

A third analysis, referred to earlier in Erickson's (1984) terms as analytic detective work, arose from the multiple readings of the transcripts while classifying the language uses and talking-to-learn emphases. Starting as an "unease" while transcribing the tapes, multiple readings of the transcripts identified several distinct areas of concern about the lessons and what the students were learning. Serious questions arose about the lack of connections being made by the students between science activities and prior understandings; whether the small group work was collaborative; and the extent to which the science lessons encouraged students to be active learners in meaningful activities. In addition, there was always the "question of time" (Driver, 1983); the time allotted to science instruction often does not coincide with the time necessary to learn science concepts.

These areas of concern are more fully discussed in the final chapter of this thesis.

Limitations of the Study

The data were collected in four specific contexts; the teacher, the students, the instructions and the setting being unique to each of these classrooms. This being the case, the data cannot be generalized to other classrooms.

However, as Patton (1990) suggested, it is possible to make extrapolations, "modest speculations on the likely applicability of findings to other situations under similar, but not identical, conditions" (p. 489). Thus, it is important that numerous descriptive studies be available as each modest addition to the literature adds details which help guide future action by researchers and teachers. While this study cannot be generalized to other classrooms, it can provide an insight into how students have reacted in specific classroom contexts, adding to our understandings of how children learn.

CHAPTER FOUR

THE LESSONS AND THE TALK

This chapter describes each of the five lessons or sets of lessons which were audio-taped and transcribed, including the context of the lessons. Each of the groups will be described briefly and any outstanding characteristics noted.

Extracts of talk, both short statements and longer discourse, are quoted in order to indicate what the children talked about in their groups during these hands-on science lessons. The results of two different analyses of this talk, Tough's (1977) classifications of the uses of language and the LINC (1991) guidelines for talk used as a means of learning, are presented with examples to illustrate these classifications. The chapter ends with a discussion of the questions, impressions and questions suggested by this talk data.

Mystery Solids

This set of lessons is based on the Elementary School Science (ESS) unit Mystery Powders (1967). The authors of that unit state that Mystery Powders is an introduction to investigatory science, encouraging children to closely examine some of the physical and chemical properties of a number of familiar substances.

Susan found it useful to schedule some of her science units in a solid block of time. As this unit lends itself nicely to such an arrangement, she had set aside two days for this study. These lessons were held in the science room, not the regular classroom. The children sat at tables in teacher-assigned groups of three.

The teacher introduced the Mystery Solids unit by first asking if any of the students knew what the word solid meant. The children contributed the ideas that a solid was something that didn't have holes in the middle, that couldn't break and that was hard. Susan then explained that scientists group things in our world in many different ways and one way that they group things is to talk about things being, solids, liquids, or gases. When she asked for an example of a gas, a student suggested it was something "we put in our car." Susan then decided to first ask for examples of liquids and received a number of answers, including water, milk, juice and cola. The class talked a little longer about the properties of liquids (they slosh around and can be poured out), then returned to gases. Susan asked the students what they saw coming out of the top of the kettle when their mothers boiled water. A student volunteered the answer "steam" and the teacher expanded on this to explain that air is also a gas, something you can not see and can't really feel unless it's moving.

"The other things in the world are solids. What are some examples of solid things?" she asked. Answers included a stone, brick, table and a nose. The lesson was then explained in this manner, "Some kids have trouble understanding that something like a table is a solid and a bunch of little things in here, little powders, are solids, too. And that's what we'll learn more about: a solid can be a big thing or a little thing." They went on to discuss the way scientists find out about things, focusing on observation using the five senses.

The morning of the first day (approximately two hours) was used to observe and describe the properties of the four solids (salt, sugar, baking soda and corn starch). The samples were distributed one at a time and the groups were given about 15 minutes to discuss what they observed about each solid. One group member was designated to be the recorder for each solid, his/her job being to write down in their Mystery Solids booklet the properties the group members agreed on. At the end of the 15 minutes, they were to decide what they thought their Mystery Solid was and why they thought this and to fill in the blanks in their booklet: "I think Mystery Solid X is _______ because ___________."

In the afternoon, the children were introduced to the tests they could use to prove the identity of a particular solid. Each of the tests causes a clear-cut reaction to occur with one of the solids: iodine turns corn starch black, vinegar causes baking soda to fizz and heating sugar over a flame causes it to melt, bubble and turn black. Each child practiced each test on each of the four solids, but one child recorded the group's observations. This phase took a little over an hour. After recess they returned to their regular classroom for non-science activities.

The children worked individually on the second day. The science room was set up with three test centers: on one table were bottles of vinegar and eye droppers, on another jars of iodine and eye droppers and on the third, flaming cans of petroleum jelly. There were also six Mystery Mixtures in containers in the front of the room - mixtures of the solids they had been observing. The students were challenged to discover what solids were contained in each mixture. When they had figured one out, they could try the next. They were to write individually in their own booklets, describing what tests they had done, their results and what solids they thought the Mystery Mixture contained. While they experimented, the teacher worked with individuals, giving help and probing their understanding of the tests and what the results meant.

In the afternoon, each student was asked to choose one of the Mystery Solids and to write everything they know about that solid. They were given half an hour for this exercise and were encouraged to confer with one another and to refer to their booklets.

Only the conversation on the first day was transcribed and analyzed. While the students were told they could talk together while doing the individual tests and writing, there was little sustained conversation, even when all three children were sitting together at the table. There were three children in the audio-taped group, two girls and a boy. The boy and one of the girls were later reported by the teacher as being two of her brighter students. The second girl, an immigrant from a Southeast Asian country, spoke fluent English, seemed very confident (even bossy) when working with her peers, but was seldom able to answer questions posed by the teacher and was unsure of how to analyze the results of the tests she performed to discover the composition of the Mystery Mixtures. This group was selected because they were seated near an electrical outlet, a necessary location for the use of the tape recorder.

<u>Tough Analysis</u>

The classification of language uses is presented in Table 1.A. This analysis of the conversations indicated that 60% of the conversation was **Interpretive** when the students were discussing the solids and their properties. The following represents a typical exchange:

T - Let's let's see. Let's see what we have got in here.

D - It looks white.

C - Oh, it's disgusting.

- It's hard.

D - It tastes

C - But it doesn't taste good. (laughter)

- It's bumpy.

- It <u>bounces.</u>

C - <u>It doesn't</u> taste good.

D - No!

T - It looks like crystals.

D - Crystals.

Most of the conversation was limited to simple *labeling*, but there were numerous examples of *elaboration* and a few of *comparison;* for example (non-consecutive statements):

Table 1

Categorization of small group talk recorded during the MYSTERY SOLIDS lessons.

A. Talk categorized according to Tough (1977)

Lesson Component	Language Functions (Percent of Utterances)[1]				
	Directive	Interpretive	Projective	Relational	NCU[2]
Describing Properties	30	60	<5	10	894
Doing Experiments	60	30	<5	10	732

1 Percents rounded to nearest 5% (see page 35 in Methodology, Chapter Three).

2 Number of Coded Utterances.

B. Talk categorized according to LINC Talking-to-learn guidelines.

Lesson Component	Number of Utterances Matching the LINC Categories[3]					
	A	B	C	D	E	F
Describing Properties	3	1	16	NS[4]	18	NS
Doing Experiments	7	1	4	NS	3	NS

3 LINC categories designated as follows:
- A. Hypothesize, predict and speculate.
- B. Relate new ideas to their previous understanding and experiences.
- C. Express and justify feelings, opinions and viewpoints.
- D. Consider the feelings, opinions, and viewpoints of others.
- E. Organize, interpret and represent ideas and information.
- F. Question, explore and think aloud.

4 Not Scored (see pages 36-37 in Methodology, Chapter Three).

- When you press on it, it's flat.

- Does it ever feel soft!

- It looks like snow.

- I think we're going to put the same as that one because it looks like it.

Conversation worked, as well, to sharpen a definition, as in:

- It tastes like like salt.

- It doesn't taste like salt.

- It tastes a little bit like salt. (discussing baking soda)

Repeating what had been stated was very common. A property would be named and then repeated once or twice by each participant. For example, when talking about corn starch:

T - It's soft.

C - Very soft.

T - Put Do you want to put this is more soft?

D - It is.

C - Soft. Really soft.

T - Smooth and soft.

D - Really smooth and soft. s-m

C - s-m-o-o-t-h

D - Smooth and soft.

C - Smooth and soft.

T - Oh, it is. Do it again. Do this. It's soft. (to teacher)

Also, when they were searching for a new property, it was usual practice to repeat what had already been written or discussed.

- It looks white, it's hard, it tastes salty. It's crystal?

Crystal has been mentioned several times heretofore, but had not yet been written down.

The members of this group appeared to work well together and no one seemed to feel threatened by the comments of the others, although there was not always perfect agreement on an observation. Less then 10% of the talk was judged to be **Relational** and, except for a period when the girls were teasing Curtis by insisting on writing the reason they knew the sample to be baking powder was because they cheated and saw the box, this was limited to comments such as(non-consecutive statements):

- I told you so.

- I like to taste it.

- I like your writing.

During this observational portion of the lesson, 30% of the talk was scored **Directive** and 40% of this was spelling related. When Curtis was the recorder, he continually asked for words to be spelled. For example:

T - It tastes sweet.

D - It tastes sweet.

C - Tastes How do you spell tastes? // (laugh) //

D - Tas tes sweet.

C - (to teacher) How do you spell taste?

D - s-w-e-e-t s-w-e-e-t

C - Taste!

D - t-a-s

C - t

D - e-s

- It tas-tes

C - It tastes

D - s

D&T - w-e-e-t

D - Taste it.

Other **Directive** questions/statements include (non-consecutive):

- So put down more.
- What else do you want me to write down?
- Taste it.
- Try to put it in order

which were used to direct one another's attention to a property or the recording task.

The second part of this unit involved performing the iodine, vinegar, and heat test on each of the solids. These tests required the children to measure out one milliliter of each solid, to put three drops of iodine on each, observe and record the reactions, then to repeat this with vinegar. Finally, they made tin foil cups and held each solid over a flame, observing each reaction.

The use of the eye droppers and the flame was new to the children, the pace was fast and the amount of **Interpretive** conversation fell to 30% of the total, while the **Directive** rose to 60%. A typical exchange would be:

D - See. Can I can I do it for you? And then everybody can have a turn.

T - Can you do that for me?

C - There's hardly nothing in here.

D - I'll that, I'll put it I'll put some in. / And then you can go first.

C - It's hard to put in.

SF - Watch this one carefully, please.

- OK.

D - It has some. I'm sure it does.

C - Three. That was two. Two. One more. //

- Three, there's

T - Now your turn.

C - Aww. Ooh, it's turning. It's it's getting fluffier. (laughter)// //

Dianne was most proficient with the dropper and would help the others, especially Teni, physically ("I'll do it for you, Teni.") or by giving instructions ("You're doing it wrong, that's why. Because you squeezed it in.") They also helped each other:

D - OK, we need one spoon of which one?

- This one.

T - Is it this one?

- Yup.

While this task fastened their attention primarily on physical manipulation, there are many examples of talk about their observations, although these exchanges were generally shorter in length than during the earlier discussions about properties. For iodine they noted:

D - It turned rough. It turned rough.

C - It turned rough.

T - It turned rough. // //

- How do you spell rough?

and

- Oh, black. This really turned like black.

and

- Look at the brownish stuff.

- It's crystal. It's crystal.

- It's sugar.

The vinegar test elicited the following comments:

- Oh, bubbles. /

- Aww awesome.

- Awesome.

- It makes bubbles. ///

- It has some vinegar in. / It has some vinegar.

and

- Like an igloo?
- Like that little egg.

and

- It melts
- like ice cream?

During the heat test, the teacher was at their table and directed questions to them, resulting in the following observations:

T - Put it higher.
C - No, put it a little downer so we can
D - It's turning brown.
 - Well, it's turning brown. //
D - Don't be scared.
SF - OK, have you noticed any change?
 - Yeah.
C - It's turning brown.
 - It's turning brown.
SF - It's turning brown. OK, what do you think is happening to it?
C - It's heating up.
SF - Yeah, it's heating up. It's turning brown.
 - Smelling.
C - It's smelling.
T - Turning brown. It smells.
D - It's smelling like smoke?
C - Like the match.
 - It's
C - Aww. /
 - I hate the smell.
 - It makes me cough (hack hack). /
D - It's yellow like smoke.

When they were finished with the tests, Dianne suggested, "Let's mix mix them all together. Let's see what that makes." She felt it was time for "messing about" (Hawkins, 1965), a phase the ESS Teacher's Guide (1967) suggests be used earlier in the unit.

LINC Analysis

The results of the LINC talking-to-learn analysis are presented in Table 1.B. The categories were interpreted quite broadly; that is, if the child's intent seemed to fit one of these categories, it was counted as an example.

In the first lesson, describing the properties of the four solids, there was little need for and few examples of *hypothesis, prediction or speculation,* but Dianne does suggest, "Let's see if it makes a mess when we try to put it back in. Spread it out here. And then try to put it in a in a little." They do relate the dough that forms in their mouths when they taste Mystery Solid Number 3 (corn starch) with bread, proving to them that this powder is flour, an example of *relating new ideas to previous understanding and experiences.* There were many examples of *expressing and justifying feelings, opinions and viewpoints,* although the justifications were generally quite basic. "It's slippery. Look at," would be a common example, using demonstration, rather than a verbal explanation to justify their observation (or opinion). Tag questions, such as "It doesn't taste like anything, right?" exemplify attempts to *consider the feeling, opinions and viewpoints of the other group members.*

There were many questions and statements which served to *organize their information,* statements such as (non-consecutive):

- So put down more.
- You have to put different words.
- What else is it?

These appear to indicate an attempt to organize and extend their information, not so much to interpret ideas. As mentioned, the members of this group worked well together, as can be seen by the frequency of the exploratory talk they engaged in; that is, they were not afraid to think aloud. "It looks like - it looks crys," and "I'm going to mystery this out here," would be typical statements.

The language patterns in the second part of the lesson, the trial tests of the solids, show a shift. There is more *prediction and speculation* (non-consecutive statements):

- OK. I think this one was the messy one.
- It it has some. I'm sure it does.
- We have too much, I think.

There were fewer examples of talk used for any of the other categories related to talking-to-learn. There were tasks to be performed and the talk reflects this focus.

Each of these two means of analyzing talk indicates that the talk in this group varied quite considerably depending on the demands of the lesson. While this finding is not surprising, it may be overlooked when teachers plan lessons. However, if languaging to learn and learning to language are to be developed, teachers will need to plan lessons giving students opportunities to engage in the different forms of talking-to-learn.

Mealworms

This set of lessons was based on another Elementary School Science (ESS) unit, *The Behavior of Mealworms* (1986). It is intended as an introduction to animal behavior and is based on observation. As children observe mealworms, a previously unfamiliar animal, it is anticipated that they will begin to ask questions about the mealworms' behavior. The investigations organized to answer these questions form the core of the ESS unit. The ESS authors state, "How to carry on an investigation is the most important thing that children learn from the unit: the factual knowledge about mealworms is comparatively incidental" (p.1).

The class investigating this subject was one of grade two and three students. During this study, a covered yogurt container partially filled with bran and containing three mealworms sat on each desk.

The students started the unit with an art project, drawing and cutting out mealworms which were suspended from the ceiling. Next, the class observed and discussed the body parts of a mealworm. Each student had a Mealworm Diary in which s/he wrote after an observation or investigation during science lessons. They were also encouraged to observe their mealworms anytime they had spare time.

Two of the lessons requiring more active observation and manipulation were audio-recorded and transcribed. The first taped lesson started with an observation component; the students were to open their containers and find the mealworms (some had entered the pupa stage). Magnifying boxes were available and it was suggested they should look for the body parts discussed the day before. They were then to share what they had noticed with their partner (a common practice in this class) and four students were selected to tell the class what they had observed. Then they wrote their observations in their Mealworm Diaries.

Following this, the teacher posed the question, "Do mealworms like a moist or dry environment better?" The students were to make a prediction, share it with their partner and write it in their Diaries. Next, each pair spread out a paper towel, put a small puddle of water on one side of the towel, placed the mealworm in different places on the towel and observed its behavior. After approximately five minutes, the recess bell rang. As the teacher was a playground supervisor that day, the lesson had to be ended and the mealworms put away. Most of the children, however, would have been willing to stay in and continue this investigation. The teacher later told me that the science lesson had started late due to a school program. She would normally have postponed a lesson under these circumstances, but proceeded with it because I was coming to tape record the discussion.

The second audio-recorded observation occurred a week later. Again, the students were to open their mealworm containers, make an observation, report it to their partner and write it in their Mealworm Diaries. This time the teacher challenged them to make their mealworms move backward. As a class, they discussed possible ways of making the mealworms do this: "Put something in front of it so it won't be able to move forward"; "Maybe by making it go backwards lots of time it'll get used to it"; "Put a finger in front of it and nudge it back," and "If your mealworm liked wet, you could like put wet at the back and put it on dry."

Working in groups of two or three, formed by negotiation, the children tried to make their mealworm go backward (as the majority of the mealworms were now in the pupa stage, they had to share the ones that were still crawling). They worked for about ten minutes, then wrote the results of their attempts in their Mealworm Diaries.

A third lesson was not audio-recorded. It was similar to the two previous lessons, but the challenge was to see if the mealworms would walk up a slant.

The children were enthusiastic observers. Most had named their worms, talked to them and were excited about the life cycle changes A few children were afraid to handle their mealworms, but someone was always willing to help them.

Two different groups (referred to as Group A and Group B) were audio-recorded during the <u>wet and dry preference</u> observation. While Group A originated as a pair of students in adjoining desks, a boy and a girl, they were joined by a girl sitting in front of them and by yet another girl later in the lesson. Group B consisted of a pair of girls who worked together very cooperatively during this lesson.

<u>Tough Analysis</u>

The classification of language uses is presented in Table 2.A. Over 60% of the conversation in both groups was judged to be **Interpretive** in nature. An example:

Group A:

T - What did you find out?

- I even put it on hers and it went bye-bye.

T - It went onto the dry?

- Yeah, I had him on wet, but <u>then he</u>

- <u>Yeah, he went onto</u> the dry.

Table 2

Categorization of small group talk recorded during the MEALWORMS lessons.

A. Talk categorized according to Tough (1977)

Lesson Component	Language Functions (Percent of Utterances)[1] Directive	Interpretive	Projective	Relational	NCU[2]
Group A "wet/dry"	20	60	<5	20	111
Group B "wet/dry"	30	65	<5	5	144
Group C "backwards"	45	45	<5	10	167

1 Percents rounded to nearest 5% (see page 35 in Methodology, Chapter Three).
2 Number of Coded Utterances.

B. Talk categorized according to LINC Talking-to-learn guidelines.

Lesson Component	Number of Utterances Matching the LINC Categories[3] A	B	C	D	E	F
Group A "wet/dry"	2	0	6	NS[4]	0	NS
Group B "wet/dry"	9	2	6	NS	11	NS
Group C "backwards"	0	0	7	NS	0	NS

3 LINC categories designated as follows:
- A. Hypothesize, predict and speculate.
- B. Relate new ideas to their previous understanding and experiences.
- C. Express and justify feelings, opinions and viewpoints.
- D. Consider the feelings, opinions, and viewpoints of others.
- E. Organize, interpret and represent ideas and information.
- F. Question, explore and think aloud.

4 Not Scored (see pages 36-37 in Methodology, Chapter Three).

- And went back to the wet so he liked wet
- Mine likes the dry, not the wet *
- He likes the ? / (Bell rings)

This group obviously did not have time to figure out the moist/dry preference of mealworms.

The other group (Group B) held this discussion at the onset of the observation:

- This guy likes the wet.
- Not not the wet. He likes the dry.
- I wonder why he likes the dry instead of the wet.
- He probably was born in
- He was born in a pet shop. He wasn't born in the water.
- Well, he could be.
- Umm. He likes the dry. (firm statement)
- Umm hmm.
- He does like the dry. M., why don't you put him on, pick him up and put him on the wet.

After resituating the mealworm:

- He likes the dry.
- Uh huh.
- He really likes the dry.
- Or does he like the wet?
- He's not moving on the wet.
- He hates the wet. //
- I think he likes wet. (slight laugh)

Two minutes later, they responded to a question from the teacher:

T - What's yours doing?

- He likes the
- I think he likes the dry. He won't move on the wet.
- Yeah, he did. He was right here.
- Yeah, he he had the napkin and then Josh (Josh is the mealworm)
- I don't know ? like that. He was moving around on the dry.
- Ms. H., one was on the wet side. Now he's going to the dry side.

After another minute of observation, they report:

- Oh, it's going on the wet. I think he likes the wet.
- Keep him on the wet.
- Yeah.

- How come he only gets little bit onto the wet and then stays there?
- I have no idea. / M., it's curling up now.

(4 lines later)

- Mealworms like wet places. Mealworms hate dry.

The recess bell rang, ending the discussion. However, as they sat waiting to be dismissed for recess, the girls were whispering together:

- I just dumped him back into his bran.
- Now we really know.
- Now he only likes water.

The observations of behavior required more than simple *labeling.* Identifying mealworm preference was scored as *association and comparison* - associating a behavior with a preference; for example, "Mine hates wet," was a statement made after the child had observed her mealworm move from the wet onto the dry part of the paper towel. Some students were more analytical, showing an *awareness of sequence,* "Put him on the wet and he'll go 'waa';" a *recognition of associated events,* "If he's headed for your desk, he likes dry;" and *recognition of a central meaning,* "I wonder why he likes the dry instead of the wet."

In Group A, one of the group members played reporter with the microphone, causing a number of reprimands from the others. This increased the number of **Relational** utterances to 20% of the total. (In the other group, only 5% of the utterances were scored **Relational.**) Twenty per cent of the conversation of Group A was scored **Directive.** Group B's talk was scored 30% **Directive**, the major difference being the amount of time spent discussing how to correctly spell words being written in their Diaries. Examples of the **Directive** function, taken from both groups, include (non-consecutive):

- Keep him on the wet..
- Let's pour a bit more water.
- C., can you move mine, please.

In the "backward" experiment, only one group was audio-recorded. In this lesson the **Directive** function accounted for 45% of the utterances, equaling the **Interpretive** statements. A segment of this lesson involved getting the active mealworms distributed among the groups as well as discussing who should be in which group, both resulting in conversation scored **Directive.** In addition, the writing-generated conversation about how to spell words was also scored **Directive.** After writing in their Diaries and getting organized, there was not a lot of time remaining to attempt to make the mealworms move backward. The **Interpretive** statements were predominantly used to report; for example, "All my mealworms are in the pupa stage," and "It's not going front wards." There were a few statements which were more analytical, *recognizing associated actions or events*:

- He's in the pupa stage I think now.
- He can't be. He's not black.

and

- This guy crawls a lot when it's pushing him.

<u>LINC Analysis</u>

Table 2.B presents the data of the LINC analysis. The LINC guidelines provide a means of considering the talk in somewhat different ways. In experiment one, the children had predicted which environment, wet or dry, they thought a mealworm would prefer. Their observations and comments were in line with these predictions, urging their mealworms to display the preference they had predicted or come to believe in. "He likes this" is not an obvious statement of *hypothesis*, but really functions as such when the child has little justification to base it on. There were a number of more obvious examples of *hypothesis, prediction, and speculation*, especially from Group B (non-consecutive):

- I wonder why he likes the dry instead of the wet.
- If he's heading for your desk, he likes the dry.
- He must be tired.

The <u>"backward" experiment</u> resulted in no similar *hypothesizing or predicting*, but elicited more commands (non-consecutive):

-Come on, Tom, move. // Move.

- Move backwards!

As has been stated, the short length of this part of the lesson did not allow the children to really investigate how to get the mealworms to move backward; they did not have time to make a prediction and then test it.

The children in all three recorded groups felt free to *question, explore and think aloud*. Much of the speech was exploratory in nature; they offered tentative statements, questioned each other and would wonder why.

There were few examples of *relating new ideas to previous understanding and experiences*. One child in Group B did observe that mealworms "Probably would not like the Arizona desert," if they did not like dry environments.

In these lessons, children did, on occasion, *express and justify their opinions*. Examples include (non-consecutive and from both groups):

- I think he likes the dry. He won't move on the wet.

- He can't be [in the pupa stage]. He's not all black.

- Mine doesn't like the wet. See, he's going bye-bye.

The members of the groups worked together cooperatively, allowing for opportunities to *consider the feelings, opinions and viewpoints of others.* This is revealed throughout the lessons in the exchanges where they listen and respond to the comments and requests of each other. Often there was a statement, followed by an agreement:

- He likes it.

- He really does. (Group B)

and

- It's not going front wards.

- I know. (Group C)

As well, they were willing to help one another.

- C., can you move mine, please.

- Yeah, I will move yours for you. (Group A)

The "wet-dry" experiment required the students to interpret the behavior of the mealworms as indicating a preference for a wet or dry environment. To this end, they were involved in *interpreting information.* There are also numerous examples of Group B students interpreting instructions and organizing the investigation, including (non-consecutive):

- Let's try him on the dry side first.

- OK, M., let's try him on the wet again.

- Good. Now let's see if you like the dry or the wet.

As well, there are examples of members of Group C talking to organize their group, interpret directions and ask for help in getting organized: "What are we supposed to do again?"

The students later wrote down their observations, but there is no talk reflecting the *organizing and representing information* phase in either the "wet/ dry" or the "backward" experiment.

The children approached these tasks enthusiastically, feeling free to investigate and express their observations and feelings. They worked cooperatively most of the time, listening to each other and responding to others' comments and actions. A lack of time, however, prevented them from pursuing the investigations to the extent recommended in the ESS *Teacher's Guide* (1986).

Peanut Power

Peanut Power was one of the lessons included in the Energy unit for the grade six students at Elm School. This is an investigation activity from the *Seeds 6 Energy Literacy Series* (Society, Environment & Energy Development Studies Foundation, 1981). The audio-recorded lesson took place during a joint class of 40 students, both classes of grade six students, in the computer room (a large room with tables placed down the middle) while the rest of the school attended an assembly. The teacher named groups of four students and indicated at which table each group should sit, two groups working at each table. Each student received a worksheet (see Figures A and B) which explained the process to be followed, listed questions meant to guide their observations, and presented two problems which directed the students through a process meant to convert these observations into an understanding of the relationship between the energy stored in a peanut (this energy value being stated in joules) and how this can be applied to the amount of energy needed to walk or cycle a prescribed distance. The teacher explained that the classes had spent over half of the previous science class previewing the procedures they would be using in this experiment and talking about food as a source of energy.

The teacher instructed the students to separate their materials, to get the water they needed and to raise their hands when they needed to have their peanuts lit on fire. The students then went to work, reading the instructions on the front of the sheet and setting up their equipment. The apparatus on which the can sat (a bent clothes hanger) was susceptible to falling over if bumped. Several groups did spill their water at least once, including Group B. Group C was disbanded and the students were sent to work with different groups after spilling their water three times.

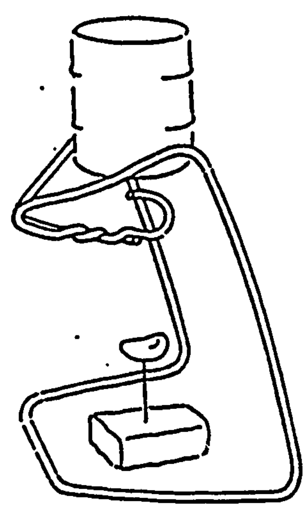
After the completion of the experiment and an adjournment for recess, both classes met in a grade six classroom for a follow-up discussion. When asked what they had observed, four hands were raised, but several others volunteered information once the discussion had started. There was a wide variation in observed temperature changes (0°, 3 °, 4°, 4°, 5°, 7°, 13°, 15°) and eight students volunteered ideas about why there might be this variation (the size of the peanut and the length of time it burned being the most often given reasons). They then reviewed the calculations necessary to convert this temperature change to heat energy, finishing with a short discussion of the possible answers to the sixth question (Does this answer give us all of the energy that is stored in the peanut? If not, where did the rest go?). They speculated that energy may have gone into the air, was still present in the peanut or that part of the peanut may have fallen off.

Figure A: Procedure Instructions - Peanut Power lesson.
(Form reproduced at 70% of original)

HOW MUCH ENERGY DOES A PEANUT HAVE?

I. PROCEDURE

1. Shell the peanut and attach it to the pin. (see picture below).
2. Pour 100 mL of water into the metal can.
3. What is the temperature of the water? ____________________
4. Place the can on the stand.
5. Place the foam block and peanut below the can.
6. Make sure the peanut is close to the can.



7. Use a match to set fire to the peanut.

Figure B: Observations, Calculations and Application Worksheet- Peanut Power lesson.

(Form reproduced at 70% of original)

II. OBSERVATIONS AND CALCULATIONS:

1. What happened when you set fire to the peanut?

____

____

____

2. When the peanut goes out, measure the temperature of the water. __________

3. What do you observe on the bottom of the can?

____

4. What is the difference in the temperature of the water?

____

5. Calculate the heat energy released by the peanut in joules.

Energy released = temperature change x 420

____

6. Does this answer give us all of the energy that is stored in the peanut? __________

If not, where did the rest go? __________

____

III. APPLICATIONS:

1. To walk 1 km you need about 220 kJ of energy. How many peanuts would you have to eat to walk 1 km? (hint: to obtain kilojoules, divide joules by 1000). __________

____

2. To cycle 1 km you need 50 kJ. How many peanuts would you have to eat to do this? __________

Table 3

Categorization of small group talk recorded during the PEANUT POWER lessons.

A. Talk categorized according to Tough (1977)

Lesson Component	Language Functions (Percent of Utterances)[1] Directive	Interpretive	Projective	Relational	NCU[2]
Group A	30	35	<5	40	364
Group B	35	15	<5	50	331
Group C	30	15	<5	55	164

1 Percents rounded to nearest 5% (see page 35 in Methodology, Chapter Three).

2 Number of Coded Utterances.

B. Talk categorized according to LINC Talking-to-learn guidelines.

Lesson Component	Number of Utterances Matching the LINC Categories[3] A	B	C	D	E	F
Group A	0	0	1	NS[4]	22	NS
Group B	0	0	1	NS	12	NS
Group C	0	0	2	NS	6	NS

3 LINC categories designated as follows:
- A. Hypothesize, predict and speculate.
- B. Relate new ideas to their previous understanding and experiences.
- C. Express and justify feelings, opinions and viewpoints.
- D. Consider the feelings, opinions, and viewpoints of others.
- E. Organize, interpret and represent ideas and information.
- F. Question, explore and think aloud.

4 Not Scored (see pages 36-37 in Methodology, Chapter 3).

In the following discussion, examples of talk from each of the three groups will be used to illustrate the range of their conversations and to give some indication of the meanings they were constructing. The functions of this talk are discussed first in terms of Tough's classification of language uses, followed by the results of analyzing this talk using the LINC talking-to-learn guidelines.

There were four students (chosen from both classes) in each group. Group A, two girls and two boys, got along quite well, directing one another during the experiment and then joining in the fun of stating observations with a heavy pseudo-Indian accent. They started to work together on the application problem, but the girls got involved in several nonsensical accented conversations. These were interspersed with short segments of talk focusing on solving the problems. Group B, three girls and Miki, the ESL program boy introduced in Group A in Static Electricity, was a less harmonious mix; during the course of the lesson one student stated, "I hate my group." The two boys and two girls in Group C seemed to like one another but were never able to get themselves well enough focused to carry out the experiment. As previously mentioned, this group was divided up and sent to work with other groups after they had bumped their stand and spilled their water for the third time.

<u>Tough Analysis</u>

The classification of language use is presented in Table 3.A. .

To illustrate the range of conversation, segments have been chosen from the transcripts of each group. These segments represent typical dialogue at different times during the lessons.

Group A:

Observations made about halfway through the lesson:

- It's cooking the peanut. /
- It's wrinkling.
- Yeah, it's like it's like this stuff is like making it like
- Oh, it's weird.
- You talk funny.
- ? /
- It's wrinkling and turning black. (positive declaration)
- It's not wrinkling.
- It's turning blue, actually.
- Is it?
- Just put wrinkling.

A mixture of **Relational** and **Directive** speech while members of the group work on the calculations.

- I've got the gigglies. (giggle)
- Stop it.
- Instead of I've got the willies, I've got the williams. (giggles) //
- How do you do this?
- ? how do you do this?
- (? accented) //
- I've got the williams. / I've got the williams.
- OK, I've got the gigglies.
- OK, what do you do here?
- I've got the williams.
- What do you have to do here?
- I've got the williams.
- First you have to divide 168
- I've got the williams.
- by 1000.
- OK.

Group B:

Setting up the experiment (**Directive** function):

- It says OK, dump these out.
- Pour 100 milliliter
- OK. Metal can, metal can.
- This is the metal can.
- ?
- Wait, Cynthia, gosh.
- ? water into the metal can.
- Yuuup.
- OK.
- OK, wait.

Halfway through the experiment, filling in the blanks on the worksheet **(Interpretive, Directive and Relational)**:

- Seven degrees.
- Oh, my God.
- It went up.
- Alle, alle, alleluia, (repeats)

- (reading) What do you observe on the bottom of the can?
- It's black.
- It's all black.
- ? //
- (reading) What is the difference in the temperature of the water?
- Seven degrees.
- (reading) Calculate calculate the heat energy released by the peanut in joules.
- (reading) Energy released equals temperature change times four.
- OK, let's see now.
- Hmmm. Don't be a moron.
- Oh, da do da do.
- Wooo. Woo woo woo. //

Continuing with the worksheet, after being interrupted by a discussion of one child's shirt:

- OK. (reading) Does this answer give us all the energy that is stored in a peanut? Yes.
- Well, how did you find ? ?
- (reading) If not, where did the rest go? Blah, blah, blah. Applications.

To walk 100 kilometers you need about 200 and (voice trails off to sounds).

Group C:

Setting up after the first spill. Mixture of **Directive, Relational** and **Interpretive** speech. (This the longest segment of **Interpretive** talk in the transcript.)

- Measure the water, you dummy.
- Yes, I did.
- You did not.
- I did too measure it.
- Not in there? // //
- Oh, this peanut looks wicked.
- Ha ha ha ha ha. I got ?
- It'll probably spill over.
- (laughter)
- What's the temperature?
- 25.
- OK, you guys, 25 is the temperature.

- Yeah, 25.
- I don't trust this table.

Dialogue leading up to a spill, (after which the teacher intervened and sent them to join other groups):

T - Do you want a match?
- Burned.
- Thanks. //
- Oh, boy, does it ever
- Smoke //
- (laughing) He ate it.
- He ate the match.
- No, I didn't. I spit it out.
- ?
- Why are you so gullible?
- Well, you put it in your mouth.
- You are the grossest.
- Gross.
- (screams) // {Water can has tipped over once again}

The **Relational** function was the most prevalent function in each group. Group B's conversation was scored highest in this category; 40% of their conversation was judged to be **Relational** in nature. Much of this talk centered on whether or not a boy in the group was telling the truth when he said his shirt was a Gucci and cost $300. The subject arose and was argued about, died during a group discussion of the solution to the heat energy problem, resurfaced, was superseded by a discussion of the kilojoule problem and was once more briefly discussed, ending with the following exchange:

- If your mum spent $300 for that shirt, then you're a spoiled brat.
M - Who me?
- You're a spoiled brat if your mum bought $300 for the shirt.
M - She does.
- You're spoiled.

The **Directive** also figured prominently, averaging more than 30% of the discourse. Examples of this talk have been given in the conversations reported on the previous pages.

There was a low occurrence of **Interpretive** talk, ranging from a high of 35% in Group A to a low of 15% in Group C. Furthermore, by far the majority (80-90%) of that speech was classified as simple *labeling* or *elaboration of detail;* typical examples include (non-consecutive):

Group A:

- It's going down.
- OK, it's 22.
- That's what I got.

Group B:

- It turned black.
- What's the temperature?
- Ours spilt.
- 294.

Group C:

- It's on there.
- Someone tipped over our water.
- It burnt.

As well, nearly 20% of Group A's statements were coded as *association and comparison,* statements such as (non-consecutive):

- That's hot.
- It smells like burnt barbecue.
- It didn't rise very much.

In all three groups, only two statements were judged to show an *awareness of sequence*, one example being, "OK, when the peanut goes out we have to measure." Two statements in Group A seemed to indicate a *recognition of associated actions or events* (non-consecutive):

- It's wents into the air. (accented) [Referring to the question, "What has happened to the energy stored in the peanut?"]

- Yeah, and I think you don't round because 600...

LINC Analysis

Table 3.B. presents the results of the LINC analysis. This talking-to-learn guideline offers a somewhat different perspective of the language used in this lesson. The lesson did not include a prediction component and no statements from any group were judged to be used to *hypothesize, predict or speculate.* Despite the fact that there was an application section to this assignment, no statements were judged to *relate new ideas to previous understanding or experience*; there was no evidence that any of the students who were audio-recorded connected the energy released by burning a peanut with the energy

released by eating a peanut. The application problem seemed to be viewed simply as a mathematics problem, the major concern being whether one should multiply or divide. The answers were never given in terms of peanuts, only as straight numbers.

There were also very few examples of students *expressing and justifying feelings, opinions and viewpoints.* The following statements, judged to fit this category, should give an impression of this usage in this lesson (non-consecutive):

- It goes right down to the center; the smoke's coming out of the center. (Group A - context-bound statement)

- That's exactly what she said not to do. (Group B - why they should not do something)

- Well, I saw him. (Group C - How he knows who spilled the water)

These groups were all chosen by the teacher and did not always work together amicably, which impacted on the number of statements judged to show *consideration for the feelings, opinions and viewpoints of others.* Group A worked quite cooperatively, listening and responding to each other's observations and directions until the active part of the lesson ended; that is, until the peanut burned out and the temperature of the water was measured. Then two of the girls got the "williams" (see conversation segment on page 59) and the group was effectively divided in two, two of them attempting to work together to finish the worksheet and two not only not attending to the task, but making statements which could be considered inconsiderate and obstructionist (non-consecutive):

- Oh, shut up. You are no smarter than us. (with a slight accent)

- Veddy veddy veddy veddy wrong.

and (consecutive):

- (loud, insistent, accented) I know the answer for number two.

- So do I. Do you?

- You know what it is?

- Yes.

- So far, I've got zero.

Group B worked together much less successfully, statements such as the following being used often during the lesson (non-consecutive):

- I hate my group.

- You did that. (accusingly)

- She's lying. She did that.

- Dummy spilt ours.

This is also the group which argued about the Gucci shirt. As in Group A, two of the students attempted to complete the worksheet, but the other two carried on a social conversation, making it seemingly difficult for the others to concentrate on the application problems.

In Group C, none of the conversation was judged to be considerate or supportive and the group was disbanded before working on the application problems, an area where some of the other students had worked cooperatively.

All of the groups displayed language used to *organize, interpret and represent ideas and information.* This is in keeping with the high **Directive** scores in the Tough analysis. However, while Group A scored lowest in the percentage of time utterances were judged to be **Directive**, they scored highest in this LINC category because their statements were often used to interpret the instructions, not just comment on the action. Examples include (non-consecutive):

- OK, it's been thirty seconds if you want to
- No, it doesn't stay. We just have to bend this one here.
- You have to wait until it goes as high as it can.
- What is the temperature, the temperature of the water? (This is an attempt to return to the task after two of the students have started to use accents and get rather theatrical.)

Again, the exploratory talk classification was not scored because this type of talk was always encouraged. Few examples of speech used to *question, explore and think aloud* were to be found, however, in any of the groups. The task seemed to be perceived as one you did, not one that required ideas to be explored.

This lesson did not seem to have engaged the attention of the students as the teacher would have desired. It was held under difficult circumstances; excited and noisy students were crowded together using rather sensitive apparatus. Afterwards the teacher remarked that she would never attempt a similar activity under these conditions. She had hoped that the pre- discussions would have prepared the students to pursue this investigation, but she felt that this had not been the case.

This lesson did allow students a chance to work together cooperatively and the conversations show some to the students working in such a manner part of the time. However, they were also often uncooperative and their talking indicated a very limited interpretation of data which might indicate an increase in their knowledge about energy. The follow-up discussion may have helped some of the students better understand the implications of this practical work, but little visible enthusiasm or connection-making was expressed by the students during this discussion.

Solar House

On the day prior to this lesson the grade six classes had discussed solar houses, talking about the placement of solar panels, windows and trees (both coniferous and deciduous) to provide full advantage of sun, shade and shelter. This was a part of their unit study on Energy.

The following was written on the board the day of the recorded lesson:

> You are working in groups to construct and properly place a solar home on a lot. Your lot is labeled W-----E and you must place the windows, trees, etc. in the best places. Remember: deciduous tree - loose leaves. Coniferous trees - Evergreens.

The students were allowed to form groups of their own choosing, the only restriction being that there be no more than four students in any group. Each group received an 8 1/2 x 11 inch sheet of paper with the pattern of the solar house, windows, trees and a mirror on it (See Figure C) and were told to cut these out, assemble them, properly place and glue them on a second sheet of paper (the lot), labeled W-----E. The teacher circulated among the groups as they worked, asking and answering questions and helping with any assembly problems. (Because the edge of the pattern was partially cut away at one point, there were a number of problems.) Group A was a group of three boys who asked to be recorded. Group B was a group of boys in the second class, but four in number. They were asked to volunteer as the group was of similar composition to the group just recorded and they volunteered very readily.

All groups in both classes differed somewhat in their approach to this problem, partially depending on the number of pairs of scissors the students could find. In some groups everyone was involved in cutting out, in others some of the students cut, some pasted and others sat and watched, colored or chatted. In both recorded groups, everyone was involved to some degree in cutting out the patterns.

Tough Analysis

The classification of language uses is presented in Table 4.A. This type of assignment allows for considerable social interaction while the students are cutting out, folding and assembling the pieces. This is reflected in the amount of **Relational** talk in the two groups, more than 55% of the total in Group A and more than 50% of the total in Group B. Topics of discussion in Group A were an up-coming baseball game and the ways to transport the team members to the game, movies, shopping experiences at a local

Figure C: Solar House Pattern.
(Form reproduced at 70% of original)

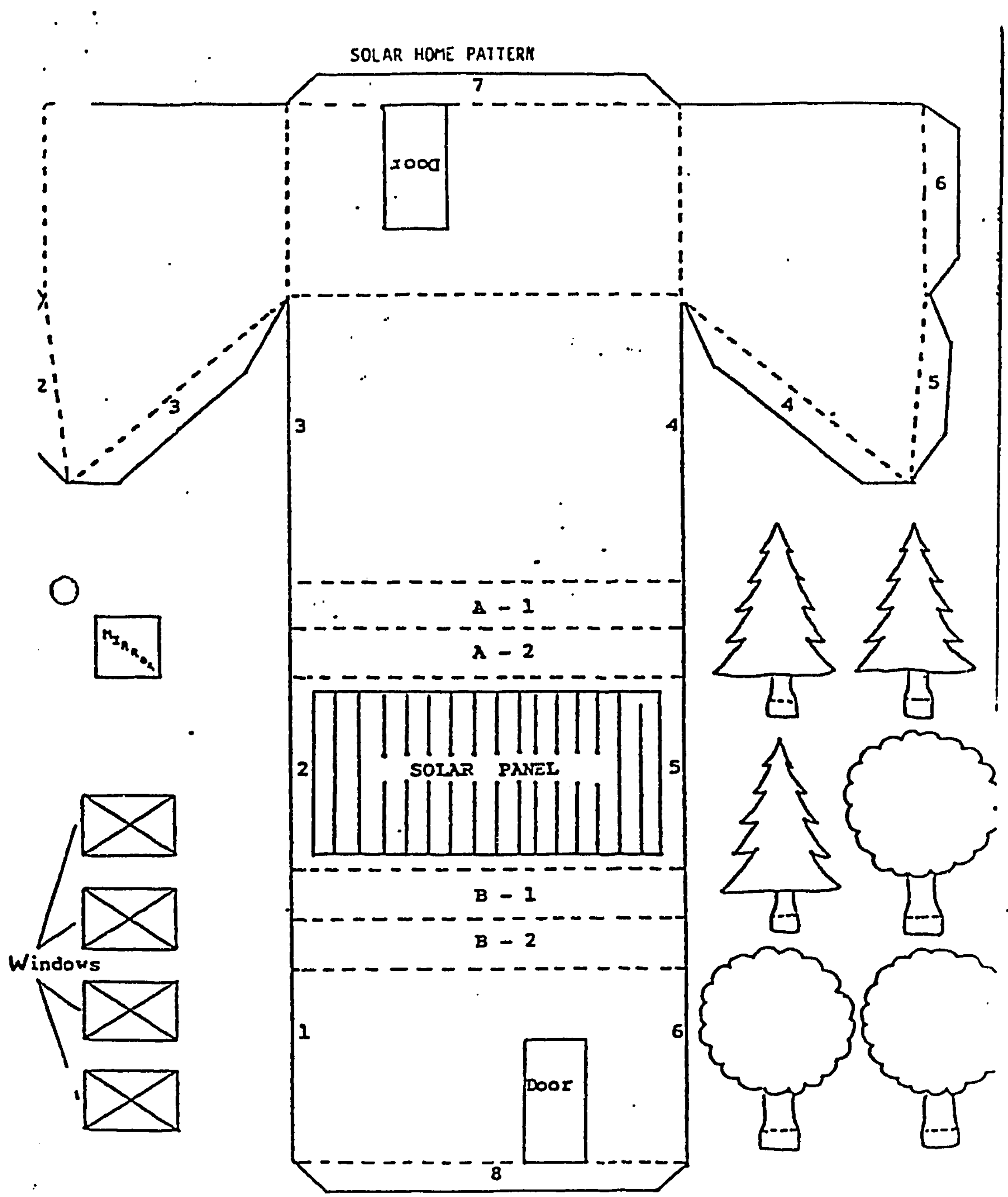


Table 4

Categorization of small group talk recorded during the SOLAR HOUSE lessons.

A. Talk categorized according to Tough (1977)

Lesson Component	Language Functions (Percent of Utterances)[1] Directive	Interpretive	Projective	Relational	NCU[2]
Group A	30	15	<5	55[3]	376[3]
Group B	25	25	<5	50[3]	416[3]

1 Percents rounded to nearest 5% (see page 35 in Methodology, Chapter Three).

2 Number of Coded Utterances.

3 Periods of more than 30 seconds of relational speech - timed but not transcribed.

B. Talk categorized according to LINC Talking-to-learn guidelines.

Lesson Component	Number of Utterances Matching the LINC Categories[4] A	B	C	D	E	F
Group A	0	0	6	NS[5]	9	NS
Group B	2	3	18	NS	11	NS

4 LINC categories designated as follows:
- A. Hypothesize, predict and speculate.
- B. Relate new ideas to their previous understanding and experiences.
- C. Express and justify feelings, opinions and viewpoints.
- D. Consider the feelings, opinions, and viewpoints of others.
- E. Organize, interpret and represent ideas and information.
- F. Question, explore and think aloud.

5 Not Scored (see pages 36-37 in Methodology, Chapter Three).

discount store, chips and bubble gum and, more closely related to the task, "oople" (apple) trees and bathroom mirrors. One exchange as an example (near the end of the lesson):

- M., are you going to be a * when you grow up?
- Brad is.
- I am.
- Pat will.
- No, I
- (noises)
- Get out of my way.
- Oople trees. We forgot to draw on our ooples.
- (silly voice)
- We forgot to draw ooples.
- ? turn it into oople trees.
- Ooples.
- Hey, we have to put the mirror on.

Group B also engaged in social conversation, but the topics were different. These boys reminisced about the past year when one of the group members transferred to their school and some of their interactions since then, skipping grades and passing report cards, job status of parents and getting hit by a car. Part of one of their exchanges sounded like this:

- We're saying all this stuff and we're being taped.
- Who cares? It's only a tape.
- It's only a tape. We're just going to be quoted at the University.
- Ha.
- So, I'll get my dad to listen in.
- Oh, your dad would kill you if ?
- I don't care. What's the worst he could do to me?
- Uh.
- Beats me.
- Put you in the foster child home.
- Nope, ground me <u>for three weeks.</u>

The next most common language function was the **Directive**, approximately 25% of the utterances of both groups being used to this end. This talk was used to ask questions (non-consecutive, taken from both groups)

- Do we cut this out?
- Where do we put these windows?
- Can I have those scissors for a second?
- Where is our mirror?
- Who took our white glue?

or to direct and comment on the on-going action:

Group A (non-consecutive):

- I did that.
- M., cut out the 2's.
- OK, I'll glue the mirror on.
- Make these trees stand up.

Group B (non-consecutive):

- I'll cut out the trees.
- Hey, you guys. Windows.
- OK, put it down. OK, solar panels. So.
- Put on the put on a window.
- I'm putting on the window.

The **Interpretive** function of language was represented in approximately 15% of Group A and 25% of Group B's utterances. These utterances were further classified to note the analytical strategies the students were using to construct meaning. Other than the greater use of the **Interpretive** function by Group B, the major difference between the groups was that 10% of these statements in Group B were classified as *recognition of a central meaning* while no statement in Group A was judged to fit this category. Examples of such statements include (non-consecutive):

- And then it comes up and it shines really hard on the south.
- All right, guys, we're going to put all the trees on the north so it blocks out all the cold.
- Yes. South is where all the heat comes.
- Put it so it reflects light onto the solar panels.
- We can't put the trees there because umm it'll block the solar panels.

Both groups engaged in a similar percentage of talk *recognizing associated actions or events.* Examples of such meaning making include (non-consecutive):

Group A:

- [responding to "That's south.") - So that's where we have to have our solar cell.

- The mirror should be on the top of the house so it like reflects and then goes back.

- No, it should be on the north side, so it reflects the sun.

- Put the solar panels to the north.

- Oh, they're wrong.

- The trees go on the north side.

Group B:

- We've got to have the solar panels facing south.

- Solar panels and windows are going to face south.

- Could the mirror reflect light inside?

- We put the mirror here at an angle so it will reflect light right into here.

Over one third of the **Interpretive** statements were classified *association and comparison.* The predominant use was for referring to the placement of their windows, trees and the mirror in the back or the front. An example from Group A which illustrates this type of analytic strategy:

(talking near the end ot the lesson)

- * we're supposed to put the mirrors on the back, too.

- No.

- No.

- That's where they go.

- No.

- No.

- That's what N. and them did. We're supposed to copy them.

- OK, we'll put the mirrors on the back.

- One of them will go in the front.

Group B (non-consecutive):

- The pine trees should be at the front.

- Why the mirror like that?

- What about here?

- K., more like that.

The *labeling* and *elaboration of detail* statements were nearly twice as prevalent, judged on a percentage basis, for Group A. Statements include (Group A, non-consecutive):

- That's south.

- Those are windows, man.

- And this is the back door.

- What have you done?

- Did you find the mirror yet?

Comments from Group B in this category are similar to the above.

LINC Analysis

The results of the LINC talking-to-learn analysis are presented in Table 4.B. As heretofore explained, it was very difficult to delineate certain statements as "more" exploratory in nature than others as thinking aloud was encouraged and commonly practiced by these students. *Consideration for the feelings, opinions and viewpoints of others* was also encouraged and was observed to a greater or lesser degree in all the groups. The groups for this lesson were self-selected and the group members were friends; there are examples of considerate statements to each other ("Yeah, that's right, R."), consensus-building statements (What about like this, you guys, like this?") and more challenging statements (R., you're not that smart yet," and "No, in the middle, duuh.") These were grade six boys, a group not known for being overly considerate to one another. Because these two types of talk were so much part of the fabric of this lesson, I did not score these categories separately.

In a lesson of this type, constructing a model based on previous learning or understanding, one would expect to hear examples of students *relating new ideas to previous understanding and experiences.* However, it is difficult to judge by their statements if they were making those links. None of the statements made in Group A were felt to unequivocally exemplify this category. There were statements made by boys in Group B which were so judged, including (non-consecutive):

- See, but if they made a real house it would be this would be more slanted out.

- Not in the middle! They won't be able to walk in.

The discussion reported earlier on pages 69 to 70 also drew heavily on their previous understanding of direction, sun and heat. Certain features of this assignment, though, may have actually hindered connections being made. To make the folding and assembly easier, the house was not a typical house shape. As well, the four windows which were to be placed on their house would not all fit onto the south side of the house in any configuration the students would have ever seen before.

Talk considered to exemplify *hypothesis, prediction or speculation* was very limited. The following two statements made by boys in Group B were the only statements so coded (non-consecutive):

- Could the mirror reflect light?

- If they go in the back they won't start on fires start fires as easy. / Start on fire.

It would appear that this assignment was not seen by the students as one requiring this type of thinking.

The boys in Group B not only engaged in more **Interpretive** talk than those in Group A, but they also *justified their opinions or viewpoints* three times more often. Examples (non-consecutive):

Group B:

- All right, guys, we're going to put all the trees on the north so it blocks out all the cold.

- We put the mirror here at an angle so it will reflect light right into here.

- No, it won't [reflect]. It'll go bazzing.

Group A held the following conversation:

- The mirror should be on top of the house so it like reflects and then goes back.

- No, it should be on the north side, so it reflects the sun.

- No because it comps(?) the sun.

Talk used to *organize, interpret and represent ideas and information* was generally used in both groups to interpret the instructions and focus the group's attention on the task.

Group A (non-consecutive):

- B., that thing's about to fall apart. I think you have to cut off the 2.

- I think there and there. (gluing)

- Hey, we have to put the mirror on.

Group B (non-consecutive):

- Yeah, this is supposed to be folded in and this like that and there's our house. It goes like this.

- All right. I got it. All right. We take the mirror and we put it sort of like this.

- First we get the windows on.

The transcripts from this lesson provide an insight into the approaches taken by two groups of boys toward a practical task aimed at assessing their understanding of a previously discussed concept. There was an obvious difference between them in conversation, but the tendencies in each group were for the **Relational** function to dominate the conversation and the **Interpretive** to receive the least attention (although the **Interpretive** and **Directive** were quite evenly divided for Group B). The distribution of these functions varied for the two groups, however. Except for a three minute stretch of

Relational speech in Group B while they settled into cutting out the pattern, there was quite a regular mix of **Directive, Interpretive** and **Relational** speech throughout the lesson, indicating a continual return to the assigned task, refocusing themselves on the necessary physical and intellectual demands of the assignment, as they recognized them. Group A engaged in longer segments of **Relational** talk, refocusing less often and for a shorter duration of time on the assigned task of properly placing a solar house and landscaping on a lot.

Static Electricity

A unit entitled Electrical Charges and Currents was introduced by a set of three hands-on science lessons exploring the topic of static electricity. Two grade six classes were observed during these lessons and two groups in each class were audio-taped. Both classrooms were arranged in a traditional manner with desks lined up in rows facing the blackboards. However, the students worked wherever in the room they felt comfortable during these lessons, often sitting on the floor. The teacher named groups of three or four students the first day and the students stayed in these groups for the three class periods spent studying static electricity.

The teacher introduced the first lesson by mentioning events students had probably experienced. She asked if any of them had ever walked across a room and got a shock when they sat down, or taken off their hats and had their hair stand up or rubbed a balloon and stuck it to the wall. A short class discussion to answer, "How do these things happen?" ensued. One student suggested that a balloon is magnetized by rubbing on hair. Another boy stated, " When you rub it against your hair it creates static electricity. When you put it against the wall, it's umm (inaudible)." The teacher then rephrased this, "OK, so your hair does something to this balloon to make it stick. So this thing called static electricity makes this stuff stick, makes your hair go out like this, and makes you get a shock. This thing called static electricity."

She next explained that they were going to be doing some experiments to see how things re[illegible] when they are rubbed against other things, what they do with each other and what they might do to something else. As they worked, the students were to try to figure out why this was happening. They were told that, "Later on it'll become clear and you'll be able to see if your ideas were correct." The students were also asked not to go on to the next activity until everyone in the group had seen and understood what was happening in each step. Each day the groups received a set of materials and each student had a record sheet with instructions, questions and space in which to write their answers (see Figures D, E, F).

The first day they received a bag containing a comb, small bits of paper, a square of wool fabric, a square of synthetic fabric and a blown-up balloon. Some groups started on the task immediately, working systematically through the exercises while others were more interested in social interactions Some groups wrote just what they had observed, while others questioned if the experiment had "worked." Most of the groups completed this page in the allotted time (the science class periods were half an hour long), but a few, including Group B, did not finish and were advised that this was no problem as there would be time to finish this in the next lesson

The students were warned at the beginning of Lesson Two to be careful not to rub the balloon or it would get charged and the experiments would not work. The students were then given their materials: a toothpick, balloon, comb and squares of wool fabric, synthetic fabric and plastic wrap. They got themselves organized into their groups and started to work, although a few had to be reminded to first finish Record Sheet 1 before starting Record Sheet 2. This set of experiments did not take as long as the first set, leaving time at the end of the class for a review of their results. When the teacher asked the first class, "What do the results of question number three tell you?" only one hand was raised and that was done hesitatingly. The teacher then wrote the following sentences on the board for the students to copy: "An object can be charged by rubbing it with another material. Charged objects always attract uncharged objects." The lesson then ended.

Because of the difficulties making the balloon experiments "work" (attract or not attract according to the laws of static electricity) in the past two lessons, question number one on Record Sheet 3 (see Figure F) was done as a demonstration by the teacher. The students then received their materials (a balloon, a square of wool fabric and a square of plastic wrap) and were instructed to do the experiments indicated on their record sheet. When they reached question number five ("Explain why the balloons acted this way"), they were to discuss their ideas as a group, but they were not to write anything down. This record sheet took most groups only a few minutes to complete. The rest of the period was used to discuss what had happened when the balloons were rubbed with the wool and plastic wrap. When the teacher asked what had happened when one balloon was rubbed with wool and the other with plastic wrap, first three and then two more hands were raised. Of the students in the recorded group, Joanna raised her hand, Devin played with something in his desk, Keir and Nancy watched the front of the room, Marcy was drawing and Alice had a note taken away by the teacher.

Figure D: Record Sheet One - Static Electricity lesson.
(Reproduced at 70% of original)

Record Sheet 1.

1. Rub a comb with a piece of wool, and put the comb near some small bits of paper. What happens?

____

____

2. Hang a blown up balloon on a string from the edge of a desk or table so that it swings freely. Rub a comb with the piece of wool and hold the comb close to the balloon. What happens?

____

____

3. Rub a comb with a piece of wool. Then hold the comb near a thin stream of water from a tap. What happens?

____

____

4. What inference can you make to explain your observations?

____

____

5. Rub a comb with wool and put it near some paper. Shake off the paper and rub the comb with your hand. Place it near the paper again. What happens?

____

____

Why do you think this happened? ____________________

6. Rub a comb with wool on one end only. Does that end pick up paper? ______ Now turn the comb around and touch the unrubbed end to the paper. What happens?

____

____

7. What inference can you make to explain why the comb and paper acted like they did?

____

____

Figure E: Record Sheet Two - Static Electricity lesson.
(Reproduced at 70% of original)

Record Sheet 2

1. Hang a toothpick from a string and attach it with tape to the side of your desk. Place a balloon, comb and ruler near it, one at a time.

   Are they attracted to the toothpick? ____________

   Can you tell from this if either object has an electric charge? ____________

   Does either object have an electric charge? ____________

2. In order to put a charge on the balloon, comb and ruler, rub each object with wool, plastic wrap and synthetic fabric, one at a time. Find out if it has received a charge by holding the object near the toothpick.

3. Record your observations on the chart below.

CHARGED OBJECT	RUBBED WITH	ATTRACTED TOOTHPICK (✓)
balloon	wool	
balloon	plastic wrap	
balloon	synthetic	
comb	wool	
comb	plastic wrap	
comb	synthetic fabric	
ruler	wool	
ruler	plastic wrap	
ruler	synthetic fabric	

Figure F: Record Sheet Three - Static Electricity lesson.
(Reproduced at 70% of original)

RECORD SHEET 3

1. Hang two balloons from strings. Tape them to the edge of a table or desk so that they are near one another but not touching. Put an X on one side of each balloon. Are the balloons sticking together, moving apar., or just hanging?

____

2. Rub one balloon X with wool. Then rub the other balloon X with plastic wrap. Turn the balloons so that the X's are opposite one another. What do you observe?

____

3. Rub both balloons with your hands. Then rub both balloon X's with wool. Turn the balloons so that the X's are opposite one another. What happens when you do this?

____

4. Rub both balloons with your hands. Then rub both balloon X's with plastic wrap. What do the balloons do now when you put them opposite each other?

____

5. Explain why the balloons acted this way.

____
____
____
____
____
____
____

The students chosen to explain what had happened gave acceptable answers (example: "One of the balloons pushes the other one away"), but they did not seem confident in their answers. The teacher would repeat or rephrase the answer, then repeat it using the term attract or repel.

"Now we have to figure out why they did that," the teacher explained, rephrasing question five. She asked, "What did we do when we rubbed them [the various objects] with wool or plastic?" A student replied, "We charged them with static electricity." To which the teacher replied, "We have put a charge on that object. There are two kinds of electric charges, one is negative and one is positive. When we rub an object with wool we give that object a negative charge. When we rub with plastic, you're giving it a positive charge." She then referred back to the experiments they had been engaged in, asking students what had happened when objects had been rubbed with wool or plastic. Next, she explained the terms "like" and "unlike" and wrote on the board. The students copied the following onto their Record Sheet: There are two kinds of electric charges, positive (+) and negative (-). Wool charges objects with a negative charge, plastic charges objects with a positive charge. Like charges (-)(-) or (+)(+) repel (push apart). Unlike charges (-)(+) attract (come together).

During this discussion, the class was quiet and the teacher was able to slowly and clearly explain the terms. She did have to stop twice, though, to reprimand students for off-task reading and writing. The class quietly copied the notes from the board. The girl sitting next to Devin attempted to explain the terms to him.

This ended the set of lessons on static electricity; the following lessons were to focus on a different aspect of electricity.

The discussions held by the groups during these lessons will be explained group by group, focussing on meaning-making segments of conversation (the **Interpretive** function). The other Tough language functions will also be discussed and illustrated. The results of the Tough analysis are presented in Table 5.A . The results of the analysis of the talk using the LINC talking-to-learn guideline will then be presented with examples of talk that illustrate these various categories.

This series of experiments was intended to illustrate and clarify the laws of static electricity. As static electricity is not always "coooperative" (Friedl, 1991; personal observation), the conversations reflect students working with observations that made little sense to them. Few, if any, patterns could have been discovered from their data.

Table 5

Categorization of small group talk recorded during the STATIC ELECTRICITY lessons.

A. Talk categorized according to Tough (1977)

Lesson Component	Language Functions (Percent of Utterances)[1]				
	Directive	Interpretive	Projective	Relational	NCU[2]
Lesson 1					
Group A	40	20	<5	35	216
Group B	40	45	<5	15	284
Group C	20	30	<5	50	345
Group D	45	40	<5	15	195
Lesson 2					
Group A	50	35	<5	10	163
Group B	30	35	<5	35	229
Group C	30	30	<5	40	296
Group D	40	30	<5	30	254
Lesson 3					
Group A	75	15	<5	15	95
Group B	50	25	<5	25	161

1 Percents rounded to nearest 5% (see page 35 in Methodology, Chapter Three).

2 Number of Coded Utterances.

Table 5 (continued)

B. Talk categorized according to LINC Talking-to-learn guidelines.

Lesson Component	Number of Utterances Matching the LINC Categories[3]					
	A	B	C	D	E	F
Lesson 1						
Group A	0	0	4	NS[4]	10	NS
Group B	3	5	3	NS	12	NS
Group C	5	0	11	NS	5	NS
Group D	3	0	6	NS	12	NS
Doing Experiments	7	1	4	NS	3	NS

3 LINC categories designated as follows:
A. Hypothesize, predict and speculate.
B. Relate new ideas to their previous understanding and experiences.
C. Express and justify feelings, opinions and viewpoints.
D. Consider the feelings, opinions, and viewpoints of others.
E. Organize, interpret and represent ideas and information.
F. Question, explore and think aloud.

4 Not Scored (see pages 36-37 in Methodology, Chapter Three).

Group A

Four students were assigned to this group, three girls, Alice, Marcy, and Nancy, and Miki, a boy whose family had moved to Edmonton the previous year from an eastern European country. Enrolled in the English as a Second Language (ESL) program in the school, Miki spent part of each school day in a regular classroom and the remainder in the ESL program.

The **Directive** was the predominant language function of this group in <u>Lesson One</u>: 40% of the dialogue was so coded. This talk was used to read the instructions, figure out what they should do and to decide who would carry out the tasks. The following conversation occurred near the end of the lesson:

- OK. So what do we do? We've got to <u>rub</u>
- (reading)<u>Rub</u> a comb with wool on one end only. <u>Then</u>
- <u>The end.</u> What do you mean?
- end pick up paper?
- Like this? One end.
- I think like this.
- Look at this. Put it right there and then just go.
- OK.

Group A scored the lowest of the four groups on the frequency of the **Interpretive** function during this lesson, with only 20% of their talk being used to reflect on the meaning of the exercise. There was little conversation about their observations and often little discussion [illegible] an answer was offered by one of the students; for example:

Answering question two:

- It attracts the balloon. (No further discussion.)

Answering question three:

- It bends toward the comb. (No further discussion; however, this was an observation made while working with the teacher.)

Answering question four

- OK, let's discuss number four. OK, because when you rub the comb against the wool it um attracts.
- Don't do that, Miki.
- It attracts static electricity.

Answering question five:

- Now it won't pick up because I rubbed it with my hands. //
- OK, rub.
- Is this number four?

- I already did. When you rub with your hands, it doesn't work. // //
- Oh, I know why this happens. //
- Don't, Miki. // Stop it. // He's such a geek boy.
- (reading) Why do you think this happens?
- Because your hand __*__.
- __?__ have no have no static. (They then went on to the next question.)

Answering question six:

- (reading) What happens?
- That means this side, doesn't it?
- So the end that wasn't rubbed.
- I already turned it.
- A little bit.
- It still has a little bit of electricity.
- Yeah, I know.
- Now.
- OK, what happens? It doesn't pick up paper. // (No further discussion)

Answering question seven:

- Which experiment do they mean?
- All of it, like. Don't you guys understand it? Like when you rub it, what does the wool do and what does the comb do?
- The wool attracts.
- Oh, I know what it does.
- Static electricity.
- Electricity. Yes. (giggle) // (Having said that, they are satisfied that they have finished.)

The **Relational** function accounted for 40% of the coded utterances. The majority of this dialogue was between Miki and Alice, the girl assigned to work with him, who treated him as a rather naughty child. At one point, she told him, "Bad! Go over there!"

Miki was not present for the second lesson, leaving this a group of three girls. The **Relational** function dropped to 10% of the total coded utterances. Once more, the **Directive** function was used extensively, comprising 50 % of the talk. It was again used to read and interpret instruction, assign tasks and comment on the action.

Statements scored as **Interpretive** rose to 35% of the total coded utterances in this lesson. In addition, there was an increase in the amount of *elaboration of detail* relative to *labeling*. The following is an example of their observations when they placed a comb near the suspended toothpick:

- Whoa. It's attracted to it.

- No, it's pushing it away.

- See. <u>It attr</u>acts.

- <u>Yeah,</u> it attracts it.

- Yeah, it makes it come far away from it.

- OK, now we have to try the Look at it. //

- No, it attracts it. Don't worry, it does.

- Yeah, it does.

The percentages of other types of analytic strategies were similar for both lessons. The following represents dialogue representing *recognition of associated actions or events:*

- Must be the same cloth.

- Yup.   (Observation after rubbing the ruler with plastic wrap.)

There was one segment of dialogue judged **Projective**:

- I don't think it's going to work.

- Neither do I.

- Nope.

- You leave it blank.

The girls were predicting what they thought would happen when they rubbed a ruler with wool and held it near the suspended toothpick.

At the end, the teacher stopped to ask them about their results.

T - Did they all work?

- No.

T - Which one didn't work?

- Umm. Ruler with comb. I mean <u>wool with comb.</u>

- <u>Wool with comb.</u> And wool with ruler.

T - [illegible]'s try them both again here. Where's your toothpick? // //

- Y[illegible]. I told you guys it work.

It did "[illegible]" and they cleaned up without any further discussion.

The same three girls worked together on the <u>third lesson</u> on static electricity. When the girls rubbed both balloons with wool, they observed:

- They attract.

- Yeah, I know, I've done this before. I know they attract. // // I think it was the same experiment.

The teacher stopped to question them and this conversation occurred:

T - Did they attract each other, the two wools? Did they really? See here.

- (rubbing sounds) //

T - Put it so your two X's are opp [opposite] facing each other. What do they want to do? // Now let them go. What do they want to do?

- They want to go apart. / OK?

T - Now make sure you rub them off really well before you do the next one.

- They detract.

There was no obvious distress that their initial observations had been disproved.

In this lesson the **Directive** function was predominant, making up 75% of the conversation, while **Relational** talk occurred 15% of the time. The girls spent much of their time giving one another instructions:

- OK, rub it. Here. // Hurry. / Do it with the plastic wrap now.

- On the X? /

- Here, go. /

- (laughing) Yo[illegible]ng with it.

- OK, that's good. OK.

- OK, Marcy.

- I'm just rubbing it.

- Marcy.

- Yeah, what?

- Hang it.

Much less time was devoted to discussing the meaning of the events; **Interpretive** speech was represented in only 15% of their utterances, using analytic strategies similar to those practiced in lesson one and two. This short exchange, though, was scored as *recognition of a central meaning*, a fuller interpretation than those used before.

(responding to the question, Explain why the balloons acted this way.)

- Because they are charged, because they are charged, because they're not charged.

- They're both charged.

- I know that.

- Because in some of the experiments the wool and the plastic charged them. In some of them they didn't.

These statements were judged to indicate that the students were aware that these individual experiments had a meaning beyond simple attraction or repulsion, whether their statements themselves were correct or not.

With those words, the girls finished their Record Sheet and chatted until the teacher directed everyone back to their own desks.

Group B

There were three students, a girl (Joanna) and two boys (Devin and Keir) in this group for the first lesson. They worked together quite cooperatively; observations written during the lesson remarked on the fun they seemed to be having together.

This might have resulted in a high proportion of **Relational** speech, but only 15% of the coded utterances were judged to be of a social, non-task oriented nature. These statements were scattered throughout the lesson, generally in groups of two to four exchanges.

The **Directive** function accounted for 40% of the conversation. The students read and discussed the instructions:

- Rub a comb
- Hang a
- OK, there.

planned their actions:

- We're not done.
- Hold on there.
- Yeah, we are!
- We have to bring our *
- Our comb
- Is this the comb?
- Just the comb.
- What about the wool?

and made comments on their on-going actions:

- I'll rub it.
- I've been rubbing it since you've been
- (laugh) Oh.
- Hold this still.
- OK.

The **Interpretive** function occurred in the remaining 45% of their utterances, the highest percent usage in any of the groups in this first lesson. As in the other groups, *labeling* and *elaboration of detail* were the most often used analytic strategies, but Joanna, Devin and Keir also engaged in a higher proportion of *association and comparison* than the other groups. When they were unable to get their wool-rubbed comb to pick up paper in question number six, they did refer back to their earlier experience in question r [illegible]

- [illegible] pick up this. //
- [illegible] was working.

This group was also characterized by the amount of wondering and "messing about" (Hawkins, 1965) they engaged in. One of the boys was curious, asking, at different times in the lesson (non-consecutive):

- How come there's string on it?
- Huh. I wonder why. My fingers are like sweaty.
- I wonder why. Because there's like wool right there.
- I'd sure like to know what this part is for.

When their comb wouldn't pick up paper for questions number five or six, they explored rubbing it on their shirts and sweaters and then tried attracting each other's hair to the comb.

Group B also engaged in a limited amount of conversation *reflecting on the meaning of experiences:*

- Like the paper that's like the comb was a magnet and the paper is metal.
- No.
- Well, it was like that.

Other examples of conversations illustrating the students' meaning-making during this lesson include the following exchanges:

(Reading question number four, "What inference can you make to explain your observation?)

- (reading) What *interfear* can you make to explain your - I don't know
- Do you understand that?
- (laughs)
- [illegible] you understand that?
- [illegible]st
- What *infearence*
- What interference
- What can you make
- Here
- to explain you observation.

- Interference. Just *infearence. Infearence.* Not interference.

(observation, following question number five)

- It interferes.

(working on an answer to "What happens?" in question number six)

- It stuck to your finger.
- Huh, I wonder why. My fingers are like sweaty.
- The comb what The comb the comb What what do I want to write? The comb gains what? Magnetism? No, the comb gets it. No.
- The comb attracts water.
- Static electricity. Comb.

They then proceed with their own explorations, returning to the Record Sheet at the end of the lesson to write an answer to question number five:

- When you put the When you rub the comb with your wool with the wool it picks up, but with your hand it does not. //

In Lesson Two they were joined by a girl who had been assigned to their group the previous lesson, but had been absent. This change was not achieved without negotiation between this group and another one she had started to work in. The fact that these interactions were occurring at the same time that they were working on their static electricity experiments did not help them focus their attention on the task. This second lesson also elicited simpler answers than the previous task, half of the **Interpretive** speech being scored *labeling*. For example:

- Yes.
- Yeah, man.
- Yes.
- Yes. (The plastic wrap-rubbed balloon attracts the toothpick.)

Relational speech rose to 35% of the dialogue, partly due to the group composition negotiations, partly due to an extended stretch of off-task social banter about the comb, followed by a section of word play. By the time they returned to the task, the class was ending.

The same group of two girls and two boys as in the previous lesson worked together in Lesson Three. The **Directive** function increased to 50% of the conversation (up from 40% in Lesson One and 30% in Lesson Two). The **Interpretive** function was used 25% of the time, making an almost two to one ratio of **Directive** to **Interpretive** speech. The remaining 25% of the utterances were coded **Relational**, much of this coming at the end of the lesson when they felt they had adequately answered the question, "Explain why the balloons acted this way."

Again, this group was aware of *associated actions or events,* remarking (non-consecutive segments):

- There's no static on this one because the string isn't sticking. See?

- There's lots of hairs.

- There's none here because of the string. Look here.

In their discussion of question number five ("Explain why the balloons acted this way"), they also *recognized a central meaning:*

- OK, why does number one do that?

- Because they're not charged with static electricity.

- Duh.

- OK, number two. Why do they come together? Because one is rubbed with

- One has static electricity.

- One is charged.

- One has a charge and the other one has none.

- No, because one is charged.

- Yeah, one has a charge and the other one doesn't.

- They pushes other apart. Number three.

- (Simultaneous voices - words detected: because charged whatever)

- OK, number four. Because they're both charged. (Seems to be trying to ram this through.)

- No, they both don't have no charge.

- (Second voice is inaudible)

- They don't have any charge.

- Yeah, they do.

- We wiped it off.

- We wiped

- With plastic?

- Yes.

- I keep charging it?

- You rubbed it on the carpet.

- (reading) Rub both balloons with your hands. See you're taking up the stuff. (reading) Then rub both balloons with the plastic wrapper. That means we're getting it charged.

- Just makes sure they ?

When casually observed, the members of Group B appeared to be laughing and playing around much of the time, but a study of their conversation indicates that these students were attempting to do the assigned task, used some of the vocabulary (charged, static electricity), and formed opinions, but that not all of them understood what they had observed nor what these tasks were meant to illustrate.

Group C

The teacher named two girls, Sonya and Nowell, and two boys, John and Sloan, to this group. Sloan was quiet and shy and th[illegible]s teased him rather unmercifully. This group was also quite obviously affected by the presence of the microphone. To mas[illegible]r real identities, the girls spent time making up names for the group members (Flo, Mo, Curly and BFG for Sloan). Because of these types of interchanges, this group scored highest for **Relational** speech in both taped lesson. In Lesson One 50%, and in Lesson Two 40 % of the talk was scored **Relational**. Only Lesson One and Lesson Two were audio-taped for this group.

At the same time the girls are busy teasing Sloan or figuring out pseudonyms, the group is working through the experiments in <u>Lesson One.</u> While the **Interpretive** function occupies only 30% of the conversation, the coded statements were distinguished by a higher level of analytical approach than those used by the other groups. The following excerpts illustrate the analytical strategies of *recognition of associated actions or events, recognition of a central meaning* and *reflection on the meaning of experiences:*

(Answering question number two, "Hang a blown up balloon on a string from the edge of a desk or table so that it swings freely. Rub a comb with the piece of wool and hold the comb close to the balloon. What happens?")

- Holy cow. It's cool.
- OK. What happens?
- It - uh- the comb is like a magnet and it takes the balloon wherever it goes.
- The comb becomes a magnet.
- The comb acts as a magnet.
- The comb
- The comb actually becomes a magnet.
- It produces static electricity. I think
- It's totally groovy.

(Answering the second part of question number five, "What happens?"):

- (reading) Why do you think this happened?

- Because there's no static, man.
- Yeah, because there's no static in your hand.
- It doesn't pick up the paper.
- No, Nowell, no electric currents in your hand.
- Currents, ha ha.
- Oh, God. I thought I just kicked Mrs. H. I went like this and I'm like ooh.
- You know what, that was funny. You were kicking
- There is no static in your hand.
- Because there is no there is no
- (reading) Why do you think this happens? There is no static.
- There's no electric current.
- There is no static in your hand.
- ?

The **Directive** function accounted for the remaining 20% of the conversation, significantly lower than that for any of the other groups. There was little extended discussion of what should be done and by whom; one student read the question and the task was usually accomplished with few comments.

The language functions in Lesson Two did not radically differ from those in Lesson One, although there was more **Directive** and less **Relational** conversation.

In Lesson Two the students concentrated on rubbing a comb, a balloon and a ruler with wool fabric, plastic wrap and synthetic fabric, then holding the rubbed object near a toothpick and observing the reaction of the toothpick. This did not require any interpretation and most of the statements (65% - 75%) from all of the groups were coded *labeling* and *elaboration of detail.* This group did engage in more *association and comparison* than the other groups. Examples of some of their observations and discussions during this lesson follow:

- (reading) Are they attracted to the toothpick?
- Yes.
- Yes.
- Are they?
- OK. (reading) Can you tell from this if either object has an electric charge?
- Yes.
- It doesn't do it with the comb, though.
- Yeah, but you can tell that one of them has an electric charge.

A later observation:

- OK, now the comb with the plastic wrap.

- I don't think so.
- Yeah, it's really going to. //
- (laughing) No.
- (gasp)
- Try again.
- It might. It's supposed to, I think.
- No!
- It is not
- No, plastic and plastic are supposed to.
- Oh, yeah.

After they thought they had finished, the teacher stopped and asked:

T - Can I see your results? Can I see your results?

resulting in the following dialogue:

- The ruler is in right there.
- That doesn't work
- I I thought it might work, but oh, well //
- Well, OK.
- What about the other?

T - Try the other two again.

- OK.
- So the wool does. What about the plastic wrap? Here
- No.
- Do the
- (disgusted) Plastic wrap doesn't work.
- Hey, it works for the other one.
- We're back.
- Yeah.
- Yeah?
- Yeah.
- Yup. And the other one works, too.
- Shit.
- They all work.
- Are we done?

There was a possible discrepant observation, "Hey, it works for the other one," but no one made any comment about this.

Group D

Group D was another group of four students, two girls and two boys. There were no conflicts nor extended sections of social conversation during either recorded lesson (only Lesson One and Lesson Two were audio-taped). Instead, the conversation of this group is characterized by a rather close ratio of **Directive** to **Interpretive** speech with an intermingling of **Relational** speech.

In Lesson One this group scored the highest of the four groups in its use of *labeling* and *elaboration of detail* (about 85% of their statements were of these types). In Lesson Two they were similar to the other groups in the percentage of time their **Interpretive** statements were judged to fit these categories, these lower level analytic strategies being used in approximately 75% of the **Interpretive** statements in the second lesson. Examples of their **Interpretive** dialogues follow.

In Lesson One, discussing what they have observed when they put a wool-rubbed comb near some small bits of paper:

- Well, it doesn't work.
- What happened?
- Well, I got it.
- Nothing's happening.
- It works.
- No, it doesn't.
- I got it.
- It doesn't work.
- Something does happen. It does pick up a bit, but not that much because

T - I don't think that makes a difference ? weather conditions.

- Hard, hard, hard, hard, hard.

T - If it's very dry it won't ?

- Nothing happens.
- Nothing's happening.
- Put nothing.
- What's happening?
- What happened?
- Nothing's happening.
- Try ?
- Who gives?
- OK, ? .
- Put it put

- What happens?

- What happens? Noth

- It pic' s up a litt

- The omb picks up the pa er a little. // The comb (seems to be writing)

Although this last statement sounde inal they return to this task:

- Nothing happens.

- Oooh. The wool pick a little bit.

- A little bit.

- Oh, give up.

- So, it doesn't work.

- (laughter)

- You're supposed to pick up paper, that what ?

- It's supposed to.

- What happens?

- OK. (and they go on to the next task)

A short while later the teacher stopped to talk to this group.

T - Did it pick up some paper for you?

- Not yet.

- No.

T - So why did you write that down?

- Because that's what's supposed to happen.

T - Yes, but that's not what you saw.

- (laugh)

T - You don't write down what's supposed to happen. You're supposed to write down what you see. And if it doesn't work, then ? keep trying.

- The comb picked up a little bit. But a little bit.

(six lines later)

T - I've done this experiment for years. I've never had ? this afternoon. It must be the humidity and the classrooms. I don't know. There - you got it.

- I got it a little bit.

- It's OK, we can still write it down because it's supposed to happen.

and these conclusions:

- (reading) Why do you think this happens?

- Because / there's no static electricity.

- No static electricity.

In this group there are also examples of repetition as noted previously in the Mystery Solids lesson.

- Nothing happens.
- It doesn't pick up anything.
- It doesn't pick up anything.
- Doesn't pick up.
- What happened?
- It doesn't pick up anything. //
- (simultaneous - two to three voices)
- Try ?
- Doesn't pick up anything.
- Doesn't pick up anything. //

The group started Lesson Two by assembling their materials and reading the instructions, followed by this dialogue:

- Oh, I know what this is going to happen. I know what's going to happen.
- Here.
- Ooh.
- Yeah, I'm going to hang something to the desk.
- (laughter)
- Do you know the answer to this question?
- (reading) Are they attached to the toothpick?
- No.
- Oh.
- Could u.'- could tell you?
- (reading) In order to put the charge to the balloon, comb and ruler, rub each object. Get it?
- So this
- ?
- ?
- You just put no for that first question.
- No, I want to do it.
- We can do it, though.
- Check it out.
- Yeah.
- OK.

After "checking it out," they observe:

- Cool.
- It's sticking?
- No.
- Yah.
- No.
- Yah.

T - Make sure that you haven't rubbed anything, OK?

- Shouldn't be sticking.

As was true in all these lessons, the conversation was closely bound to a context visible to the students, but not to a listener removed from the classroom scene. This does make it difficult at times to interpret the reference of a statement.

Once again, the teacher is able to make "it work."

T - Did your comb work with the wool?

Voices - No.

T - Did you rub it on the woolen carpet?

Voices - Yeah.

T - Let's see.

- Guess you have to rub it a little harder.
- Where's the toothpick?
- Yeah.
- Oh, now it does. OK.

At the end of these observations, as they are starting to clean up and play around, a student declares, "They all have charges." No one comments on this statement, either to agree or to point out that their previous observations would not lead to this conclusion.

<u>LINC Analysis</u>

Table 5.B presents the results of the LINC analysis. Using the LINC talk guidelines to evaluate the talk during these lessons on static electricity offers a similar, though somewhat different, view of the lesson. Reviewing the conversations, it is again clear that the classroom climate established by the teacher encouraged small group talk and cooperative action. Also, students did not appear to feel the presence of the teacher required them to change their language; the following is one of several examples of continuity of dialogue after the teacher stopped to talk to a group of students:

T - Do does either object <u>have an electrical charge?</u>

- <u>Inky, pinky.</u>

- Ask her.

T - Do any of the objects have an electrical charge?

- Yeah, they do, but not like as much as the balloon did.

As explained earlier, no separate scoring for *consideration of feelings, opinions, and viewpoints of others* was done. The students did listen to one another, often agreed, sometimes disagreed and sometimes appeared disagreeable, at least from an adult's perspective.

There were statements which qualify as *hypothesizing, predicting and speculating.* The following statements exemplify the most common usage in the category (non-consecutive and from all groups):

- It's supposed to...

-I don't think it's going to work.

- Oh, I know what happens.

Except for Group B's explorations when "it didn't work" for them, there were very few times when the talk indicated that students were *relating new ideas to previous understanding and experiences.* This could be due to the fact that the results seemed capricious; the students were not aware of the emergence of any clear pattern or meaning which they could relate to any of their previous experiences with static electricity.

The questions that asked for inferences or an explanation of why something happened did encourage talk to *express and justify feelings, opinions and viewpoints.* None of the justifications were lengthy, the following being typical examples (non-consecutive):

- Now it won't pick up because I rubbed it with my hands. (Group A)

- The comb acts as a magnet. (Group C. Group B made a similar observation)

- One has static electricity. (Group B)

- One is charged. (Group B)

- When the comb came toward it, it moved over here more. That's what I saw. (Group A)

- See, see look, it's sticking. (Group B)

Both the above were justifications based on observations they could point to.

A much greater percentage of their talk was used to *organize, interpret and represent ideas and information* as has been demonstrated in talk cited earlier. The bulk of this talk was to interpret the instructions and observations and to give one another directions on how they should proceed, what they should do and what they should write.

Thus, excepting for *relating new ideas to previous understanding and experiences,* this lesson created a context which allowed students to use language for a variety of reasons. The talk itself, however, does not indicate any real growth in understanding of the subject matter. The students copied the laws of static electricity into their notebooks, but there is little indication that the students were able to relate these laws to the experiments they had been doing. Patterns were not discernible from the data most of them collected in the experiments. Indeed, once an observation was written down, it was only rarely referred to again, "Must be the same cloth," being an exception. While such a series of lessons on static electricity in grade six science is common in this school district, the talk during this lesson raises doubts about its usefulness in helping students gain knowledge about electricity or in increasing their ability to do investigations in science.

Impressions, Questions and Conclusions

This study has been based on the assumption that "To bring knowledge into being is a formulating process and language is its ordinary means, " (DES, 1975, p. 50). Talk during small group science lessons was recorded, this being language used in a setting designed to help students formulate knowledge and skills in science. I anticipated that these conversations would allow a glimpse of the type of thinking and meaning-making occurring during these lessons. I believe that the recorded talk does allow a means of observing students learning to language and learning through language (Halliday, 1982). As well, it provides information to answer two of the questions posed in this study:

1. What do children talk about during small group work in science lessons?
2. What is the purpose of this talk?

The examples of talk reported in this chapter were chosen to illustrate the answer to the first question. That talk, within the reported contexts, stands on its own, requiring no further interpretation. These were children interacting naturally, for the most part, during their science lessons. The audio recordings allow us to listen closely to that talk. The Tough (1977) classification and the LINC (1991) talking-to-learn guidelines help provide answers to the second question. These classification models served as frames of reference for listening not just to the words themselves, but to the functions served by this talk, directing attention to specific aspects of the conversations that might have otherwise been overlooked. The models complemented each other as each focused on somewhat different aspects of the children's talk.

The Tough categories allow one to ascertain the ratio of **Directive** to **Interpretive** to **Projective** to **Relational** talk. These numbers appear to indicate the type of student involvement in a lesson; that is, did the students seem to feel intellectually challenged, was the challenge more physical (handling an eye dropper or rubbing a balloon) or did the teacher's task seem less important to them than their own social interactions? The aspects of the lesson that students attend to have obvious important implications for the learning outcomes. Students need to be actively involved with ideas or processes for learning to take place, both doing and reflecting being considered active engagement. If students are interacting only marginally with the concepts or processes being advanced in the lesson, the chance of knowledge formulation occurring is certainly decreased, at least the learning envisioned by the teacher.

Additional interpretations of the lesson were possible when viewing the talk from the perspective of the LINC talking-to-learn guidelines. Of course, no one lesson is likely to require an extensive use of all of these types of talk. However, teachers need to be aware of these different uses of language in order to plan lessons and situations which provide students with numerous opportunities to develop and use a broad talk repertoire.

After working intensively with each lesson or set of lessons in isolation while writing the preceding descriptions of what the children talked about and the purposes of that talk, I reread the transcripts, focussing this time on specific aspects of the talk across all the lessons. My thoughts - impressions, questions and conclusions - form the remainder of this chapter. The following discussion uses Tough's language functions and the categories of talking-to-learn listed in the LINC guidelines as focal points, and concludes with partial answers to the questions, what does talk-for-learning look like and under what conditions does it flourish? (MacLure et al, 1988).

Tough's classification of the uses of language

When comparing the use of the **Directive Function** of language across all the lessons, I was particularly struck by one recurring dichotomy: Directive language was either used, on the whole, to promote cooperation or this use was obviously absent.

I started reading through the transcripts in the order I had recorded them, beginning with the Mystery Solids lessons. In these lessons Directive language helped carry the action forward. The children used the Directive function for many purposes, the most usual being to ask for and give help (instruction). Examples include (non-consecutive speech):

- Can you help me pour that?
- How do you spell ... ?
- Do we need waxed paper?
- OK, what else should I put?
- You have to put different words.

- But you guys didn't do it. You didn't hold it down.

- Not like that. Teacher said like this.

Besides acting as a form of peer tutoring, such cooperation also relieves the teacher; children help one another rather than always having to ask the teacher for assistance.

Directive language was also used for a number of different ends in this group. It was used to focus group attention on the task and on observed phenomena (non-consecutive):

- Look at that. We've got too much water.

- Just wait. We haven't felt it.

- We should do number four now. We should do number four now, guys.

- What do we have to do?

The children worked together to divide up the tasks and forward-plan (non-consecutive):

- Who is going to [draw a picture]?

- Who wants to go next?

- You carry two, I carry two, you carry three.

-Then we'll have to put more um baking powder in. Because you didn't have to.

They checked with the others to ascertain the correctness of their personal observations (non-consecutive):

- Taste it. Does it taste?

- Let's see. That's smaller, right?

There were comments that accompanied their actions (non-consecutive):

- I'm going to see it with the ma , the glass [hand lens]. Whoa!

- Oh, that's a little bit too much.

The children were generally considerate to one another (Do you want to put the rest on yours? and Want me to fix it?), but this was not an unnaturally agreeable group. They did have their disagreements; for example, about who was to blame for a mess, and whose turn it was to record.

After reading through the Mystery Solids transcripts and recording the talk listed above, I proceeded to the next set of recorded lessons, the Static Electricity transcripts. There were significant differences. In these lessons, the predominant use of Directive language was to read the instructions or questions on the worksheets and to clarify those instructions (non-consecutive):

- Can we use just one piece of paper?

- Which side do you use? This side?

- So where do we put our answer?

- OK, what do we do?

The group participants also often gave each other directions (non-consecutive):

- Rub it some more. Rub it some more.
- OK, don't move the balloon. Keep your arm straight.
- We still have to do one more thing.
- OK, read the next question.
- We have to write it picked up the small bits.

The students also used talk to divide up the tasks, to choose "who will do it" (non-consecutive):

- I'll do that.
- You do this, J.
- I get to try this.
- Someone has to rub their comb.

As well, students would report on their actions (non-consecutive):

- I'm rubbing the comb.
- We're rubbing the balloon.
- I keep on rubbing it.

The impression taken away from reading the two sets of transcripts is undoubtedly stronger than that gained from reading these selected statements. In the Mystery Solids lessons, the children appeared to be working cooperatively; the Directive language helped both carry the action forward and maintained and enhanced positive relationships within the group. The talk in the Static Electricity lessons appeared to be aimed much more at organization and very seldom contributed to positive personal relationships. In the other grade six lessons, the Peanut Power and Solar House lessons, the Directive talk was very similar, being used predominantly to direct actions and divide up the tasks. I found it interesting that this pattern was maintained in the Solar House groups, as these groups were self-selected. This might be expected to result in a greater percentage of cooperative talk. Instead, a typical exchange sounded like this:

- M., can I have those scissors for a second.
- How come?
- I need to cut this.
- Tough.

The grade three Mealworms lessons more closely followed the types of talk heard in the Mystery Solids lessons, the Directive talk being obviously more cooperative than that recorded above.

Perhaps these difference can be attributed to the different relationships between children in grade three and those in grade six. Perhaps, but my impression suggests that successful group work requires the type of cooperation heard in the grade three lessons. I believe that the tone of the Directive talk, the degree of cooperation expressed by the children, is an important indication of the extent of collaborative effort in the group. It is this collaborative effort which enables students to collectively accomplish "what none of them could have done individually" (Torbe & Medway, 1981, p. 48). At a minimum, if children are working in groups during lessons, it is important that the members of the group learn at least as much collectively as they might have individually. The transcripts indicate that this was not always true. An oft-repeated word, "let's," heard in one Mealworm group sums up the spirit of cooperation that must be encouraged if students are to benefit from group work.

There is a long history of group work in science lessons dictated by the necessity to share limited space and materials. In the past, the number of students placed in each group appears to have been driven more by these practical considerations than for any pedagogical reasons. The effects of group size on learning is an aspect I believe teachers need to take into consideration in their lesson planning. I am not suggesting that there is one correct group size, but that teachers should carefully watch and listen to group interactions and note if corrections should be made at a later date. For example, my impression when reading the transcripts was that three, not four or five, students worked together more productively in the Static Electricity lessons. The task was more evenly divided among three students, keeping each one of them more involved in the activity. In groups of four students, there was a tendency for two of them to do the work while the other two chatted. This observation can be extrapolated to the Peanut Power lesson as well. What is of importance is that teachers are aware of the effect that group size can have on learning and include an assessment of that effect in some of their classroom observations.

Numerous examples of **Interpretive** talk have been included in the foregoing descriptions of the five science lessons or sets of lessons. Data from the tables indicate that the percentage of children's utterances judged to be Interpretive in nature ranges from 20 to 60 percent. When used as an indication of student involvement in a task, the lower figures are certainly of concern, especially if they are combined with a low level of cooperative Directive talk. In lessons combining low Interpretive scores and a low degree of cooperation, evidence that children were actively involved in more than minimal meaning-making is lacking. It cannot be claimed that they learned nothing. However, using the type and extent of Interpretive talk as indices of student involvement and meaning-making in a lesson, my impression is that an unintended message was delivered to these students. For them, science did not seem to involve meaning-making, and hands-on work was a prelude to the teacher telling you the right answers.

To be blunt, an analysis of the Interpretive talk indicates that students were not (or only marginally) involved in meaning-making in the majority of the recorded hands-on science lessons. Listening to the students reveals this deficiency; aware of this failing, teachers can make changes to their lessons. An assumption that the expected learning is occurring can have more serious repercussions; lessons that do not help students to make better sense of their world may be used year after year with similar results; good students pass the tests and the others do "as well as might be expected."

What I found surprising when comparing the grade three lessons which emphasized observation with the grade six lessons, with a greater emphasis on concept building (the laws of static electricity, the use of solar energy, energy production from a burning peanut), was that there was not a significant difference in the Interpretive use of language between these two groups of students. Interpretive student talk in all these lessons was focused on reporting concrete details, on labeling, simple elaboration of detail and comparison.

Only three groups of students used more analytical strategies (recognition of associated actions or events, recognition of a central meaning or reflection on the meaning of this experience) in more than 20% of their Interpretive dialogue. Examples of this usage can be found in the preceding descriptions of the talk during the Solar House lessons (pp. 69-70) and Group C's conversation while completing the first Static Electricity lesson (pp. 89-91). In fact, the majority of that talk in each of the groups occurred in short, concentrated exchanges of views and opinions. The dialogue then returned to its usual function; the Relational accounted for 50 percent or more of the dialogue in each of these groups.

The question, then, is how to design lessons that increase the amount of time students spend using higher order analytical and reasoning strategies. The transcripts indicate that the students are capable of using such talk. (The members of the aforementioned groups appeared to represent a range of scholastic ability; not all of these students were the brightest in the class.) Based on an understanding of education described in Chapter Two, Review of the Literature, I suggest that science lessons should focus on investigations which students find interesting, which engage the students and encourage them to seek answers to questions they see as meaningful.

Children can, and did, ask excellent questions, including:

- Why is it turning like that?
- I wonder why he likes the dry instead of the wet.
- I'd sure like to know what this part is for.

(Sadly, some of the transcripts contain no good student-generated questions.) Children's questions need to be encouraged and used to guide further investigations. Small children are prolific questioners; too often, though, curiosity appears to decrease over the period of time children spend in school. The formulation of good questions and the subsequent search for answers to the student-posed questions are useful in encouraging students to question and in engaging them in explorations that are of interest to them. I believe that children must be offered such learning opportunities if there is to be a significant increase in Interpretive language used for purposes other than basic reporting which ultimately is reflected in the amount of meaning-making occurring in schools.

On a different note, the transcripts suggest that the grade three "observe and report" lessons are an excellent tool for building vocabulary and language skills for English as a Second Language (ESL) students. These lessons ask the children to examine and describe directly observable materials. As reported, multiple repetitions of each observation were common, reinforcing the words and the meanings being made by the children.

There was, as well, a wide variation in the talk judged to fulfill a **Relational function.** Successful conversations rarely exclude this function entirely; salutations and asides (which might be considered off-task in classrooms) are usual components in even serious "real life" conversations.

In these lessons, Relational talk was used to express concern (non-consecutive):

- Is your foot itching with warts?
- Sorry that happened.
- Poor you

personal opinions (non-consecutive):

- Yuck.
- I don't like this experiment. (In contrast, two variations on "This is fun, isn't it?" were heard in the grade three lessons.)
- I hate my group.

and to establish and maintain relationships (non-consecutive):

- I like you
- Here, I've got chips.

Relational talk also allowed the students to interact on a personal level, which can have positive effects on children working together collaboratively:

- This glue this glue has a problem.
- Glue with an attitude

and

- It's gross [the taste of a sample]. Oooh.
- Why do we even have to taste that one?
- I don't know. It's so gross, isn't it?

In addition, Relational speech was often heard at the end of a lesson as children cleaned up, played word games and made plans together for recess or lunch time activities.

While Relational talk is valuable in collaborative group work, extended Relational conversation sounded more like "pointless chatter" (DES, 1975, p. 189) which "does the gravest possible disservice to the development of fruitful learning talk in our schools" (Jones, 1988, p. 66). Such chatter in the recorded lessons gives the impression of not only engaging the attention of those involved in the talk, but of sometimes distracting other group members while they attempt to work on the science activity. An excerpt of conversation in Group A in the Peanut Power lesson found on page 59 is illustrative of this disruptive chatter.

I do agree with Wallace's (1986) comments that all of these types of talk are necessary for the successful functioning of a group. Besides the obvious benefits of Interpretive talk in constructing meaning, Relational talk helps build group cohesion and Directive talk is necessary for organizing, directing attention and forward-planning during an investigation. A correct balance among these functions is the key to successful collaborative group work.

Short Relational exchanges are healthy for the smooth operation of any group. Extended Relational exchanges, however, were seen to be of little or no value to the learning process, even being detrimental as they drew attention away from the learning activity. I suggest that when more than a quarter of talk is Relational, it is a warning that meaning construction may be adversely affected and changes to the lesson need to be considered, changes designed to involve students in challenging and purposeful activities which they will choose to pursue.

There were too few examples of **Projective** speech in these transcripts to allow for meaningful comments. While a lack of empathetic and imaginating talk is not surprising in a science lesson, one would expect more predicting talk. As this category overlaps with, but is more exclusive than the LINC category *hypothesize, predict and speculate*, I have chosen to discuss it in the following section.

LINC talking-to-learn guidelines

The LINC talking-to-learn guidelines were written to direct teachers' attention to the importance of using talk as a means of learning, concisely outlining the types of talk to be encouraged for accomplishing this end. Used as an analytical tool, they give an indication of the amount of talking-to-learn exchanges that have occurred in the course of a lesson. Their primary value, though, is as a tool for teachers, to be used both while planning lessons with a talk component and then as a checklist while listening to the resultant talk.

Only statements clearly exemplifying the six LINC categories were scored in this analysis, while all unambiguous utterances were coded using the Tough classification model. The results indicate quite a small percentage of the total number of utterances could be considered talk for learning, but one important omission must be noted. Neither the *question, explore and think aloud,* nor the *consider the feelings, opinions and viewpoints of others* categories were scored. As explained in Chapter Three, the three teachers had established classroom environments where the students felt free to express their ideas in their own words and where collaborative group work was encouraged. In all three classes I observed, the children were expected to *question, explore and think aloud.* Students were also encouraged to *consider the feelings, opinions and viewpoints of others*; without this students will not risk sharing their ideas. While the groups differed in the consideration shown for each other, the three teachers involved in this study expected considerate behavior from the students.

In their group work, children never seemed to feel it necessary to use "final draft" language; that is, formal speech "well-shaped and polished" (Barnes, 1976, p. 108). Instead, there was no hesitation to think aloud, to state observations and opinions that were not fully formed before being uttered. Examples would include (non-consecutive):

- It feels it it feels when you put it up to your ear, it feels scratchy

- It's kind kind What else can we put down?

- The comb what The comb the comb What what do I want to write, the comb gains what? Magnetism? No, the comb gets it? No.

- Oh, man, one hundred - you know how hot that would be?

In the category of *consider the feelings, opinions and viewpoints of others,* I had one major question, how do preadolescent children show consideration to one another?

To an adult, being called dumb, gross, a loser or other similar terms would be considered offensive, but it did not seem to have any effect on these children. Perhaps recognition is important, with recognition for being kind, helpful and polite considered an insult. Without an answer to this question, it is difficult to decide what to classify as considerate language for children of this age. The younger children exhibited much more conventional consideration; they were more polite in their requests of each other, showed affection and generally tried to be helpful.

Excluding the few examples of disruptive chatter, the students generally listened to one another; conversation flows from one statement to the next. Students also occasionally used questions and tag endings to negotiate doing and meaning-making. Examples include (non-consecutive):

- What about like this, you guys, like this?
- It is like jelly, isn't it?
- Nothing's happening, is it?

While the sample is too small to prove a positive correlation between consideration for others and group learning, I would feel comfortable making a reverse claim. The transcripts that include few indications of students showing consideration for the feeling, viewpoints and opinions of others also indicate few gains in knowledge, in either school or action knowledge (Barnes, 1976).

Given the emphasis placed on hypothesis and prediction in contemporary science education, it was surprising to see such a low number of statements in these transcripts felt to exemplify the category of *hypothesize, predict and speculate*. More specifically, no statements in the Peanut Power lesson and the third Static Electricity lesson and only two in the Solar House lesson were judged to fit the category, making one wonder if these numbers deliver an important message. The draft Alberta Education Elementary Science Curriculum (1992) states, "Science in the elementary school should aim to retain and nurture [children's] initial curiosity and promote a sense of wonderment and joy as children explore their world" (p. A.1). However, no one in any of the three lessons listed above said, "I wonder," or " I think it should..." or even "Maybe..."; there was only an "if" and a "could."

Science should never be perceived to be so predictable, requiring so little curiosity and sense of exploration. When children's language tells us they are not hypothesizing, predicting and speculating in science lessons, that lesson is of questionable benefit to the students.

Of particular interest was the limited amount of talk in all the lessons used to *relate new ideas to previous understandings and experiences.* A central theme in constructivist theory deals with the necessity for a person to actively make connections between what s/he already knows and what is new in order to expedite and ground learning. Without such connections, science lessons may seem to be merely a series of discrete events, perhaps interesting in themselves, but of little relevance to real life. If we believe that children should learn science in order to make better sense of their natural world, we must help them understand the links between science lessons in the classroom and the natural world outside the doors of the school. This theme of Connections is more fully discussed in Chapter Five as I feel it has serious implications for science learning.

In my first classification attempt using the LINC guidelines, I interpreted *organize, interpret and represent ideas and information* to mean organizing and interpreting data and then representing it in some form, a perfectly valid interpretation under some circumstances. If this category were to have any meaning in this study, however, a reinterpretation was necessary. While portions of the original interpretation were relevant in the Static Electricity lessons, there was little evidence in most lessons of interpretation and representation of ideas and information. Reading through the transcripts a second time, I expanded my interpretation to include "interprets instructions" and broadened *organize ideas and information* to include a more general "language for organizing" classification.

The numbers listed in the tables represent, for the most part, two types of organization and interpretation. The first, talk to organize information (and, occasionally, ideas) is represented by statements such as (non-consecutive):

-What else is it?

- Peanut splits. Put peanut splits.

- Do you want to put more down, a little bit more?

- You just put "no."

The second, talk to interpret instructions, included such statements as (non-consecutive):

- You're not supposed to tie it.

- OK, it's been 30 seconds if you want to

- Teni, put it in the middle.

As might be expected, when students were recording information, there was more talk to organize information. When there were instructions to follow, talk to interpret these instructions was more common.

As organizing and interpreting ideas and information are important components of meaning-making, teachers should be listening for indications of students engaged in this type of talk. Again, if they hear little of this occurring, adjustments much be considered. Students learn to use language by using language. The teacher's role is to provide activities which help students to broaden their talk repertoire and to guide and encourage them as they struggle to communicate their ideas. Struggle, yes, though certainly not always. In Vygotsky's (1986) words, instruction "must be aimed not so much at the ripe, but at the ripening functions" (p. 188).

The last LINC category to be considered, *express and justify feelings, opinions and viewpoints,* is one I will not discuss at length so as not to belabour opinions already stated.

Children learn to express their feelings, opinions and viewpoints quite early. As they age, they are more often asked to justify or explain these. When they go to school, schools should provide them with additional opportunities to form and develop opinions, viewpoints and feelings and encourage children to express, explain and justify these.

The children in these lessons did express feelings, opinions and viewpoints, though seldom at length. (Language in context-bound situations such as hands-on science lessons is often abbreviated. It is not even necessary to refer to an object by name; a nod or glance will often serve.) Questions posed on the Static Electricity work sheets (for example, "Explain why the balloons acted this way") were intended to promote discussion in which students would express and justify their opinions. My impression is that these questions failed to promote such discussion because the exercises failed in developing any opinions or viewpoints about static electricity. A language component was included, but the content component failed. Again, the children's language suggests that knowledge was not being formulated and changes need to be made to the lesson.

Briefly, when activities allowed a number of opinions to be expressed, numerous examples of talk illustrating this category can be found (although the incidence differs markedly between groups in some lessons). The Peanut Power lesson was more straight forward, conducting a simple experiment and doing a series of calculations, and elicited few examples of talk in this category. The conclusion must be that children will *express and justify feelings, opinions and viewpoints* when they see a reason to do this. The teacher's job is to provide those reasons.

A quotation from Wells (1984) sums up many of the conclusions reached in this study: "What schools should provide, therefore, is the opportunity to develop and extend [children's] conversational skills by putting them to use in the exploration of the new ideas and experiences that the more formal curriculum provides."

However, whether the children are learning to language and using their language to construct meaning will only be known to teachers who listen closely to children as they talk together, exploring ideas.

Talking-to-learn

After consideration of the descriptions and analyses of the children's talk, what has been learned about "what talking-to-learn actually looks like and the conditions under which it flourishes" (MacLure et al, 1988, p. 3)? (To guide my observations, I have defined the "learn," in talking-to-learn, as building understanding.)

In reviewing the transcripts, seeking to locate examples of conversation illustrative of talking-to-learn, I first looked for discourse that was predominantly Interpretive and of a sufficient length to allow opinions and viewpoints to be exchanged. This length I set arbitrarily at ten consecutive Interpretive utterances, possibly interrupted by one or two Directive or Relational utterances. Using this criterion, three transcripts (from a total of 21) were eliminated from consideration, two Peanut Power and one Static Electricity transcript.

The second reading used a more subjective measure, asking if there was evidence of meaning being constructed while the activity was being pursued. Sometimes one extended exchange of ideas was accepted as sufficient evidence, sometimes an impression gained over the course of a lesson indicated that a group was slowly making some sense of the activities. If the longer exchanges were only a sharing of observations, as in:

- It can't move.
- It is kind of moving backwards.
- Yeah, it's moving.
- Yeah.
- It it just moved backwards. See, it's moving backwards.
- It's eating.
- No, it's not.
- Ours isn't moving. It's eating.
- No, ? ____
- No fair. /
- Yeah, it just moved backwards.
- It's no fair, J. Ours isn't moving. It's eating. It's being a pig of itself.

(Mealworm, Group C)

the conversation was not considered to be of sufficient value for meaning-making to warrant inclusion as talking-to-learn. This decision eliminated more transcripts; conversation in one Solar House and two Mealworm groups were considered to be more a continual sharing of observations than a collective effort to make sense.

The entire set of transcripts for the Static Electricity lessons was eliminated when the criterion for talking-to-learn was meaning-making. The members of most of the groups worked together to complete the worksheets, but the inconsistencies in their findings made sense-making impossible. As one student answered in response to the question, "Explain why the balloons acted this way?", "Because in some of the experiments the wool and plastic charged them. In some of them they didn't."

Transcripts of talk in three groups remained: for Dianne, Curtis and Teni working together on Mystery Solids; for the pair of girls exploring the wet or dry environment preferences of Mealworms; and for the four boys trying to properly design and place a Solar House on a lot. As mentioned earlier, the bulk of the boys' conversations was Relational, as might be expected in an activity requiring a considerable amount of cutting and pasting. When they did discuss the location of the house, trees, windows and solar panels, however, I felt there was real evidence of students talking to learn.

Examples of this talking-to-learn can be found in Appendices B, C and D. The Mealworm transcript, a short one, is reproduced in its entirety. A page of talk from the Solar House lesson, the best example of this group talking to learn, is also included. The third selection is a four page excerpt from the Mystery Solids group, chosen to reflect the general tone of their conversations. To allow for comparison, one of the transcripts from the Static Electricity lessons was randomly chosen and reproduced in Appendix E.

Having selected examples of talking-to-learn from the recorded lessons, the conditions which fostered those conversations can be described, providing documentation for a better understanding of conditions under which talking-to-learn flourishes (MacLure et al, 1988).

First, the tasks set in the Mealworms and Mystery Solids lessons were open; there was no one correct answer. In the Mystery Solids lessons, the children were asked to closely observe the samples, using all their senses, and write down "those things you're noticing." The mealworms were to be placed on a wet and a dry paper towel and the children were to decide which environment the mealworms preferred. The Solar House task was more closed; there was a correct placement, but the task appeared to be sufficiently interesting to initiate talking-to-learn. To maintain talking-to-learn, the task must also be one that involves children for the period of time necessary for them to build understanding. In this aspect, the Solar House lesson was less successful than the other two lessons. These observations confirm Jones' (1988) suggestion that tasks which are open and of interest to the students are important for the success of talking-to-learn. The data from this study also indicates that tasks must be "doable," that the activities must provide a means by which students can construct understandings and concepts.

Of perhaps equal importance as the task is the group. Of whatever size and composition, if the children are not working collaboratively, there is little chance for the success of talking-to-learn. Oracy is talking and listening; it is that cooperative effort to make sense together that enables students to do "together, with mutual support, what none of them could have done individually" (Torbe and Medway, p. 48).

These conditions are certainly possible to create. I believe that thev exist, to differing degrees, in most classrooms. By combining these elements, teachers should be able to promote talking-to-learn in their classrooms.

Practicing teachers, however, do not have adequate time to transcribe and analyze their lessons to the extent described in this study. That is a task for researchers. Research, though, can suggest topics for teachers to research in their own classrooms; I propose that closely listening to children as they work together to construct meaning during the course of a lesson is such an area. Since concentrated listening is difficult in a regular classroom with its attendant multiple demands on the teacher's attention, I recommend audio-recording lessons which can be listened to at a later time.

Furthermore, I would recommend that an audio-recorder become a normal fixture in the classroom, regularly used to record group talk. Only a very few tapes will be listened to, but regularly recording lessons enhances the chances of natural conversation on the tapes.

Listening to a tape need not be an arduous task. The teacher will want to form an impression of the meanings that are being constructed during the lesson, probably jotting down an occasional statement to illustrate a good observation, an interesting idea or a possible misconception. S/he will listen for indications of student involvement in the task and for evidence of the lesson's interest and relevance for the children. As well, the LINC talking-to-learn guidelines provide an excellent checklist by which to judge to what extent the children are learning through language and learning to language.

Yes, this will require an additional committment from teachers who already feel overextended. However, only the occasional lesson need to be analyzed in this manner and, after listening carefully to a number of tapes, teachers should find it easier to recognize the occurrence (or lack) of meaning-making in the classroom, reducing the need for listening to tapes.

Kid-watching (Goodman, 1985) is well accepted. *Kid-listening* extends our understanding of how our students are actually handling an assignment, their degree of engagement, their meaning-making and how a lesson helps them (or does not help them) develop a skill or come to a better or fuller understanding or appreciation of a concept or phenomenon. From this enhanced understanding of the "workings" of a lesson, teachers can plan lessons that better direct students' attention toward intended outcomes.

The implications for science education derived from the talk of these students is the subject of Chapter 5.

CHAPTER FIVE

IMPLICATIONS FOR SCIENCE EDUCATION

The previous chapter described the lessons and the talk that the students engaged in while working in small groups on hands-on science. In addition, the results of the analyses done on the talk, Tough's (1977) classifications of uses of language and the LINC (1991) guidelines on the types of talk which are valuable "if the primary purpose of talk is to learn" (p. 11), were discussed and examples were given. This talk clearly illustrates language across the curriculum; that is, the transcripts provide examples of students concurrently learning to use language and using language to learn.

As indicated in the Introduction, this study has a dual focus. Student talk not only reflects student thinking, but concomitantly provides information about the lesson itself. This latter focus, the science lessons themselves, will be pursued in this chapter. While listening to the children, a number of concerns emerged which, I suggest, need to be taken into consideration when planning science lessons in elementary school. As opposed to the previous discussion, this discussion includes reference to talk which did *not* happen. Drawing on the areas of consensus among science educators discussed in Chapter Two, this chapter will elaborate on concerns about:

- the formation of connections between science activities, prior understandings and the natural world beyond the classroom
- collaborative group learning
- the extent to which the science lessons encouraged students to be active learners in meaningful activities

The question is: Were these lessons hands-on and minds-on science?

Connections

As was discussed in Chapter Two under Constructivism, this study is based on the assumption that knowledge is made, not received; that learners must be actively engaged in formulating knowledge and that involves making connections between what is new and what is already understood. In addition, interconnections between knowledge structures, "seeing the significance of the parts in terms of the whole" (Anderson & Pearson, 1984, p. 263), play a significant role in knowledge formation. This section focuses on the connections students were observed to be constructing (or not constructing); on connections between new and old ideas, between school learning and their life outside school, as well as connections between this new knowledge and major concepts capable of extending their learning beyond the present unit of study.

Drawing on constructivist research on learning in science, there are a number of strategies which enhance the probability of science being minds-on as well as hands-on. A commonly advocated practice (Driver, 1985; Osborne & Freyberg, 1985) is helping students articulate and clarify their own beliefs about the topic being introduced; that is, to activate their relevant schema, their background knowledge. This not only provides the "hook" onto which each student will connect new knowledge, but also reveals to teachers the beliefs presently held by the students and how these differ from those they propose developing. As Ausubel (1968) wrote, "The most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly" (p. iv).

It is recommended that teachers present opportunities for children to interact with materials and ideas, to discuss in small groups and larger groups the meanings they are constructing during this process and then to reflect on these meanings in order to incorporate them into their own personal knowledge constructs. For learning to be useful and lasting, students must understand how the topic they are studying connects to the physical world as they experience it; this grounds their framework and allows students to perceive the relevance of this knowledge in their personal lives. If these connections cannot be made, the teacher may want to reconsider introducing a specific unit of study.

Finally, "to enable students to detect connections and patterns that provide continuity throughout the natural and constructed world" (Alberta Education, 1992, C. 4), units of study need to be incorporated within larger themes. These themes, also called big ideas, overarching concepts or unifying constructs, act to connect the facts and "make such information manageable and useful" (Calif., 1991, p. 26). Forming links between new and old knowledge and between classroom learning and the world outside the school, both incorporated within overarching concepts provides learners the best chance for increased understanding and the ability to use this learning in new situations.

How often is the development of such connections being encouraged in our elementary science classrooms? To provide a partial answer, I will examine the series of lessons on Static Electricity for evidence of the promotion of linkages.

The teacher opened the lesson by citing three examples of static electricity commonly experienced by students. There were nods from many of the students as she mentioned shocks, hair standing up and balloons stuck to walls. She then asked how these things happened and accepted the two answers which were volunteered (see page 73); the other students remained quiet. It seems doubtful that many of the students were able to activate their background knowledge about Static Electricity in the time provided in this introduction.

The worksheets and bags of materials were then distributed and the children broke into learning groups. The materials could have provided an invitation to the students to freely explore this phenomena, to pose questions of interest to them and to then plan investigations to answer these questions. Instead, the worksheet anchored most of them to activities meant to illustrate the laws of static electricity, activities which, unfortunately, certainly left many of the students more rather than less confused about how things react when they are rubbed against other things. "Oh, well, doesn't work," was a common comment. Sometimes the students recorded what they observed and sometimes recorded what they thought they should have seen. The latter could, of course, indicate that they were drawing on prior knowledge.,

There were questions on the worksheets which asked the students to make inferences or explain why they thought something happened. The usual response, while lengthier than the answers to questions calling only for an observation, was a short statement by one student, sometimes repeated or slightly expanded by other students (see page 94). While these questions did elicit more thoughtful answers, the answers did not indicate that the students were making connections between the worksheet exercises and any prior knowledge of electricity. Actually, it was often doubtful whether the students were even making links between the experiments they had done and the answers they gave to the inference and explanation questions.

As well, fewer than a dozen statements made during the lessons seemed to link these classroom exercises to the outside world and most of these connections were made by members of Group B (pp. 85-89). They remarked that the comb was like a magnet, that "it gave me already quite a big shock," that it "was a kind of vacuum cleaner", "this is charged batteries," and that the repelling balloons "both have static guard." But even these students almost certainly did not see this work as contributing to any useful learning which would help them to use this new information in other situations.

The unintended message conveyed by these lessons is also most disturbing. Students seemed to view science as experiments which either "work" or "do not work," rather than as a study involving real questions worth investigating. If the teacher questioned their conclusions, the students simply changed their answers. The assumption seemed to be that science is a series of right answers which they would be told in due time. Science, despite being an enjoyable set of hand-on experiences, is perpetuated as a body of facts which has but doubtful relevance to the lives of students. This was certainly not the intention of the teacher, a dedicated and hard working teacher of science.

However, if a lesson is unable to help a student get knowledge from 'out there' to 'in here' (Barnes, 1976), to make connections between what is new and what is already known, framing this within a broader conceptual picture of his/her world, then that lesson is not likely to effect any permanent change in that student's understanding. As described by West, Fensham & Garrard (1985), "Learning is giving personal meaning to public knowledge" (p. 31). However, this study would suggest that personal meaning-making appears to be minimal in many elementary school science lessons, causing one to question the amount of learning (learning, that is, as envisioned by the teacher) that is actually occurring in these lessons. Using Edwards and Mercer's (1987) terminology, there can be little doubt that the knowledge gained by the students in this set of lessons was *ritual knowledge*, knowing how to do something "without any grasp of what is was all really about" (p. 99). Real learning requires students to make connections, to understand "the issues and concepts and their relationship to the activities" (p. 99). Making connections is crucial to learning. Too little connection-making was heard during these lessons.

Collaborative Group Work

A practical outgrowth of the research describing the social and linguistic underpinnings of cognitive growth has been a description of classroom practices which encourage students to talk together to mutually construct understanding. If we accept that language is the major means by which we formulate knowledge and that learners must be active participants in formulating their own knowledge structures, it follows that learners must be involved in active language use if meaningful learning is to occur.

It is not, therefore, surprising that active student participation in classroom discussion has been stressed by many to be an important means by which student understandings and intuitions can be aired (Marland, 1977; Osborne & Freyberg, 1985; Corson, 1988). However, whole class discussion too often tends to be teacher dominated. Even if student-student interaction is encouraged, whole class discussion usually does not allow students enough time to fully express their ideas. Students also generally feel less comfortable engaging in exploratory talk in large groups (Barnes, 1976; Jones, 1988). Exploratory talk, "marked by frequent hesitations, rephrasings, false starts and changes of direction" (Barnes, 1976, p. 28) is more easily carried on when the group is small and relaxed. In this setting, students have a better chance to try to make sense of a topic in light of their own present understandings. In talking about a topic, students must define for themselves and for others their present understandings of the concept being discussed.

In attempting to explain their views, students develop important linguistic competence. As well, they come to realize that others hold views which may not match their own. Since students will have had different experiences, it is also possible for them to build an understanding of the presented concept which is broader than that available to any one of them.

As indicated in Chapter Two under Constructivism, collaborative group learning has been advocated for its efficacy in promoting active knowledge construction. Thus, collaborative group learning is a teaching tool to be given serious consideration when the focus of a lesson is on conceptual change; that is, the construction and reorganization of knowledge (Driver, 1989). It is possible to assess the value of collaborative group work by seeking evidence of students thinking and rethinking, and formulating and reformulating ideas (Sharan, 1988) in order to construct "more complex, powerful, and abstract" (Cobb, 1988) conceptual structures.

In all these lessons the teachers chose to group their students in collaborative learning groups, encouraging joint action and discussion. As conceived by the teachers, the groups were intended to encourage equality in peer interactions and to foster mutuality in discourse. Groups named by the teacher for the Peanut Power and Static Electricity lessons included boys and girls of mixed abilities. (The groups for the Solar House lesson were self-selected, possibly reducing heterogeneity.) All groups could be considered potentially high on mutuality, as all the students were accustomed to and comfortable working and talking in small groups. In reality, the groups varied widely in their approaches to the tasks set by the teacher. While no student in any of the recorded lessons appeared to be deliberately disruptive, it was obvious that the members of some groups were more compatible than members of other groups. Students in the former groups listened to each other and appeared to respect each other's opinions and views. They kidded each other, but their remarks appeared to be perceived as friendly. Group B in the first Static Electricity lesson is an example of compatible students working together to complete an assignment. In other groups there did not seem to be this desire to work together; silly banter by members of some groups, insistent kidding in others, and off-task arguments in others disrupted the lesson, having a negative effect on any concentrated effort to complete the task. These groups probably accomplished less as a whole than the group members would have if they had worked individually.

However, the assigned tasks have to be considered as well as the composition of the groups. In the lessons for all three grade six topics, teacher explanation and whole class discussion preceded the hands-on work. It would appear from the conversations in the recorded lessons that these introductions had generally been inadequate in engaging the students' interest or in starting the process of recalling relevant background information. The tasks were, thus, perceived by the students to be isolated events and irrelevant to their world outside school. The tasks themselves were quite closed, seldom asking questions requiring speculation and active discussion of differing ideas. It was also apparent that there usually was a correct observation or response to the questions ("It's supposed to..."), further reducing the students' perception of these as problems open to interpretation and debate. While these lessons seem pedagogically sound, with an introduction linking the subject to students' lives, an exploratory phase when students handled equipment and recorded data meant to illustrate a concept, and a follow-up discussion or application phase, the tapes would suggest that any discussion of concepts during the small group work was minimal.

In contrast, the two investigatory science units - Mystery Solids and Mealworms - were much more open tasks and allowed groups considerably more scope for exploring and discussing and helping one another build meaning. The transcripts suggest that the group working together on the Mystery Solids lessons was the most successful in constructing a joint understanding of the phenomena presented in the lesson.

We have again witnessed a less than desirable gain in conceptual understanding in these lessons. In the examples taken from this study, most of the small group work failed to meet the criteria of collaborative group work as a joint exploration of ideas due to the nature of the tasks. Collaborative groups in themselves will not necessarily advance the group members' understanding of the science concepts being presented. To do this, the assigned tasks must elicit the type of conversation critical to learning, conversation requiring students to "make sense together" (Barnes & Todd, 1977, p. 24). As Jones (1988) suggested, three elements are important for the success of learning-talk: "The talk should be of interest to the pupils; the task should be an open one, where a number of responses ... are possible; and there should be as far as possible a purposeful and understood 'outcome' from the talk" (p. 103). Successful collaborative group work is also dependent on these elements.

Active Learning

Although I initially planned to entitle this section inquiry-based education, I eventually chose the term active learning as it seemed a less limiting term. Inquiry or problem-solving may be interpreted as an approach where teacher-posed questions are rigidly investigated using the process skills, perhaps following the methods of the excessively popular "scientific method." Unfortunately, the term active learning can also be open to misinterpretation if the activity rather then the learning is understood to be the more important component. For this reason the criteria for active learning must stress learning as sense-making. In Cobb's (1988) terms, lessons should aim to develop in students understandings that are "more complex, powerful and abstract" than the ones held previous to the lesson.

As active learners are the central element in this approach, active learning can be best defined in terms of the characteristics of these active learners. Active learners:

1. Ask and 'explore earnestly' (Trumbull, 1992, p. 9) questions which they consider important.
2. Make sense of learning experiences by relating them to their previous understandings.
3. Share their understandings with others.
4. Apply concepts to real-life situations.

As defined, children actively engaged with hands-on exercises but displaying little or no commitment to making sense of the phenomena or concepts being studied would not be considered active learners.

Inquiry and problem-solving will be important parts of an active learning program, with an emphasis on learning as sense-making engaged in by the students. As Henriques (1992) has indicated, it is the mental activity rather than the physical manipulations which needs to be emphasized.

In science, active learning closely resembles the constructivist approach to science teaching. As mentioned previously, it is generally described as including three phases: an initial exploratory phase, a discussion phase and a more focused investigatory phase, although one will not necessarily proceed in lock-step fashion through these phases, but may cycle through them in differing order more than once during a unit of study. A fourth phase - taking action - has been suggested by the National Center for Improving Science Education (Loucks-Horsley et al, 1990) to ensure that students "have truly integrated this newly discovered information and proposed explanations into their existing conceptual frameworks" (p. 61).

Using the criterion for active learning to be a focus on the learning (not the activities) that occurs during a lesson, we can return to the conversations and direct our attention to examples of students attempting to 'explore earnestly' and make sense of the information they were gathering. As well, the perceived relevance of the lessons for the students will be considered. The connections made to previous understandings and to real-life situations were talked about in a previous section of this chapter.

There are numerous examples in both the Mystery Solids and the Mealworms lessons of students earnestly exploring the materials in the lesson; an example (from Mystery Solids):

C - What else is it?

T - I don't know.

D - It's it's squares.

C - Square. It's squares. It's squares. No, it's circle.

- No, it's square.
- See that shape? Square.
- Yeah.
- Over there, look look at over there.
- It's square. (and they continue on this topic for six more turns)

Here the children were observing and exploring the sample in front of them and collaboratively defining what they saw; they were quite engrossed in this discussion. These children were willing to follow the instructions of the teacher and worked hard to observe, express their observations and write these down, despite there being little evidence that they saw much relevance in this exercise to their lives outside the classroom. Their samples were common kitchen substances, however, and the salt and sugar, in particular, were recognizable. Thus, the conversations indicate that these children were actively engaged even though they had not framed the question and it is doubtful that they were able to understand the relevance of this investigation to their world beyond the classroom.

In the Mealworm unit the children were equally engaged in observing mealworm behavior. Even the children who did not like to touch the mealworms were interested in these organisms, had named them and enjoyed observing them. As most of these students had probably observed insects and worms or caterpillars in the past, these mealworms were seen to be somewhat familiar and, as such, had a relevance to their understanding of their surroundings. The questions they investigated were posed by the teacher. One of these, (Do mealworms prefer wet or dry?), produced sense-making conversation, while the other, (Can you make your mealworm go backwards?), was not nearly as successful.

It was not easy to make the mealworms go backwards without possibly injuring them and the most common strategy, telling the mealworm to go backwards, produced few results. The talk shows children making little sense of this exercise; a teacher, recognizing this, would modify or eliminate this investigation. Better yet, the teacher would encourage active learning by helping the children to ask and answer their own questions.

The three topics presented to the grade six classes were markedly less successful in involving the students in sense-making. The lessons themselves were components of a broader topic, Energy. Each had an introductory phase, an investigative phase and a discussion phase and were intended to link to phenomena familiar to the students. Most of the conversations, however, do not reveal learning as sense-making. I will briefly elaborate on this statement topic by topic.

The excerpts of conversations quoted in Chapter Four were selected on the basis of their potential to indicate typical discourse in each group, with an emphasis on talk used to come to an understanding of the concept/s involved in the lesson. Reading through the excerpts or the complete transcripts of the lessons on static electricity, it is not possible to come to the conclusion that the children have developed, to any degree, an understanding of static electricity that is anymore "complex, powerful or abstract" (Cobb, 1988) then the one they started with. Indeed, "The comb gains what? Magnetism? No, the comb gets it? No." (Group B), has more the flavour of Driver's (1983) observation that students often become more, rather than less, confused by hands-on science. The overwhelming impression of these lessons is that of a group of students doing what they are asked to do with no idea of what they should be learning or that their observations should be meaningful. These transcripts provide evidence for the argument that hands-on science is not appropriate for the verification of laws of science. In short, the conversations reveal students who are unable to make sense of their observations. Sense-making was made even more difficult because they did not seem to view these sets of questions as having much relevance to their lives; this was a school exercise of little obvious importance.

As indicated earlier, the Peanut Power lesson included an introductory discussion of food as a source of energy and application questions tying the results of the experiment to the concept of the body using the energy from food to do work. But there is no indication on the audio-tapes that the students understood this connection. The statement "Who cares?" sadly typifies the students' reaction to this experiment; they could make little sense of what they were doing and showed no recognition that this topic was in anyway relevant to them.

Given the amount of information written about environmental issues and the emphasis on these issues in our schools, the students would have been exposed to the idea of alternate sources of energy. In the Solar House activity, there was conversation in both groups directed to solving the problem of the proper placement of the house, solar panels, windows, trees and mirror; that is, there are examples in this lesson of students actively engaged in sense-making, although this was much more obvious in Group B than in Group A. There was little indication, however, that this was perceived to be a subject of any relevance to their lives; again, this science experience appears to be disconnected from their lives and interests outside the classroom.

In summary, while the students were all physically engaged in active manipulation of materials during these grade six lessons, there was little indication in any of the conversations of an earnest exploration of phenomena or concepts which the students perceived to be of relevance to their lives or to making sense of their world. While this is a discouraging statement, the knowledge gained from listening to the students can be used to design better lessons, lessons which will encourage active learning.

This brings us to the topic of the role of teachers in implementing an active learning science program. Teachers are being caught in a paradigm shift in education. Most teachers have been educated, from grade one through university, in classes based on a transmission (Barnes, 1976) or banking (Freire, 1990) view of teaching. This approach is what they know and feel comfortable with. This approach is what parents know and feel comfortable with. However, research in education in the last 25 years has indicated ever more clearly that students do not learn best by being told, but must actively participate in learning by relating what is new to what they already understand. The emphasis is on long-term learning, building networks of conceptual understandings, not on short-term recall of facts and ideas that will be forgotten after the test is completed. As our schools have evolved into institutions mandated to educate all the children in our heterogeneous society and as society seems to transform itself ever more rapidly, it has become increasingly evident that education faces challenges that cannot be solved by an information transferal education model. Children must learn to learn; they must learn to ask questions, consider options and choose the best, although rarely a perfect, solution from among those options. That is, they must learn to reason logically.

The teacher's role becomes one of a provider of experiences that will allow students to gain competencies in all the subject areas and help students move toward independent learning and reasoning. More broadly, I would advocate for the assertion, "Only awareness is educable" (Gettegno, cited in Mason, 1987), but that goes beyond this dissertation.

Teachers set a 'climate for learning' (Torbe & Medway, 1981), once again applying a definition of learning as growth in understanding. Teachers select the topics to be studied, locating this topic within a broader theme (Key Ideas). Teachers must next convince the students that this is a topic that is meaningful to them and is worthwhile investigating. After engaging students' attention, teachers must provide the materials, the collaboration, the support and the "space" necessary for the students to work and reflect on their learning. To help create "common knowledge" (Edwards & Mercer, 1987), all the teacher's professional knowledge and understanding is demanded, both content knowledge and strategic pedagogical knowledge (Shulman, 1986). To be successful, teachers need to be able to listen for and evaluate what the students are learning, to draw on explanations and strategies to help the students continue to make gains in understanding and to help students relate this learning to the real world. As Brophy (1992) has observed, this kind of instruction demands more from both teachers and students, but the rewards are greater and more satisfying.

Within this framework, there are, of course, subject-matter specific activities the teacher should be aware of. Science, for example, allows students to be active learners, both physically and mentally, as asking, predicting and empirical testing are vital components of the study of science. Tools such as introducing discrepant events to stimulate cognitive conflict are possible in science and need be part of the teacher's repertoire.

A teacher who strives to fulfill the roles outlined above is truly a professional, a person who continues to grow in depth of knowledge and in the ability to apply that knowledge. It is very demanding; it can be very satisfying. It also appears to be a very difficult shift for teachers to make (Neale et al, 1990; Constable & Long, 1991). If teachers are to be willing to make a change in their approach to teaching, they will need to feel that their present teaching is inadequate; they must feel dissatisfied if conceptual change is to be a likelihood (Posner, Strike, Hewson & Gertzog, 1982). Listening closely to students and critically assessing the learning gains being made convinced me that the well-structured science lessons I observed were not working, or not working as well as they might have. Teachers, too, need to listen closely and assess critically the understandings being generated by their students. If teachers deem this understanding to be inadequate, they may be willing to invest the time and effort necessary to reconstruct their knowledge of teaching and learning, by no means an easy task. But, I feel, a necessary one if all students are to be given the best opportunities available for learning.

CHAPTER SIX

AFTERWORDS

A Question of Time

I am not able to complete this thesis without mentioning a factor present in each of these lessons - the time factor. There has been an increasing consensus among science educators in the last two decades about the features desirable in a lesson to facilitate learning in science. As described in Chapter Two, Hands-on and Minds-on Science, these science lessons are often described in terms of three phases: an initial exploratory phase, a discussion phase and a more focused investigatory phase. While introducing a science program incorporating these features demands little additional funding for special materials or texts, it does require additional time. Exploring and constructing meaning are processes which take time and cannot be rushed. However, in the classes I observed, it was common for a 30 minute science lesson to dwindle to 20 minutes or less by the time the science lesson actually commenced. This was never intentional, but school programs or other housekeeping details, follow-up from the preceding lesson in another subject, special visitors and similar disturbances affected the actual time spent on science activities. This is true, of course, for all the subject areas. However, science is the core subject mandated the least amount of curricular time in elementary school and it suffers disproportionately; five minutes out of a 30 minute lesson represents 16% of that lesson.

Driver (1983) wrote, "Not only do pupils need time to undertake practical activities, but more time is needed to make the most of those that are undertaken;" it is "a question of time" (p. 83). The additional time "to make the most" of the hands-on activities refers to reflective time; the time necessary to make the lessons also minds-on. For significant learning to occur, students need time to "figure it out," to make sense of their experiences, to formulate an "understanding [of] the issues and concepts and their relationship to the activities" (Edwards & Mercer, 1987, p. 99).

The draft Alberta Elementary Science Curriculum Guide (1992) stresses that students should be actively engaged in inquiry and problem-solving in their science lessons and that "children learn science best through participating and reflecting on the meaning of what they are doing" (p. A.1). I would argue that these inquiry and problem-solving goals will rarely be met if students are given only 75-100 minutes a week to "do science," particularly if lessons are not even as long as planned by the teachers in their lesson plans.

Most 30 minute lessons are too short to allow the students to become really involved. One long science lesson once a week results in too much discontinuity between lessons. With a gap of a week between lessons, too great a proportion of each lesson has to be devoted to remembering what was being investigated the previous week and what had been discovered so far, leaving too little time for patterns and discrepancies to be recognized. If the time allotted to science is not adequate for "students to explore earnestly" (Trumbell, 1992, p. 9), to reflect on and discuss their investigations and discoveries and to use this developing understanding in further explorations, then we cannot expect students to make the gains that are possible in their conceptual knowledge or in their understanding of how to find answers to their questions.

Teachers state that they simply do not have the time to plan and organize materials for science units given the limited amount of time allotted to this subject. They feel that their energies should go toward developing lessons in the subject areas which receive more emphasis in the curriculum. Thus, science lessons are reflecting the message that is being delivered in the Curriculum Guide in terms of time allotted to subjects (Grades 3 through 6):

Language arts	30% of instructional time		
Mathematics	13%	"	"
Social studies	10%	"	"
Science	7%	"	"
Fine arts	10%	"	"
Physical education & health	10%	"	"
Undefined	20%	"	"

Again, it is a question of time.

To explore this question of time, I will evaluate the Mystery Solids lessons in terms of the three phases mentioned above: an exploratory phase, a discussion phase, and a more focused exploratory phase.

<u>Mystery Solids</u>

This unit is intended to "introduce children to the detailed examination of some chemical and physical properties of familiar substances" (ESS, 1967, p. 1). The children in the observed classroom were given about 15 minutes to examine each of the Mystery Solids, time enough for them to start to explore more than the immediately obvious properties of colour and taste, and to include others such as feel, and shape and stickiness. These observational activities could be called the exploratory phase. However, the discussion phase, a time when students can compare their techniques and observations, was quite short. The teacher asked the students to decide what each of the four samples was after showing them the boxes which had contained the Mystery Solids. She accepted the suggestion of one of the students that you could figure out what your sample was by comparing it to a known sample. The students tasted their sample of baking soda and compared it to a sample taken directly from the baking soda box. They all agreed that both samples had the same disagreeable ("yucky") taste. There was little additional discussion; identification of the Mystery Solids was revealed and the class ended for the morning. This was a natural time to break, but, unfortunately, no later time was made available for students to compare the samples or to try out explorations suggested by students in other groups. Specifically, the students in the recorded group would have been curious about the differences between flour and corn starch; they had been very certain that the sample of corn starch was flour. Most students simply did not get the time to become well acquainted with these solids and their characteristics.

In the afternoon, the children did the three tests on the solids: the vinegar, iodine and heat tests. The children were involved in, and excited by, the results they observed, but many children appeared to be tired. Both the brisk pace set by the teacher (in order to minimize the chance that the vinegar and iodine would get spilled or the children burned by the flaming petroleum jelly) and the students' desire to see what would happen next, resulted in several groups failing to record the results of their tests. This, of course, had an impact on their ability to identify the Mystery Solids by means of the observed reactions to the tests. It did not appear that this exploratory phase in the afternoon allowed many of the students to develop the skills or understandings necessary for successfully continuing this investigation.

At the end of the first day all the students seemed to be aware that there was a number of differences between the four Mystery Solids which they had been handling that day. It would appear that most students had made advances, through their collaborative observations in their groups, in examining the properties of a substance. I do not feel, however, that they had a chance to really "mess about" (as suggested in the Teacher's Guide to this unit) and to integrate this process of observation into their approach to understanding their world.

I observed, but did not audio-record, this same set of lessons in another classroom as well. The teacher used a similar approach and the results were also similar. When the focused exploratory phase, the identification of mixtures of the four solids, was introduced, some students were able to quickly complete the tests and successfully identify all the Mystery Mixtures. The majority of the students started more slowly, but gained expertise in doing the tests and interpreting the results and were able to identify most of the Mystery Mixtures; and a few of the students did the tests but were unable to interpret the meaning of their data. They had not had enough time to explore, to test and test again, and to think about what all this information told them.

As the ESS Teacher's Guide (1967) warns the reader, "It is easy to forget that learning is a very slow process" (p. 8).

In these lessons the students were involved, generally enthusiastic and had the chance to explore some to the characteristics of the substances. However, the children did not have enough time to reexplore, compare and reflect. Specifically, the Teacher's Guide suggested that "the activities can be completed within 10 lessons of about 45 minutes each" (p. 1); that is, in about 7.5 hours. The recorded class completed the unit in approximately 4 5 hours. As a result, the students did not make the gains in experimenting, observing and drawing conclusions based on their observations that forms the core of this unit.

Susan, the teacher, displayed many of the characteristics of exemplary science teachers described by Tobin and Fraser (1987). She was friendly and supportive, offered continual assistance, was confident of her ability to teach science, provided sufficient appropriate materials for the students to use in their investigations and her science lessons were predominantly activity-based. The limiting factor for science learning was an inadequate amount of time devoted to science. The investigations were *not* based on student-generated questions. Developing good questions can take a lot of time. There was no time for repetition and verification of their explorations; this would require additional time. There was also little time for reflection or for assimilation of this new learning into their knowledge structures. Too little time.

A Personal Note

The reading I have done while pursing this study indicates the consensus among educational researchers to be that meaningful, long-term understanding requires the active involvement of learners in the construction of meaning. Thus, there is compelling evidence in educational literature for implementing a constructivist approach to learning and teaching. Nor does educational research stand alone in advocating for a constructivist perspective; a constructivist theory of learning has also gained prominence in the field of cognitive development. In striking contrast, the dominant practice I have observed in the schools, in my own children's and in the others I have visited, remains one of transmission.

While the "introduction of any new teaching practice is a complex and problematic process" (Neale et al, 1990), I firmly believe that the implementation of constructivism must be the goal in education if, as stated before, all students are to be given the best opportunities available for learning. Otherwise, I fear, there will be another cycle of 'back to the basics' with the emphasis in education once again being on developing methods for most effectively transferring information to our children. And too many children will, once again, fail to gain the "common knowledge" necessary for success in our society.

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APPENDIX A

Transcription Notations

- <u>most heat comes from</u> - <u>Biggest windows</u>	Underlining indicates simultaneous speech
*	Unintelligible word
?	Unintelligible phrase or sentence
/	Pause, 5 seconds
//	Pause, 5 to 10 seconds
// //	Pause, 10 to 20 seconds
infearence	Italics indicate phonetic spelling

APPENDIX B

Mealworms - wet or dry preference

Group B

Note: T in the transcript is the teacher

- (before group starts) ? I have to pour the water.
- Ok. Now I have the water. Let's put the mealworms on.
- (whisper) Not yet.
- A * of water
- Cold.
- (whispering) Stupid worm.
- (whispering - 2 comments)
- Ok.
- Are you ready for the mealworm?
- Yes.
- Can you open it?
- Yeah.//
- What's wrong with it? //
- I think they're all in the pupa stage.
- No, they're actually still living. /
- Yup, still moving.
- Yes, let's put them on the dry side first.
- You can put it on for me.

T - (voice louder than girls' voices)

- ? like this.
- I think you got me.
- Not that way. //
- He likes the dry.
- He really likes the dry.
- If he starts going ? //
- He's your friend.
- I think that's

T - Does he go onto the dry? Give them a chance to crawl around and see where they end up. / See if they move onto the dry or

- This guy likes the wet.
- Not not the wet. He likes the dry.
- I wonder why he likes the dry instead of the wet.
- He probably was born in /
- He was born in a pet shop. He wasn't born in the water.
- Well, he could be. /
- Um. He likes the dry. (firm statement)
- Um hmm.
- He does like the dry. M., why don't you put him on, pick him up and put him on the wet.
- Ok. See what he does.

- Come on, guy. Get in here. Come on (laugh). I don't want to pick him up. Only if they're in the pupa stage. Good.
- Ok, just drop him there.
- Uh. Looks like he ?
- He's not moving. /
- Giddy up, giddy up, worm.
- He likes the dry.
- Uh huh.
- He really likes the dry.
- Or does he like the wet?
- He's not moving on the wet.
- He hates the wet. //
- I think he likes wet. (slight laugh)
- What do you mean * ?
- Oh, yeah, yeah.
- Look at him go.// Look at him go. (giggle) Look at him go. (giggle)
- Let's pour a bit more water. /
- ? wet
- Ooh. He likes that.
- ?
- ?
- Don't worry. ?
- Look at him go. (giggle) // Look at him go. (giggle)
- There, hmm. He's tired. / Come on, it's ok.
- Come on, Josh. It's ok. He's got to start moving. //
- You're a real friend.
- He likes it.
- He really does.
- Josh is always the lightest.
- Yeah.
- Did you say lightest?
- Yes.
- Why is he the lightest?
- I don't know. /
- Come on, stay moving.
- Ah, there he goes.
- Yup.
- I think he likes the dry.
- Yup, he oop
- Uh, oh.
- If he's heading for your desk, he likes the dry. // //
- Meal worm.
- Ok, M., let's try him on the dry again.
- Just a minute. //
- Go this way.

- ? go!
- Oh, don't please don't go on the pupa stage now. Please, Josh, please. Be a good worm.
- Josh, Josh, Josh. I think
- (crying sound)
- Don't worry.
- Josh. Josh. // //
- I think so. You're not moving. I don't know if he likes the dry or the wet.
- He's still moving, but he wants his pupa. //
- Come on.
- Make him *
- Just a minute.
- Let's put him on the dry.
- ? he fell off.
- Hey.
- Just a minute, I don't want to pick him up. /
- ? in here.
- Oh, boy.
- Come on.
- And at the age of 7.
- Uh, oh, I think he's gone into the pupa stage.

T - What's yours doing?
- He likes the
- I think he likes the dry. He won't move on the wet.
- Yeah, he did. He was right here.
- Yeah, he he had the napkin and then Josh
- I don't know ? like that. He was moving around on the dry.
- Ms. H., one was on the wet side, now he's going to the dry side.
- (other children come to speak to T.)
- M., I hope he's not going into a pupa.
- Well, he's still moving his feet.
- Hello.
- Come on, * . I think you like the * , you like dry. Come on, come on, guy.
- ? dry place.
- Probably wouldn't like the Arizona desert. // //
- Come on. /
- Ok, he's on /
- I don't want to look ?
- Come on, Josh.
- Ok.
- Good. Now let's see if you like the dry or the wet. /
- ?
- No, not * . He's not moving. Come on, Josh.
- Come on, Josh. You can do it.
- ?

- Giddy up, worm. //
- He must be tired. /
- (sigh)
- Come on. It's ok. Come on. Go.
- I think he likes the dry. He likes the dry.
- ?
- I forgot to put dry.
- I just looked into your magnifying box. /
- * still good. (laugh) / I hope they grow up to be beetles.
- ? beetle ?
- ?
- ?
- Josh doesn't ?
- Ok. I've put too much water, M. // //
- I'll be right back ?
- I just want to put *
- (gasp) He likes the wet. He likes the wet!
- He likes wet. He likes wet. (seems to be turned away to address another person)

T - Now he's heading back. Well, that's interesting. See if he actually stays on the wet or if he heads onto the desk.

- Ms. H., I put it on the dry and now it's going back to the wet.

T - See where he ends up. //

- Mine likes mine likes the wet. (?this group)
- Is yours start?
- Um hmm./
- Come on, M. Put him back onto the dry and see if he wants to
- Uh oh. He's starting to curl up, I think. /
- Oh, dear.
- He'd better not get into a pupa before this experiment * //
- Whoa.
- (giggles - ?this group)
- I got to tell * . I'll be right back.//
- (giggles, comments - can't tell this group from class)
- Look at mine, * //
- Oh, it's going on the wet. I think he likes the wet.
- Keep him on the wet.
- Yeah.
- How come he only gets a little bit onto the wet and then stays there?
- I have no idea. / M., it's curling up now.
- Ah, he's staying there for
- ?
- Hmm.
- ? science.
- Come on.
- Mealworms like wet places. Mealworms hate dry.

{Recess bell. Cleaning up.}
- Let's get him into this bran.
- Just a minute. /
- ? your bran.
- Come on.
- Recess time. Boy, time goes by.
- I'll play with you.
- What are you going to play?
- I don't know. Go round or something.// //

T - Let's go, guys.
- Start playing.
- Josh looks happy in his bran.
- (children are to be quiet and ready for dismissal)

Girls whisper: I just dumped him back into his bran.//
It's so much fun.
Now we really know.
Now he only likes water. /
?
?
? too wet.
Thank you.

APPENDIX C

Solar House
Group B
Note: T in the transcript is the teacher

T - instuctions
- Alright, guys, we're being taped.
- Testing, testing 1,2,3.
- (tapping on mike) Don't do that!
- Just talk normally.
- Alright.
- N.!
- Hey, guys.
- Shh. (T starts to address class about the mirror. Some student talk during this.)
- The windows have to be on the south.
- Yeah, so does the solar panel.
- The solar panel faces south, right, guys, because that's where the most elec
- <u>most heat comes from</u>
- <u>Biggest windows</u>
- Yeah, that's true, Richard.
- And the biggest window.
- And in the north we'll have all the trees in the north, alright?
- To block out all the cold.
- I'll cut out the trees.
- <u>We'll have all the trees in the north?</u>
- <u>No, it's the south</u>
- <u>The south has the is the sun is where the sun really shines</u>
- ________?______
- Yes, it is.
- No, the east is where the south
- That's that's sunrise /
- Yeah, I knew that.
- And then it comes up and it <u>shines really hard on the south</u>
- __?____.
- So we have to get it on the south, alright?
- ___?__________
- We've got to ____?___________
- <u>Can I please go get a</u> drink? I'm really thirsty.

T - You should get another pair of scissors, though.
- I can't. I don't have any scissors.
- Alright, guys, we're going to put all the trees on the north so it blocks out all the cold.
- That's cool.
- It depends.
- No, but
- Your pine tree

APPENDIX D

Mystery solids

Describing Properties - Baking powder

Note: SC is the teacher
C - Curtis
D - Dianne
T - Teni

- s
- s-o-n-d. She even said

D&T - No.
C - Yes, sound is s-o-n-d.
T - No, it's supposed to have a u inside.
D - Yeah.
- s-o-n-d.
C - Miss C., how do you spell sound?
T&D - See. // See. (laughs)
C - S-o-n-d. Sound.
T - But he forgot the u.
C - No. // d. //
- It's n-d.
T - Sounds squeaky.
C - Make that sounds.
- (unclear) (?)You're making my sweater ?
D - Squeaky.
C - u-e, no v.
- ?
- What?
- It sounds - squeaky.
- ?
- It's soft.
- It's tiny?
C - * * tiny.
T - Why would he say tiny?
- ?
- It's circle.
C - No, it's not circle.
- It's tiny.
- It's flat.
- It's fluffy. It's fluffy.
C - When you press on it, it's flat.
- It's flat.
- Flat.
- It's flat.
- Ok. //
- Flat.
D - F-l-a-t.

T - It's flat. What else do you want me to put down?
C - It's flat on the paper. (laughing)
- Flat.
- Finger prints all over it.
T - Finger prints!
D - No.
C - What else does it have? //
- It's it's slippery?
D - S-l-i-p-p-e-r-y.
C - It's slippery. Look at.
- It's slippery.
D - It's slippery. Ok.
T - It's slippery.
D&T - S-s-l-l-i-i-p-p-e-e-r-r-y.
C - It's slippery.
D - What else is it?
C - I'm thinking, I'm thinking.
D - Oh, it's tiny.
C - It's smooth?
T - It's smooth, but we should put it's it's soft.
- It's it's soft, it's flat, it's smooth.
C - It's kind of like
- It's kind kind What else can we put down?
- It's
- I don't like it.
- But We thought that was flour, but it wasn't, was it? It's baking powder.
C - It cleans easily?
- What?
- It cleans easily.
T - It - cleans - easily. (writing)
C - See. Look.
- Aw awesome.
- e-a-s-l-y. Easily.
C - It makes a mess.
T - It makes a mess. //
- Its make it clean.
SC- (to group) What does it mean when you said it makes a mess? What do you mean by that?
C - When you spread you finger on it, it gets stays on it.
- ___?_____
SC- Ok, good. When you rubbed #1, did it stick?
All - Yeah.
SC- To the paper? Or could you get it all cleaned off?
D - Well.
T - Nearly all.

C - Most of it.
SC- Most of it. Do you think you could do that here? I think C's right that it rubs into the paper.
C - Yeah. /
D - It could.
T - Can I try?
D - It makes a mess.
- It makes a mess?
- It's cleaning.
C - Yip.
- Erase it cleans easily.
C - Yeah, it does, doesn't it.
- It's // it's // what
- Makes
C - Um it, it, it, it, it, it
D - A mess. m-e
- ? I forgot
- (laughs, mimics) M-e, I forgot // //
- No, you can't
- I know.
- You have to let the other people read it first.
- (looking at sample through a hand lens)
C - Aw awwsome.
- It's
- shiny
- It's shiny.
- It's shiny.
- Yeah.
- It's crystal.
D - It's not it's not crystal, it's shiny.
T - Yeah.
C - Oh, another one. Ah ha.
T - It makes
C - ?
T - It makes Hey
- Then we'll have to put more um baking powder in. Because you don't have to
C - Oh, that's a little bit too much.
- Oh, well.
D - Spread it out.
C - No, that's too much.
- Spread it out so we can all see it.
- Make a start.
C - Why'd you do that?
SC- (to class) Ok, what do you think Mystery Solid #2 is? Write it down and write underneath the reason why.

APPENDIX E

Static electricity
Group C, Lesson 2
Note: T in the transcript is the teacher

- Oh, I see the tape recorder.
- It's on, maan.
- Is it on?
- It's on.
- It's on.
- S., you have to talk. /
- Ok.
- BFG, you have to do one of the
- Ok, let's
- Jolly Green Giant.
- ?
- Please be kind. BFG, do the first one.
- No, do the hardest one.
- Jolly Green Giant.
- J., you were right.
- What?
- ?
- What?
- Wake up, T., T. (sounds of bag being opened)
- Oh, I was
- Read it.
- About what?
- Hang a the toothpick.
- ? .
- Shut up.
- (reading) Hang a toothpick from a string and attach it with tape to the side of your desk.
- ?
- Place it.
- Louder. I can't hear you.
- Place it
- Louder.
- No.
- Place the balloon
- Louder. (laughing)
- Place the balloon, comb and ruler near it, one at a time.
- I can't hear you.
- Ok.
- I'll just read it. (quiet hmming sound)
- Ok, I can hear you.

- Slow.
- Are you having fun? //
- Oh, baby. Whew(whistle)
- What does it do?
- It *
- Ok.
- *
- Are they attracted to the toothpick?
- Yes.
- Yes.
- Are they? //
- Ok. Can you tell from this if either object has an electric charge?
- Yes.
- It doesn't do it with the comb, though.
- Yeah, but you can tell that one of them has an electric charge.
- Ok, so <u>from either object.</u>
- Hey, J., you have
- No, no, no, no.
- Does it have an electric charge?
- Yes.
- <u>Only</u>
- I was <u>I was circling</u> the ones I like best.

T- Ok, you said yes they are. All 3 of them were attracted to the toothpick?
- Well, <u>yes.</u>
- (?) <u>No.</u>
- <u>and</u> <u>the comb</u> does.
- So far 2.

T - Let me see your comb. Show me that your comb is attracted to the toothpick.
- Oh, no.

T - You're not supposed to rub it on anything, J. No, no rub it off with your hands.
- Oh.
- You used a name. / His name's Jo. I'm Flo.

T - It's not attracted, is it? Try your ruler. Who brought the ruler?
- ?

T - Who brought the ruler.
- So, so far only the balloon does.
- Mrs. H., so far only the balloon does.

T -Tthat doesn't do anything either, does it?
- No, there's a lot of electical charge on this. /

T - This one is really charged.
- Maybe not.
- Look at here.

T - Yeah, the balloon is going to be effective. So you can just say only the balloon does.
- So <u>doesn't</u>
- <u>I just</u> circled balloon.

- Ok, now (reading) can you tell from this if either object has an electric charge?
- Yeah (quietly)
- Um hmm.
- L., is this it?
- What are you doing?
- Oh, my God.
- ?
- What did he do?
- (whisper) He just farted ?
- (laughing)
- Oh, my God.
- And he did too.
- I know.
- Flo. /
- What?
- Flo, you farted on it.
- I did not, Jo.
- I think.
- S. (laughing)
- I didn't do it.
- The BFG.
- I didn't do it.
- BFG. Big G, the friendly giant.
- No, bi
- the Jolly Green Giant
- Big Fat God God. Big Fat God
- Can you tell from this?
- Oh, so
- if either object has an electric charge?
- Can you talk in this?
- Yeah.
- Yes, you can.
- You can.
- Ok, does either object have an electrical charge?
- Yeah.
- Yeah.
- The balloon.
- Yes, just put yes again.
- Balloon
- Balloon.
- Yes, balloon.
- And put, yes, balloon.
- Yes, balloon.
- (laughing)
- I can't believe he did that. // (laughing)

- What?
- What?
- She'll be listening. She'll hear all of a sudden phftt.
- (laughs)
- What?
- (laughing)
- Ok.
- ?
- Um. (reading) In order to put a charge on the balloon, comb and ruler, rub each object with wool, plastic wrap and sy whatever fabric one at a time.
- Synthetic.
- Find out if it has received the charge by holding the object near the toothpick.
- Ok,
- What is our synsetic ?
- This.
- Here.
- The other side.
- Is this ?
- This?
- Yeah
- Yup
- The red one, Jo.
- That's the wool.
- Jo.
- What?
- The red one.
- The other one.
- Curly. //
- ? //
- (whispers)
- ?
- Jo, this damn thing and
- Jo.
- What?
- She goes like this. (laughing) //
- Where is our other stuff got?
- Is that it?
- I don't know.
- Ok, so plastic wrap, synthetic fabric and wool. One at a time.
- So, do we rub it?
- Ok, charged object rubbed with
- Ok, balloon
- With the wool first. /
- Ok.
- (laughs)

- Let's go with the plastic. //
- and then what happened? Oh, is it attracted to the toothpick? // //
- Yes.
- It is?
- Yes.
- Ok, so check
- Balloon and wool worked. Or balloon and
- Wool worked (laugh)
- Balloon and plastic
- Ok, balloon and plastic.
- Oh, do we do the wool?
- The wool.
- Ok, the wool we're doing now.
- (giggle)
- (quietly) It's sliding all over. //
- ?
- Yes.
- Yeah.
- Ok, now the comb with the wool. No, the comb, the balloon with the synthetic fabric. //
- J., doesn't even try anymore.
- Hey!
- What?
- My name
- I said Jo./
- Jo
- A comb. The comb with the wool.
- Jo, Flo, Mo and Cur Cur
- Curly.
- Jo, Flo, Mo, Curly, and BFG. (singing)
- Steve. I mean, BFG you get tapes.
- Here, see the comb and the wool.
- Steve, I mean BFG.
- Aah, did that hit you?
- E., I threw a comb at him and it stuck on his shirt. (laughs) /
- It did.
- You used a name.
- So.
- Steve, I mean, BFG. I Ste, I mean, huhm I th
- Yes.
- Now.
- Steve, did you err BFG, did you do it good?
- Yeah.
- Do it on the rug <u>it works</u>
- <u>Do it on</u> rug. It works better. The rug's wool, anyway, so /

- Ah, it's a comby fritter (laughter) /
- It does.
- My sister her hair would just be like
- Uh, oh, my God.
- Yeah, I guess so. (laughter)
- Ok, now the comb with the plastic wrap.
- I don't think so. /
- Yeah, it's really going to. //
- (laughing) No.
- (gasp)
- Try again.
- It might. It's supposed to, I think.
- No!
- It is not
- No, plastic and plastic are supposed to.
- Oh, yeah.
- Plastic and plastic?
- How many check marks do you have? 4?

T - Put it right next to it, James. Let's see.
- Yeah. / It does, doesn't it?
- No, it doesn't, does it, Mrs. H?
- Can't see it *
- It seems to be doing something, doesn't it? What's it doing?
- Pushing it away.

T - That's nothing. Try it again. I don't think everybody saw what's going on. Move the *.
- No.
- ? (rubbing sound) //
- I chased it away.
- Ah.
- Ah.
- Cool.
- Ok, the synthetic wrap, the syn synthetic fabric
- synthetic rub
- synthetic wrap with the comb //
- This is fun, isn't it?
- ? (weird voice)
- Rub it on the ground. What's that song? Synthetic wrapper. (giggles)
- Synthetic wrap.
- Synthetic wrap (dramatically)
- Synthetic wrap, Julie. (laughter)
- Synthetic wrap.
- Start something in there.
- Jo, er. No, I'll be nice, I won't say it. (laugh)
- * * already.

- Well, yup.
- Yup, it does. (laughing)
- Ok, now the wool and the ruler.
- ?
- Did you see what I did?
- She just grabs.
- Did you see what I did? I went
- Yeah, I know.
- He looks like a Grade 3er.
- N. did that at least last year in the back.
- * guys. (giggling)
- This isn't working.

(tapping on mike) Oh,vibrations.

- You'll hear better from the bottom. That's where it comes thruough.
- It does?
- {Throughout, low level giggles from girls}
- Look at that little slit. It's the only way it comes through unless this is really sensitive.
- That's what she says.
- Ah choo.
- Sneeze right into it.
- ? (laughing)
- (retching noise)

{Acting for mike} - J., I think that supper last night really got to you.

- Go to the washroom. Hurry up. Get ?
- Oh, bye, see you. (clunks) I'm back. You know, I think those hamburgers really got to me last night.
- Synthetic fabric with the comb
- The ruler doesn't do anything.
- Did the ruler do anything?
- No.
- No, for either one.
- Clean it up, Steve.
- For all 3 of them?
- So, no, no, no.
- Where are you guys going?
- ? , J.
- We're done.
- We are?
- Stay here.
- Oh, oh, yeah, ok.
- Ok. Now
- Jo, Jo, we're not done yet.
- We're not done yet.
- We aren't?
- We're not?

- No, we're not. //
- ?
- Ok.
- Where's the bag?
- So, so, so what number are we on?
- Ok, did we do ruler and synthetic?
- Yeah, we did all of them.
- Hi.
- Well (silly sounds)

T - Are you guys done?
- Yup.

T - Can I see your results? Can I see your results?
- Yeah, right here.

T - ?
- Did you?
- Ok, we're not done yet, people.
- Where's my pen? Who stole my pen?
- It's right by your legs.

T - Ok, where's the ruler?
- Right there.

The ruler is in right there.
- That doesn't work
- I I thought it might work, but oh, well //
- Well, ok
- What about the other?

T - Try the other 2 again.
- Ok.
- So the wool does. What about the plastic wrap? Here
- No.
- Do the
- (disgusted) Plastic wrap doesn't work.
- Hey, it works for the other one.
- We're back. //
- Yeah.
- Yeah?
- Yeah.
- Yup. And the other one works, too.
- Shit.
- They all work.
- Are we done?
- I think we're done.
- Are we done?
- Ok.