

**TEACHING SCIENCE IN A GRADE THREE CLASSROOM: RHETORIC AND  
REALITY; THEORY AND PRACTICE.**

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*For Hope, Laura and Rebecca. Thank you for making all those late nights  
and long Saturdays possible.*

## ABSTRACT

This study is a qualitative examination of the teaching and learning of science in one mixed ability grade three class of twenty-five students. Data for the study was collected over a period of six months. Data was derived from teacher journal entries, anecdotal notes and student writing. The study is divided into two parts. Part One examines a variety of curriculum orientations that presently inform our understanding of the teaching and learning of science. These orientations are defined as: science as a school subject; science as process; science and "children's science"; science and "language across the curriculum" and integrated science. Part One concludes with a brief description of the classroom context within which these orientations occur. This context is described as a "Whole Language" one. Part Two is a critical and reflective examination of selected data from a variety of teaching and learning contexts. The study concludes that the teaching and learning of science within this classroom is reflective of a variety of curricular orientations. That in the planning of science activities emphasis is placed upon the following orientations: *school science*, *children's science* and *integration*. However, the implementation of these plans emphasises a *Language-across-the-Curriculum* orientation. In addition, the study concludes that there are many examples of science teaching and learning that occur outside specific curricular orientations. These examples are examined and defined as *incidental science*.

## **TABLE OF CONTENTS**

Proposal.....	1
A personal note: the study's origins.....	2-3
Introduction.....	4-6
<b>PART ONE : <u>The nature of science in schools: curriculum orientations for the teaching and learning of science.</u></b>	
Science as a school subject.....	7-13
Science as process.....	13-17
Science and "Language across the curriculum".....	18-20
Integration.....	21-27
Child Science.....	27-31
My classroom and its total program.....	31-37
<b>PART TWO: <u>Examples from the classroom</u></b>	
Introduction.....	37-43
Hot Air rising: the case of the rising tissue paper experiment.....	43-47
The water, candle and jar experiment.....	47-55
Examples of "Integration" within the Unit on Air.....	55-60
Science within a theme.....	60-68
A Unit on magnets: planning.....	68-69
Beginning the Unit.....	69-76
Concluding the Unit.....	76-82
The story of "Incidental Science".....	83-92
Conclusion.....	90-97
Afterword.....	97-101
Bibliography.....	102-107
Appendices.....	108-128

## **Purpose**

### **1**

To review and examine the variety of orientations presently informing curriculum and instructional practices in Science Education.

### **2**

To make a comparative study of these orientations through the teaching and student responses of one grade three classroom.

We go about our daily lives understanding almost nothing of the world. We give little thought to the machinery that generates the sunlight that makes life possible, to the gravity that glues us to an Earth that would otherwise send us spinning off into space, or to the atoms which we are made of and on whose ability we fundamentally depend. Except for children(who don't know enough to ask the important questions), few of us spend much time wondering why nature is the way it is....In our society it is still customary for parents and teachers to answer most of these questions with a shrug, or an appeal to vaguely recalled religious precepts. Some are uncomfortable with issues like these because they so vividly expose the limitations of human understanding.

(Carl Sagan: Introduction to Stephen Hawking's: **A Brief History of Time.**)

### A personal note: the study's origins.

This study has its origins in the reading of two books: Rosalind Driver's The pupil as scientist (1983) and Douglas Barnes' From communication to curriculum (1976). Both books were encountered while on sabbatical at the University of Lethbridge.

My encounter with Driver's book was pure serendipity. The book was discovered while browsing in the science section of the University Library. Just why I was browsing in that section I can't recall. However, the book's title and possibly its thin shiny-black appearance caught my attention. I remember sliding down into the aisle between the bookcases as the content and style of the book demanded my attention. Although I have no formal post-secondary education in science other than that connected with the History of Science, I found myself being quickly persuaded by Driver's arguments and examples concerning the teaching and learning of science in the middle years. I was struck, in particular, with Driver's concern for the role of experiments in science lessons and what, precisely, the pupil was learning and understanding during these experiments. Driver's book rekindled, personally, a variety of questions that had lain dormant over the years concerning the teaching and learning of science in elementary education. As a consequence, I began to search out all that Driver had published, and quickly became immersed in the fields of "Child Science", "Misconceptions" and "Alternative frameworks"!

The reading of Barnes' book was less serendipitous but equally influential. I was familiar with some of his earlier writings and was directed towards this particular work by my professor, Dr. Laurie Walker. I found in Barnes' book a critical examination of the relationship between content learning and language, particularly that of the teacher's talk and control of classroom dialogue. I

was also struck by Barnes' epistemology, in particular his distinction between *school knowledge* and *action knowledge*. As a consequence, I began to reexamine not only the problem of teaching and learning science but also the problem of the relationship between language and science.

Barnes and Driver precipitated the writing of an independent study: "Words, meanings and concepts"(1986). In this study I taught seven lessons on Electricity to one grade six class. The study further whetted my appetite for a more detailed examination of the teaching of science. During this period of study I was also becoming interested in the nature of "Whole Language". While continuing my interest in science I wrote another independent study: "Teaching "Whole Language" in a Junior High School", an examination of two teachers implementing a prescribed Language Arts draft curriculum. At the same time I prepared two thesis proposals on examining children's scientific understanding. Both were destined to remain just that, proposals. Questions remained however, concerning the teaching and learning of science, particularly the role of language in that relationship.

A gap of approximately six months gave me time to reflect further on just what it was that I wished to try and answer concerning the teaching and learning of science. This study is, I believe, a little closer to what it is that concerns me as a classroom teacher: the relationship between child, language and learning. The acquisition and understanding of knowledge is, I believe, fundamentally related to the relationship between language and learning. It is also a study that examines the relationship between theory and practice. Hence the study's title: Teaching science in a grade three class: theory and practice: rhetoric and reality.

### **Introduction**

*Reflection is the soul of action for it strengthens and gives our intentions sustenance and elevates our impressions. Reflection is not an act of looking backward to what is known, nor merely remembering. Rather it is an "engagement of impressions" that results in the illumination of layers of meaning (Burton,1982,p.723).*

Writers such as Holt (1964), How Children Fail ; Armstrong (1980), Closely Observed Children; and Lucy McCormick-Calkins (1983), Lessons from a Child, have considerable personal appeal. Through description, anecdote and personal insight these writers capture in critical ways the world of teaching and learning. There is an attractive empathy and poignancy in the content of these writings. In a literary sense the material of these authors is not dissimilar to the diaries, notes, journals and letters of the poet, novelist or dramatist. In the treatment of their material they could as easily be described as novelists as educational researchers. They are, in a sense, a *genre* in their own right, but have become included under broader educational research categories such as biography, ethnography, action research and teacher as researcher; which in turn are broadly defined as qualitative research. They are, at heart, story-tellers. We are all tellers of stories, differing only in the forms and sense of audience by which we desire to express them (Rosen,1985). So, I propose also, in this study, to tell a story. A reflective story about science teaching in one grade three class. This story is derived from a variety of data: children's writing, personal journal records, observation notes of colleagues and class discussions.

The "weakness" of this kind of research is that as participant observer I can never remain objectively neutral. (Can one ever?) Hence the emphasis upon story. It is not my purpose to create either a fiction or a highly selective analysis that neatly conforms to a particular viewpoint. I am obviously aware of a wide variety of orientations and approaches pertaining to the teaching of science but I



really am not sure just *precisely* how I teach science. Hence, the project's sub-title: "Rhetoric and Reality; Theory and Practice". I may on one hand articulate a preference for "Whole Language" or "integration" but the reality of my practice may differ. Equally, I may internalise cognitively a theory of teaching which I believe informs practice. Again, however, that relationship may not exist as clearly. As Elbaz (1981) remarks:

*The prevailing view of the teacher as a passive transmitter of knowledge does not accord with [her] own experience, in teaching and in work with teachers, of what the teaching act requires. But a view of the teacher as playing a role in the implementation of new curricula, adapting and changing the materials which come his or her way, may also be inadequate insofar as it rests on similar assumptions about the teacher's ability to initiate and shape actively the classroom situation(p.43).*

The story to be told however is not pure narrative. There is reflection upon this narrative from the point of view of specific curriculum orientations.

The idea of curriculum orientations is not new. Elliot Eisner in The Educational Imagination, describes five broad orientations that influence educational curricula (pgs.50-73). For Eisner, these five orientations "are intended to function as tools for the analysis of existing school programs and as foundations for a sharpening of discourse about the planning of new programs"(p.72). These orientations, Eisner argues, are applicable to all curriculum endeavours. Douglas A. Roberts(1982) identifies seven science curriculum orientations. Depending upon political, economic and cultural factors these seven orientations will go in or out of fashion. However, "it is not that there are some "correct" emphases and other "wrong" ones. Each is a legitimate candidate for choice". Curriculum orientations, therefore, can possibly provide one useful reference point by which to understand how one teaches.

While no clear definition of Science exists either philosophically or educationally, there does exist a wide variety of orientations and approaches that contribute to the understanding and practice of science teaching and learning in education. These orientations and approaches have competed for attention across all grades and a wide variety of countries both developed and developing. Although the primary focus of this study is one elementary class and its teacher, it is this author's contention that since many of these orientations of science are derived from theories of history, philosophy, psychology and language and learning, they are broadly applicable across all grades. These orientations and approaches have also formed the rationale for the creation of science curricula locally and nationally. The following characterisations are not proposed as definitive statements of theory and practice in "*school science*" but provide rather useful labels by which to eventually analyse the science teaching of one class. The variety of orientations and approaches have been defined in the following manner:

- (1) Science as a school subject
- (2) Science as a process
- (3) Science and "children's science"
- (4) Science and "language across the curriculum"
- (5) Integrated Science

The next section contains a brief discussion of each curriculum orientation. Part One of my study will then conclude with a brief description of my classroom. Such a description will provide a picture of the context within which these curricular orientations takes place.

## **Part One**

**The nature of science in schools: curriculum orientations for the teaching and learning of science.**

**Science as a school subject: *school science*.**

*School science* is an historical and curricular response for the need to have students, at all levels, exposed to some scientific knowledge. The practice of *school science* is essentially understood as the practice of the requirements of a clearly defined and mandated core curriculum. Furthermore, I would argue, that when dealing with science as a school subject, *school science*, we are dealing with an understanding of science essentially distanced from science as practised by the majority of scientists within the scientific community. This is particularly true of elementary science. For the purposes of this study, therefore, *school science* is understood as being synonymous with the teaching of a prescribed core curriculum.

Arguments for the inclusion of science as a school subject have been long and extensive within both European and North American state/public schooling contexts (Shulman and Tamir, 1973; Layton, 1973; and Millar, 1985). In the past they occurred over the need to include Nature Studies. "Nature Study" in its original meaning included the environment of sun, soil and water which affect living things, as well as the living things themselves and some of the products we obtain from them. We can still recognise in many science curriculum and textbooks today vestiges of a scientific content not dissimilar to the "Nature Study" of the past. This is particularly true of environmental studies.

Similarly, science was originally defined as a fixed body of definitional knowledge ready to be transferred by rote learning. More recently, however, discussions on science as a *school subject*, have focussed upon scientific literacy, technology, conceptual knowledge, environmental studies

and the relevance of the traditional trio of physics, chemistry and biology.

Essential to each of these historical discussions and arguments is the fundamental recognition that *scientific knowledge*, however defined, is necessary to a child's education. Within both nineteenth and twentieth century industrial contexts, *scientific knowledge* has gained further legitimacy as society recognises the economic and intellectual importance of this knowledge. The Sputnik era and present concerns with school science reflecting micro-technology are present day examples of this phenomenon .

Within this orientation, therefore, an education at whatever level, is incomplete without some exposure to *scientific knowledge*. This is equally true of early educational concerns(K-3), when science content is often mistakenly viewed as secondary to other educational goals. In their review of official aims and goals of science the authors of Science Education in Canadian Schools (1984) concluded:

*Not surprisingly, perhaps, the aim most frequently encountered in guidelines at all levels was for students to learn something of the content of science. Clearly, in a science course, science content must be present. But often, especially at the early years, one hears the claim that the chief function of content is to act as a vehicle for other educational goals. Yet, as even a brief examination of many [Provincial] guidelines can demonstrate, the detailed arrangement of the science topics to be learned frequently occupies most of the document (p.74).*

From this recognition of the need for *scientific knowledge* there has been derived a wide variety of science curricula. In response to this fundamental principle the most recurrent and predominant debate has, in historical terms, been one between the methods of science and the content of science:

*The history of school science education is a recurrent cycle of periods in which the method of science has been strongly emphasised in curriculum rhetoric, interposed with periods when content features more preeminently. This pattern appears to be a very general one, crossing national boundaries (Millar and Driver, 1987, p.34).*

Such cycles are apparent within my own teaching experience and the scientific literature of my own shelves. In, An Approach to Primary Science (1969), I read:

*Essentially, then, primary science is not science in the understood sense of a logical development of arguments based on observation, classification, hypothesis, experiment and theory in the traditional way. It is rather the accumulation of experiences tending to the formation of scientific ideas (p.4).*

This, then, is an emphasis upon fundamental scientific ideas. In this example the authors argue that the physical world is best understood through key scientific concepts, in particular four: energy, structure, change and life. Not that these be taught, necessarily. These key concepts act as guidelines and enable teachers to manipulate the science curriculum and thus "react with scientific integrity" (p. 4). The emphasis is upon teacher knowledge and its ability to flexibly construct a curriculum based on the children's interests.

In, Nature Study and Science ( 1981), I read:

*On the contrary, the aim is to offer a wide range of subject matter and methods, from which teachers can choose what appeals to them and what seems suitable and interesting for their class (p.1).*

Here, the emphasis is not only upon a wide range of *content* but upon *methodology* which, in this example, may be broadly defined under the processes or methods of science.

Most curricula and documents pertaining to science as a *school subject* have, as their starting points, the recognition that *scientific knowledge* , however defined, is a necessary component of any science curriculum. Within a Canadian context this recognition of science as a school subject and the fundamental principle of *scientific knowledge* has led, in elementary school terms, to a consensual core curriculum in science (Ch.V: Science Education in Canadian Schools (1984) ). Four categories of aims appear in all guidelines among all provinces and territories: science content, scientific skills and processes, personal growth and science related attitudes. The present Alberta Elementary Science Curriculum (1983) is representative of this consensual core curriculum in its:

- (1) general objectives(p. 2)
- (2) its outlining of desirable characteristics(p.3)
- (3) its emphasis upon process skills(pgs.4-6; 67-95)
- (4) the prescribing of specific content in its Program of Studies(pgs.19-43).

This consensual and common core curriculum is a response, in many respects, to the historical debates concerning the treatment of *scientific knowledge* within the school subject, science. In as

pragmatic a manner as possible, present core curricula, while emphasising the processes or methods of science, attempt also to satisfy the developmental needs of children, promote scientific attitudes and present scientific content. The pragmatism of a core curriculum in science may be represented thus: all children should have the opportunity to gain basic ideas that lay a foundation for a gradually more sophisticated understanding of the world. These basic ideas are derived from what is recognised as not only helpful to a scientist but also of benefit for those who wish to become scientifically literate. These basic ideas recognise the need to give teachers who are non-scientists support and engagement in activities that will give success to the student. If we recognise that scientific knowledge is necessary to a child's education we must not leave this to chance. As Harlen(1978) argues:

*Core content means a set of ideas, generalisations and facts which children could encounter.....Among the many ideas which children could encounter there are some that they should encounter (p. 621).*

Thus, the basic ideas should be:

- (1) within the grasp of children at their cognitive level of development.
- (2) ones which are found in action and help the understanding of everyday phenomena.
- (3) attainable through simple investigation using simple equipment.
- (4) ones which form a basis for further science education.

Although considerable emphasis is placed upon the fostering of process skills(to be discussed later) and attitude, the fundamental assumption of a prescribed curriculum is that in order to encourage development of these skills and attitudes it is more effective to work on some kinds of problems than on others, and to use structured materials rather than unstructured ones.

Furthermore a core curriculum provides a basis from which a non-specialist may work.

There are, of course, arguments in opposition to a core science curriculum. Briefly, these arguments are as follows:

- (1) the aims of elementary science cannot be achieved if children are constrained to work on particular problems or investigate phenomena in a given way.
- (2) since scientific concepts and theories change, fixed content may quickly become redundant. (This particular argument is more applicable to junior and senior high than elementary.) It is more important to learn how to learn. This would imply support for the processes of science over content.
- (3) core curricula, can be inflexible, and discount regional and local environmental variations as well as cultural ones.
- (4) core curricula militate against integration, and emphasise the segmentation of knowledge.
- (5) the motivation for learning and developing concepts is very strong when children are working on what interests them, and it will not be the case that all are interested in the content chosen by someone else.

Although considerable emphasis is placed upon the fostering of process skills and attitude, the fundamental assumptions of a prescribed core curriculum are to equally encourage and develop scientific knowledge.

School science, therefore, is essentially an historical and curricular response to the need to have students at all levels exposed to some scientific knowledge. This is necessary for intellectual and



economic well-being within both developed and developing nations. How this scientific knowledge should be defined and understood within instructional and curricular terms has created a wide variety of debate and response within the history of science education. One such fundamental debate has been between the content of science and the method of science. Core curriculums have traditionally recognised both although reserving an emphasis for one or the other. Within the present Canadian, and more particularly the Albertan context, the emphasis is upon both scientific method and content. *School science* is best understood, therefore, within core or prescribed curricular terms. How I respond to and manipulate the goals and aims of a core curriculum, is one way in which I can begin to gain insight into the teaching of science as *school science*.

### **Science as Process**

*The most significant feature of curriculum development in science during the past twenty years has been the move away from the teaching of science as a body of knowledge towards the experience of science as a method of generating and validating such knowledge. Science teachers have been encouraged to provide courses which exemplify scientific method and which put the pupil in the position of 'being a scientist'. This entirely laudable intention does, however, carry with it the assumption that scientific method can be fairly easily characterised and taught. A consideration of the extensive literature in the philosophy of science reveals that such an assumption cannot be sustained (Hodson , 1985, p. 34).*

*The inquiry processes of science have been analysed in terms of the skills that a scientist exhibits when engaged in scientific enquiry. Because of this, many science educators have become preoccupied with helping students develop these process skills-observing, classifying, hypothesising, and so on . Although these skills are worthwhile, two caveats are in order. First, some educators tend to forget that scientists use these skills in solving real*

*problems of which they possess considerable background understanding and not in a substantive vacuum. Scientific observation, for example, has as much to do with what is in the observer's head as with what is done with the eyes. Second, science is not unique among the disciplines that use rational arguments and critical thinking, and therefore science education cannot be an exclusive vehicle for the development of these skills. Although science should play an important role in a student's general education, it must play this role in harmony with education in the arts and humanities (Report#36, Science Council of Canada: Science for every student: Educating Canadian students for tomorrow's world, p. 17).*

An emphasis upon the teaching and learning of the processes of science has been a dominant feature of school science for the last twenty-five years. Originating in the work of Gagne (1963 and 1970) these processes are described as: observing, classifying, describing, communicating, measuring, recognising and using spatial relations; drawing conclusions, making operational definitions, formulating hypotheses, controlling variables, interpreting data, and experimenting. These processes, which are hierarchically organised from the *simple* (e.g. observing) to the *complex* (e.g. experimenting), are further organised on the assumption that upper level processes are dependent on the ability to use the *simpler* lower level processes. Furthermore, proponents of this particular curriculum orientation insist that these processes of science have three additional merits:

- (1) each process is a specific intellectual skill used by all scientists and applicable to understanding any phenomena
- (2) each process is an identifiable behaviour of scientists that can be learned by students
- (3) the processes are transferable (generalisable) across content domains and contribute to rational thinking in everyday affairs.

The present Alberta Elementary Science Curriculum (1983) is reflective of this orientation of science as a process (pgs. 67-95).

Unfortunately, the *science as process* curriculum orientation is, despite its widespread use, considerably flawed in its assumptions about the nature of science. Essentially, this view of science is a very simplified and highly reductionist view of the nature and operation of science. Finley (1983), Hodson (1985) and Millar and Driver (1987) in extensive examinations of the processes of science argue that while some generalisable processes *may* be identified, they cannot be definitively organised such that they:

- 1) accurately reflect how scientists work
- 2) necessarily describe how children learn science
- 3) necessarily describe instructional methods by which science can be taught.

All four authors, quoting from the history and philosophy of science, conclude that the learning and teaching of science cannot be encapsulated within a linear hierarchy, such that learning begins first, with observing and ends with experimenting.

Finley, identifying the historical origins of this curriculum orientation within a philosophical commitment to empiricism and inductivism concludes:

*There are several implications for science education if science is viewed in this alternative light [i.e. science is conceptually driven- science is hypothetically deductive rather than inductive ]. First, science educators must recognise that conceptual knowledge drives the science processes and does not result from them. Second, the science processes are likely to be context bound. The processes will be different from discipline to discipline and different even within a discipline when different conceptual aspects of the discipline are in use. In short, it is unlikely that there will be content-free intellectual skills that are generalisable across multiple enquiries. Third, if science educators are to understand better the nature of science processes, the relationship between content and process must be understood...Without such representations science educators run the risk of*

*presenting the process aspect of science inaccurately to our students (p.53).*

Hodson (1985) identifies the origins of *science as process* within the historical context of the late sixties and early seventies. The major impetus of this period was "the fusion of inductivist ideas about scientific method with progressive child-centred views of education"(p.40). This was both a European and North American phenomena. Such a fusion of ideas has led, according to Hodson, to ambiguity in understanding and a misrepresentation of the nature of science. Hodson suggests, in his analysis of the scientific method(pgs.34-45) that:

*How to teach science is not a scientific question and neither science nor philosophy of science can give us infallible guidance on how to proceed. Scientific theory does not contain within it a means of teaching and learning science, nor does scientific method represent a significant means of acquiring scientific knowledge (except for those involved in scientific research). The patterns and structures of science do not constitute "well tried learning mechanisms", as Ramsey (1975) alleges. Adoption of learning methods based on a model of science is not a logical requirement of a commitment to acquaint pupils with an understanding of the methods and procedures of science. To make such an assumption is to confuse aims with methods. Not all learning experiences should attempt to mimic scientific method. It is absurd to suggest that the quite separate aims of understanding the procedures of science and learning scientific knowledge require the learner to be put in a situation where he has to learn the content through the method(p.41).*

Millar and Driver (1987) conclude similarly in their reviews of the history and philosophy of science that :

*whilst we might not wish to deny that scientists have characteristic ways of working, and of reporting their results, we would argue that there is no*

*warrant for portraying the "scientific method" as a series of specific stages, or as anything which remotely approaches an algorithm or a set of rules of procedure(p.41).*

Millar and Driver's central concern with *science as process* is its assumption that it can be taught. Arguing, from within contemporary constructivist views of learning, Millar and Driver suggest that learning is primarily "an active process in which the learner brings prior sets of ideas, schemes or internal mental representations to any interaction with the environment"(p.45). Within such a perspective, *context* plays a significant role in the formation of knowledge. Furthermore, this knowledge is dependent more upon particular bodies of knowledge than the application of generalisable reasoning skills. The organisation of knowledge is not primarily around *processes*. They conclude:

*To organise instruction, therefore, around activities such as observing, inferring, controlling variables, etc.(where the domain of activities may range from butterflies to clouds. from crime detection to card games) may make it more difficult to make links between experiences which would be meaningful to them(p.53).*

To be critical of *science as process* is not, however, to return to didactic approaches to learning. *Science as process*, while being optimistic in its general applicability to learning and teaching science, does recognise the active participation of the learner. It does, however, suggest that knowledge is objective and revealed; and theories absolute. Knowledge can be equally viewed as personally and socially constructed; and theories provisional. Just how I understood such an orientation in practice will be examined in Part Two.

### **Science and "Language across the curriculum"**

*Talking, writing and learning are the instruments by which pupils come to understand all school subjects, and every teacher should concern himself with pupils' progress in language abilities. Concepts of relevance are narrower in lessons other than English. Pupils must learn the appropriate ways to organise, use and articulate information. However, a child's concept of what constitutes a subject, what chemistry or history is about, develops only gradually. Pupils cannot take over complicated systems of thinking and writing outright. Those who appear to have done so are often found to have acquired only a superficial understanding. To say that the basic concepts of a subject must be acquired before we can become active in our learning is to misunderstand the process. The activeness of learning from the earliest stages is stressed in Piaget's well-known model. The learner accommodates his existing framework to take in new information while at the same time assimilating and modifying this new information to make it digestible. If an idea or piece of information is quite unlike anything which he has previously encountered he will need some help in understanding it. The teacher must act as a mediator between pupil and information. 'Starting from where the pupil is' has become a tiresome cliché, but where else can we sensibly begin? (Schools Council Working Paper 59, p.217).*

Language across the curriculum (LAC) is primarily concerned with the problem of bridging the gap between school and learner, either linguistically or epistemologically. Barnes (1976) has described this gap as one between "school knowledge" and "action knowledge". Vygotsky (1962), in respect of conceptual understanding, describes it as the gap between "spontaneous concepts " and "scientific concepts". These definitions are not presented as dichotomies, but represent a continuum along which students make an educational journey. The questions of conceptual understanding and the difficulty of accommodating prior knowledge are intimately related to the role of language in instruction and thought. As Rorty (1982) writes:

*If there is one thing we have learned about concepts in recent decades, it is that to have a concept is to be able to use a language, and that languages are created rather than discovered(p.222).*

Research, in LAC, suggests that both linguistically and conceptually this is not an easy journey; neither is it necessarily one that all students will make or should make. It is through the work of Barnes (1976), Britton (1970)) and Vygotsky(1962) that the relationship between school subjects, especially science and language and learning has most fully been examined.(See Appendix(2) for detailed analysis of Barnes' and Vygotsky's theories).

What then is Language- across- the -Curriculum? First, it is not about "*grammar across the curriculum*" nor about "*making spelling count*" in essays and stories. It is not a program to reinforce standard English, nor is it about "*formatting across the curriculum*" : mastering the conventions and genres of specialist subjects. It is about the value of writing and talking to enable the discovery of knowledge. Barnes', in an interview with the English Quarterly (1980), prefers "language for learning" or "talking for learning" and "writing for learning", partly to get across the idea that we are not merely concerned with the development of language, but also with the language of subject specialists outside of English while acknowledging the fact that what they are interested in is learning science, math or geography. As Knoblauch and Brannon (1983) have written:

*Presumably what any classroom seeks to nurture is intellectual conversation, leading to enhanced powers of discernment. Since writing enables both learning and conversation, manifesting and enlarging the capacity to discover connections, it should be a resource that all teachers in*

*all disciplines can rely on to achieve their purpose (p.473).*

While no definitive history or work has been written to define LAC, certain fundamental principles can be identified. Fillion (1983) identifies three basic tenets:

*Three basic tenets of language across the curriculum are that language develops primarily through its purposeful use, that learning involves and occurs through talking and writing, and that language use contributes to cognitive development (p.703).*

Thaiss (1986), in an N.C.T.E. publication, also emphasises three basic tenets by suggesting that the theoretical and philosophical heritage of the last twenty-five years suggests three consequences for all classrooms.

First, "children will understand, and thus remember only what they have the opportunity to talk about ( and perhaps write about, sing about, draw about, make plays etc.)"(p.6). Second, children "can learn to read and listen beyond mere word recognition only if they regularly practice expressing their own meanings in speech and writing to themselves and others"(p.8). Third, children "learn only if knowledge is defined in action as a dialogue, or conversation between teacher and student, student and student, student and the text, and student and the world"(p.11). The making of all classrooms as "language-rich" environments is, therefore, a primary goal of LAC.



## INTEGRATION

*Teachers often claim that science is "integrated" into other class activities. In some cases, this approach involves using themes from reading textbooks, about pets for example, in order to get scientific information across to the children. The idea of "integration" is so vague, however, that it can only be determined by close classroom observation and by interviews with teachers who say they use this method.....Today "integration" stands more for an ideal of an interdisciplinary approach than a truly practical and applicable solution. Council believes that, in the short term at least, specific attention should be paid to science as such and that it should be offered to all students in elementary schools ( Report#36 Science for every student: Science Council of Canada. April, 1984, p. 36).*

*Whatever we think of Richard Pring's idea [Curriculum Integration, 1971], he is certainly right when he says that we fall too easily into thinking that 'Integration= Good, subject- based study =Bad (Haigh,1975, p. 90).*

If there is one curricular orientation that is particularly difficult to understand it is that of "integration". The difficulty is directly related to the terms widespread use in official curriculum documents and varied educational literature. Frequency of use does not necessarily equate with a consensus of understanding. The popular use of the term, "integration", has created on one hand vagueness of meaning, while on the other an immunity from definition which borders on the sacrosanct . Understanding just precisely *what* "integration" means and implies within curricular and instructional terms is not easy.

Certainly, the term "integration" carries with it the connotation of a desire for connectedness. On

this point there *is* a consensus within the literature. (The concept emerged at the end of the nineteenth century under the term "correlation"). However, *what* is to be connected and *how*, creates the diversity of meanings. I would propose that apart from the connotation of connectedness, there exists no one single definition of "integration". From my own reading and struggles with understanding the term I have derived, for the present, a personally pragmatic solution to the terms meaning. This *solution* is derived from the terms historical origins. From within this historical context I perceive two ways of broadly understanding "integration":

- 1) "integration" within traditional subject boundaries
- 2) cross-curricular or interdisciplinary approaches to "integration".

First, some definitions.

#### Integration within traditional subject boundaries.

Within this understanding of "integration" the integrity of traditional school subjects is retained. What is being taught and planned for clearly fits within traditionally recognised subject boundaries. However, there is the recognition within these traditional subject boundaries, of the need to "*integrate*" two fundamental educational ideas. First, ways of learning other than rote memorisation and recitation. Second, a desire to describe and understand the concepts of any subject by exploration within meaningful and relevant contexts. In this sense, "integration" represents a shift away from the traditional approaches to learning often associated with traditional subject boundaries. Shulman and Tamir (1973), quoting Klopfer (1971), illustrate this point:

*.....the traditional science courses concentrate upon knowledge of scientific facts, laws, theories, and traditional applications, while the newer courses put emphasis on the nature, structure, and unity of science and the processes of scientific inquiry. The traditional programs attempt to cover a*

*great number of topics, while modern programs prefer depth to breadth. The traditional courses are taught largely by the lecture and recitation method and see confirmation in laboratory exercises which are not essential to the course, whereas the modern programs employ discovery investigations as the basis of course development (p.565).*

"Integration", in this sense, is an attempt to make the integrity of the subject's content sensible to the learner without throwing away the worth of this subject's traditionally derived content knowledge. This is a conservative interpretation of the term "integration". The conservatism of this view represents an historical compromise, I believe, between the erosion of traditional subject barriers and the traditional debate, specifically within science education, concerning the balance between content and method.

**"Integration" as: cross-curricular integration or inter-disciplinary approaches.**

This is the logical extension of "integration" within traditional subject boundaries. The fundamental concept of *connectedness* is extended. Within this definition, the nature of knowledge is understood as being inter-related in a multiplicity of ways. Many common elements in terms of content, concepts and skills exist within traditional subject barriers. These common elements encourage the development of themes which develop traditional curricular goals within meaningful and relevant contexts. Themes such as "Pollution" and "Hunger" could integrate genuine scientific content alongside the development of discussions in terms of economic and political questions, for example.

Each of these definitions is derived from educational concerns that dominated the sixties and seventies. These concerns gave precedence to particular views of knowledge and learning. Within

the educational sixties and seventies, both in Canada and Britain, there arose two opposing views concerning the role and nature of education. The first view was represented by those who were satisfied with the traditionally compartmentalised curriculum that invaded all levels of education. The second view was represented by those who perceived only elitism, selection, lack of relevance and inappropriateness in this traditional curriculum. Two clearly opposed ideologies competed for official curriculum attention. The debates were not merely political and sociological they were also deeply concerned with the nature of knowledge and the psychology of learning. These debates, in particular, had considerable impact upon science education.

The traditional view for retaining a compartmentalised curriculum is best represented by the philosophy of Professor Paul Hirst. Hirst argued in Liberal Education and the Nature of Knowledge (1973) that the heterogeneous nature of knowledge has six distinct "Forms of Knowledge". These are: mathematics, physical sciences, human sciences and history, literature and the fine arts, morals, religion and philosophy. It is not Hirst's contention that these "Forms of Knowledge" correspond exactly with traditional school subjects. Nevertheless, his views can be taken to support the need for subject-centred learning. Hirst believes that every child must be initiated into each one of these forms of knowledge. By forms, Hirst referred to the idea of traditional Platonic universals. To deny this, argues Hirst, leads to a curriculum that is comprised of what is most convenient and unexceptional. Hirst writes of "a curious notion of the needs of the pupils in which other needs are of higher priority than the development of rationality and a perverted doctrine of the importance of a pupils present interests ". Essential to Hirst's argument is the notion that there *is* a worthwhile body of knowledge that it is our duty to introduce to children. It was against this notion of externally-determined knowledge that proponents of "integration" railed.

*The most dangerous [philosophy of the curriculum] starts from an inflated concept of knowledge . It is conceived as an almost mystical entity of permanent and universal value to mankind that exists in its own right like the life hereafter. As such it is a source of privilege and superiority- often described as excellence for its possessors ( Haigh, 1975,p.90 ).*

Proponents of "integration" looked for further theoretical support in their epistemology and psychology to the works of Jerome Bruner, Joseph Schwab and Language -across- the - Curriculum theorists (LAC).

Jerome Bruner in The Process of Education(1960) provided psychological insights into the nature of subjects and their content, and the relationship of the learner to these insights. Bruner's provocative proposition that "the foundations of any subject may be taught to anybody at any age in some form", challenged the hierarchical and sequential nature of traditional subject barriers. Furthermore, Bruner's focus on the processes of learning challenged traditional instructional methodology by emphasising ideas such as readiness, discovery and intuition.

Schwab's contribution was to further diminish the superiority of traditional subjects by analysing their *substantive* and *syntactic* structures. Put crudely, these referred to the conceptual structure of a subject and the processes of inquiry by which these concepts were attained. Neither, according to Schwab, was independent of the other but inter-related in different ways for different subjects. The work of Joseph Schwab over an extensive period of twenty years in the sixties and seventies, contributed significantly to many educators' understanding of the nature of traditional subjects, especially science. Within a North American context Schwab's work contributed to numerous State and National integrated science approaches.

Finally, the Language-across-the-Curriculum movement emphasised the close relationship between language and learning. This fundamental underlying principle was uniform to all subjects and their content. This provided the key for the development of many inter-disciplinary and thematic approaches to curriculum development.

However, the arguments for "integration" were not only epistemological and psychological, they were also pragmatic. At the time of these debates children were staying at school longer, the validity of traditional selective measures: national exams, departmentals and standardised testing was being eroded. In the search for a meaningful curriculum, proponents of a traditional curriculum became attracted to the connectedness and relevance of "integration". Adherents of "integration" placed enough pressure on subject centred curriculums to modify their positions. New "studies" such as environmental studies were placing yet further pressure on notions of fixed subject barriers, especially in relation to science. Studying the environment scientifically meant using a wide variety of concepts from different sciences.

This is obviously a broad and simplified summary of events. However, the sixties and seventies witnessed both the erosion of traditional subject boundaries as well as the nature of those subjects themselves. The desire for "integration" within these subjects is a measure of this change. Although there would be many who would argue, by *definition*, that this is not "integration" at all! Alberta curriculums, for example, are still organised under broad traditional subject headings but within each there are regular references to "integration".

As a curriculum orientation "integration" is difficult to define. I have proposed that, essentially,

"integration" be viewed as a movement away from isolated content and skills specific to traditional subject boundaries. However, this can be interpreted very conservatively or very liberally. The view of "integration" being offered here is that of a sliding scale that ranges from high to low. At its lowest, it conforms to *"integration" within traditional subject barriers* . A liberal interpretation conforms with *"integration" as a cross-curricular or inter-disciplinary approach* . If the sliding scale were extended beyond a liberal interpretation one may have a curriculum which is *total "integration"*. That is, the desire to educate always under broad themes with instructional practices that encourage genuine choices and student negotiation of the curriculum agenda. Such a notion is, I believe, idealistic although often hoped for, especially within an elementary setting.

### **Child Science**

Research within the last ten years suggests children, prior to teaching, have specific ideas of fundamental concepts in the areas of physics, chemistry and biology. Research further suggests that these prior ideas, beliefs and knowledge, have an important influence upon learning, and that children possibly influence their own learning beyond our previous expectations. A child's view is often different to a scientist's view and is frequently not well known by teachers.

The wealth of individual pieces of research is such that there is now available a number of documents that review these findings ( Driver and Erickson 1983; Driver, Guesne and Tiberghien 1985; Gilbert and Watts 1983; Helm and Novak 1984 ). These individual pieces of research have investigated how children acquire their ideas and how children's existing ideas can be changed or modified in a wide variety of contexts (Hewson 1980,1981; Posner,Strike, Hewson and Gertzog, 1982; Hewson and Hewson, 1984; Cosgrove and Osborne 1985). These studies have revealed numerous examples of "children's science". They permit teachers to anticipate in the teaching of

science concepts a wide variety of views and explanations concerning natural and everyday phenomena. The interest is such that there now exist a large number of research studies in "children's science" in many countries: New Zealand, Britain, Australia, France, Sweden and the United States. Furthermore, this interest in children's prior ideas, knowledge and beliefs is reflected in conferences and seminars world wide (Achenhold, Driver, Orton, and Wood-Robinson 1980; Sutton and West 1982).

The children's conceptions have been designated in studies in various ways. The terms 'misconceptions' and 'children's science' now being broad headings for: "alternative frameworks" (Driver, 1983), "novice science" (Carey, 1986), "spontaneous concepts" (Viennot, 1979) and "mini-theories" (Claxton, 1984). Fundamental to each category is the idea that children's conceptions are the result of thinking and trying to understand the world around them, rather than conceptions that are wrong or misconceived. It is not the purpose of these studies to either denigrate the ingenious efforts of students to make sense of what they are struggling to learn or the teachers' efforts to teach science.

Much of the research cited is developed within a tradition of constructivist psychology. Driver and Erickson (1983) suggest that amongst science educators and researchers interested in children's ideas there is a strong commitment to some form of constructivist psychology. This tradition rests on the view that a learner's existing ideas are all-important in responding to, and understanding stimuli. The learner makes sense of experiences by actively constructing meaning (Magoon 1977, Pope, Watts, and Gilbert 1983). Osborne and Wittrock (1985) identify the writings of Piaget as a major influence on the constructivist tradition. West and Pines (1984) also cite the importance of Piaget, specifically, his interview techniques and ideas about assimilation and accommodation.



The prior ideas, the alternative frameworks of pupils, offer plausible conceptions of events. However, many science curricula do not recognise a pluralistic view of science (Driver 1983, p.83). This, possibly, leads to many students being "turned-off" science because of this perceived gap between the content of the science lessons and their own world views. Therefore, before we can proceed with formal conceptual instruction, students must be given opportunity to demonstrate in meaningful ways their "spontaneous concepts", "action knowledge" and "beliefs", before being guided towards the formal knowledge and language of the specialist teacher. As Driver(1982) explains:

*In fact learning the accepted conceptualisations in school may place pupils in a parallel position to scientists who have to undergo a paradigm shift in their thinking. We are optimistic or unrealistic if we think we can program it to happen at the time in the order and at the rate which our teaching takes place(p.361).*

For significant and meaningful conceptual development to take place, child science researchers would emphasise the need for students to take a significant part in the formulation of their knowledge. However, the students' ability to play an active part in the formulation of knowledge is partly controlled by the intentions, beliefs, spontaneous concepts, and expectations which they bring to lessons, and partly by the patterns of communication set up by the teacher. If we wish to resolve the conflict between the teacher's desire to develop a specialist vocabulary and knowledge and the personal experiences and language of the student, we need to recognise where the child is, and secondly we need to examine how best we may work from, and within that knowledge.

Everyday language and communication experiences enable children from an early age to be scientists of a sort (Kelly 1963).

*Experience is made up of the successive construing of events...It is not what happens around him that makes a man's experiences, it is the successive construing and reconstructing of what happens(p.18).*

That is, like scientists, children gather facts and build models to explain known facts and make predictions. However, these "everyday experiences" have difficulty in accommodating the abstract reasoning which scientists are capable of. Nor are these everyday explanations neatly organised within theoretical models.

*With their limited experience and concerns for a specific explanation only, children can latch on to any one of a number of possible explanations which are reasonable from their restricted outlook (Osborne,Bell and Gilbert 1983; p.2).*

A growing body of literature exists that suggests children bring to formal instructional situations in science prior ideas, beliefs and knowledge different from those of school science. The literature further suggests these prior ideas are applicable to a broad range of school age children. Of growing concern and interest to science educators and researchers alike is the enduring nature of these prior ideas and beliefs (Gunstone,Champagne and Klopfer,1981; Posner,Strike,Hewson and Gertzoz, 1982; Nassbaum and Novak, 1976). Carey (1986) remarks: "We cannot effect scientific understanding without grasping the depth and tenacity of the student's preexisting knowledge"(p.1127). While Andersson(1986) in a study of pupil's explanations of some aspect of chemical reactions concludes:

*We know very little about how pupils function when placed in*

*learning situations in which attempts are made to encourage them to give up their spontaneous, everyday ideas in favour of an atomic conception whose potential for further understanding and inquiry is very great. It is probably not possible to achieve quick and facile results (p.562).*

Children cannot discover all scientific knowledge for themselves, nor can they be given scientific knowledge as though they were empty vessels waiting to be filled. New knowledge has to be firmly anchored to existing knowledge. Thus, it is important for teachers to recognise the differences between real science and children's intuitive views of the world.

I have, so far, examined a variety of curriculum orientations concerning the teaching and learning of science. I do not suggest that these orientations be viewed as a definitive review of science curricula. They represent, rather, my present knowledge of ways in which science teaching and learning can be understood. How these orientations affect my classroom practices is the subject of Part Two. However, before proceeding to Part Two it is appropriate, I feel, to offer a brief description of the kind of classroom in which these orientations operate.

### **My classroom and its total program**

What follows is a brief description of my classroom. The purpose of such a description is to provide a *picture* of the context in which the teaching and learning of science takes place. Although I describe this context as a "Whole language" one, it is not my purpose to describe in detail what this implies. That would necessitate another study! The purpose of this *picture* is to highlight certain beliefs and values that influence the nature of my classroom environment. These

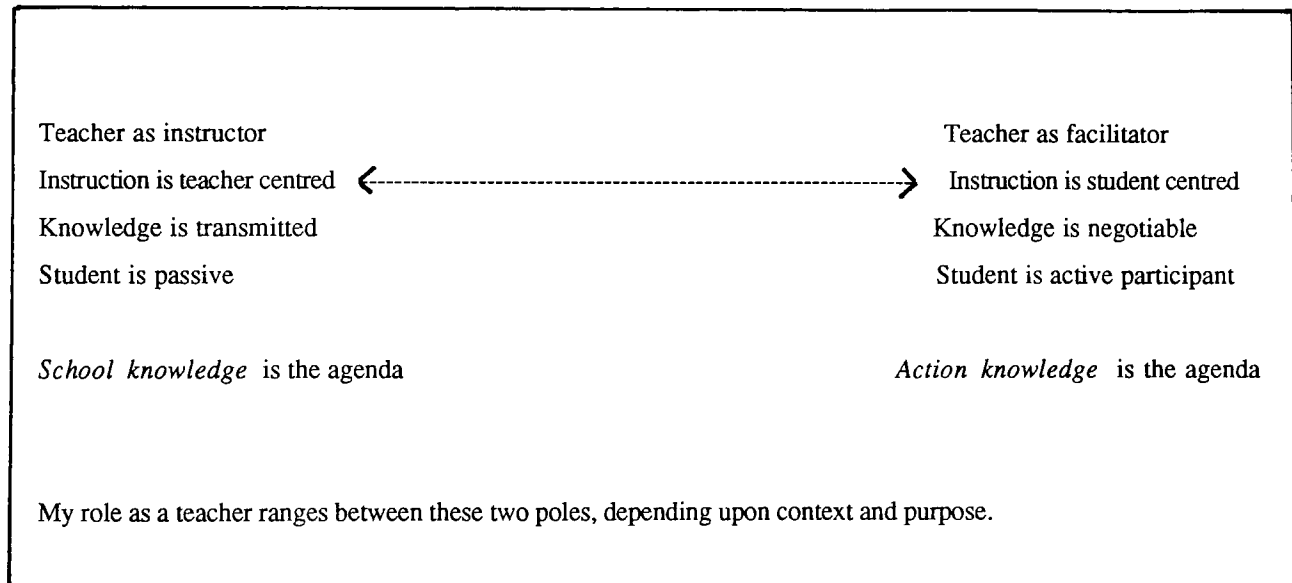
beliefs and values play an important role in how the curriculum, particularly the science curriculum, is understood in my classroom.

I believe my classroom to be a "Whole Language" classroom. That is, my instructional practices, classroom organisation and understanding of prescribed curricula is derived from a specific set of beliefs and values concerning children, language and learning. These beliefs and values form a set of fundamental guiding principles (Appendix 1). These guiding principles create a variety of learning conditions: an emphasis upon children immersing themselves in writing; numerous demonstrations (by both teacher and children) of how print is used and understood; an expectation that children can and should be "risk-takers", to *have a go* is acceptable; numerous opportunities to practice and develop learning in meaningful situations; and that engagements with and responses to the content of the learning is meaning-centred, non-threatening, functional and relevant to the children's needs and interests. I begin first, with a brief description of my classroom's organisation.

My classroom is a utilitarian rectangle of white breeze blocks. There is one door and one very small window. Two walls are covered by large bulletin boards, the other two by chalk boards. The floor is carpeted. The desks are arranged in groups of fours, threes, twos or ones. For this study, the arrangement accommodated twenty-five children. Children select their own groups and negotiate changes about every two months. A variety of bookshelves, single desks, round and hexagonal tables, cushions and easels are arranged to accommodate "learning centres" and to create *child spaces*. The arrangement of the furniture is such that children can move freely about the room as well as find a variety of work spaces. There is also enough room for small group work. My desk is allocated an inconspicuous corner as I rarely sit at it. It tends to become a *dumping*

*ground* for student work and other paraphernalia. My classroom often assumes a cluttered, workshop-like appearance with regular spillages into the carpeted hallway. Within this classroom environment a variety of instructional practices are used.

My choice of instructional practices are, I believe, determined by my desire to strike a balance between two important teacher roles: teacher as instructor and teacher as facilitator. This can be best described diagrammatically:



Consequently, the children are *taught* either in groups, individually or as a whole class. Flexible groupings and an acceptance and encouragement of individual choices and responses are as

apparent as homogeneous and carefully monitored instruction. The choice is dependent upon appropriateness and meaningfulness. Furthermore, teaching and learning are not always dependent upon me. I encourage and expect the children to act as peer models and supports in teaching and learning. A wide range of instructional practices, therefore, is experienced and encouraged within my class.

Finally, how do my beliefs and values determine my manipulation and understanding of the prescribed curriculum content as mandated within an Alberta context? In fulfilling the requirements of this curriculum I try, as far as possible, to operate within broad themes. The themes change approximately every three to four weeks. However, there are aspects of this curriculum that do not easily fit specific themes. For example, certain aspects of the social studies curriculum. When this occurs I choose to teach these aspects as discrete units of work. Although I strive, therefore, for an integrated approach within my classroom, it is not true to say that integration is apparent at all times. Given this brief, thumb-nail sketch of my classroom, what may a typical day look like?

### *A typical day*

My mornings are divided into two large blocks of time. The morning begins with the children gathered on the carpet around my reading/ author's chair. The first five minutes is devoted to functional activities such as: collecting milk money, attendance and notes etc. A further routine at this time is called "menu-for-the-day". This is when I briefly outline the day's events and activities. Following this the children listen to a story. I maintain a careful balance between reading fiction and non-fiction to the children. The story may also be one written by the children or one chosen by them. If it is selected by me the story will be related to the month's theme. Depending on the story, children are encouraged to respond orally to its content or illustrations.

Differences and similarities between this and other stories is also encouraged. Following "carpet time", the children are given approximately thirty to forty minutes free writing time. This period may also be a specific teaching time when a particular skill or problem is examined. During this writing period children choose and explore topics of their own choice. Children work wherever they wish desks, floor, corners or the hallway. They may also work individually or in pairs. My role at this time is to act as facilitator, audience, editor, policeman, etc. The children have access to a wide variety of paper and materials if they wish to publish their own books. This, then, typifies the first part of the morning.

After recess the children divide into three groups. The groups participate in activities under the broad headings of math, reading and writing and art. Groups are organised so that there is balance of girls and boys as well as abilities levels. The groups are rotated each morning. The composition of the groups is changed every theme. The group activities are connected with the class theme. For example, in the case of a theme on Giants, the following activities occurred:

Art group: plasticine models of whales, looking carefully at pictures and diagrams, painting of whales at the easel. Additional activities drawing and sketching of whales.

Math group: using concrete materials(Key Math Blocks) children build models that "grow" according to specific patterns(2's or 4's). Children choose a variety of whales and measure their lengths in the hallway using metre tape measures. Children complete block graphs of children's heights.

Reading and writing: children listen to taped story about a whale, read from a selection of whale books and begin preparing material for "*A giant book of giant things*".

Activities within the groups are selected to give a balance between those which are teacher directed and those which are student directed. For example, the initial art and reading/ writing group activities are self-directed ones. This allows me approximately ten to fifteen minutes with my math

group.

The afternoon is also divided into two parts. The afternoon begins with fifteen to twenty minutes quiet reading. Following this, the whole class will participate in either science, social studies or math. As far as possible, the content of these subjects will relate to the class theme. For example, during the Giant theme the class explored microbes as a contrast to exploring very large things. However, we also explored, at this time, Air as a separate science topic.

The second half of the afternoon is used in the following manner. A period of time is given for children to finish-off any incomplete work. This is an "open -period". The day is concluded by having the children either read examples of what they have written, discuss examples of work and review what they have done. I usually conclude with reading a story.

With this description of a *typical* day I conclude Part One. Within Part One I have described the study's origins and rationale. I have also outlined, briefly, a variety of curriculum orientations concerning the teaching and learning of science. These orientations reflect my own personal knowledge concerning science curricula. They are, therefore, more likely to influence the way I manipulate the science curriculum. In precisely what way these orientations manifest themselves or not in my classroom, is the subject of Part Two.



## **Part 2**

### **Examples from the classroom**

What follows are a variety of personal and selective vignettes which reflect on science events within my classroom. Selective is a key term for space dictates that from a wide amount of data I must exclude some material. I have drawn data from three topics: AIR, MAGNETS and GIANTS. An additional topic, that of "Incidental Science", is also examined. The topics have been selected because they represent science work that ranges from planned/teacher-centred work to unplanned/child centred work. They are, as far as is possible, representative of the variety of ways in which science is manipulated within my classroom. What I have tried to create is a narrative. I begin first at the beginning with how science, essentially, originates within my classroom.

Science occurs in two ways within my class. First, there are the teacher initiated science activities. These science activities and occasions are **planned** ones. Second, there are those activities which occur in an **unplanned** manner where the children initiate and determine the science to be explored. This does not imply that unplanned science cannot occur within planned science activities. As many examples within this section will later demonstrate, the course and direction of planned science activities often takes unexpected turns! However, there are events and activities which have a genuine scientific content and interest that do not easily fit within the definition of planned. For the purposes of this study I have termed *these* unplanned science activities *incidental science*. A full discussion of the nature of *incidental science* occurs later. I begin with an examination of **planned** science activities.

When planning for science, I emphasise three curricular orientations: *school science*, *child science* and *integrated science*. *School science* I have defined as "the practice of the requirements of a

clearly defined and mandated curriculum"(p.10). As such, it is concerned with the acquisition of scientific knowledge (*content*) and the application of the scientific method (*process science*). My planning of the science Unit "Air" reflects such an orientation in that Documents 1-5(Appendix 3) make clear references to both the Alberta Science Curriculum Guide(1983) and the accompanying Program of Studies. There is also an emphasis upon the acquisition of scientific concepts (Document #3: Appendix 3); the allocation of a specific time within the week for the teaching of this content and an emphasis upon teacher demonstrations, "experiments" and hands-on activities as the instructional method by which to acquire these concepts (Documents #'s 5,6 and 7(Appendix 3). The unit plan is highly structured- everything is defined and described. This is, initially, a teacher-centred operation.

*Child science*, which I have described as the way in which children's prior ideas, beliefs and knowledge affect formal instruction in science(p.27) is reflected in the planning of the Unit on Magnets. Document #8(Appendix 3) reflects an emphasis upon children's questions and interests. This is a less structured and open-ended approach to understanding scientific concepts and content. Instructionally, there is an emphasis upon group activities and flexible timing. My planning here, anticipates a student-centred focus.

*Integration* occurs within science units that are planned as discrete or separate units of study and within themes. When planning for integrated science activities within a discrete unit I am integrating "within traditional subject boundaries"(p.22). When planning integrated science activities within a theme I am integrating within " a cross-curricular or inter-disciplinary approach"(p.23). The exploration of lungs and breathing(p.57) is an example of integration "within traditional subject boundaries". An examination of the science within the theme "Giants"(p.60) is an example of a

"cross-curricular or inter-disciplinary approach".

These, then, are examples of ways in which science activities are planned for in my class. But what determines, if anything, whether I choose a separate topic or an integrated topic? My planning, I believe, reflects a variety of factors:

- 1) my classroom context and instructional approaches
- 2) local and external requirements
- 3) personal beliefs and experiences

For example, in planning the Unit on Air, I had a clearly specified series of concepts that I wished the students to learn and understand. In this example I quite genuinely believed that an ordered and sequential approach was the most appropriate one for encouraging children to acquire a scientific understanding of simple but important concepts concerning Air. Furthermore, the topic chosen and the instructional approach were a reflection of my specific classroom context. As I have previously described, my classroom reflects a "Whole Language" approach. That is, my classroom instructional practices, are guided by the application of specific guiding principles (Appendix 1). This approach is physically, intellectually and pedagogically demanding. I therefore plan within the day's activities for some class and teacher centred activities. I therefore selected this class-centred time for the Unit on Air.

Clearly, daily classroom constraints can determine particular instructional practices. For example, at the time of developing the Unit on Magnets, the children were involved in a specific language arts theme that reflected a more unified and structured instructional approach. I therefore felt able to be less structured and more flexible in my science focus. Coincidentally, the less structured approach had been enhanced, by the incidental introduction of a large magnet into the class, a week prior to the

theme's planned introduction. This had created a meaningful context for an already interesting subject. Children of all ages, I have found, retain an abiding interest and curiosity in understanding , manipulating, and experimenting with magnets.

Finally, there is planning that reflects local, external requirements. I am required, by my Deputy Superintendent, to submit at the beginning of the school year, long and short range plans of classroom activities. These plans *must* reflect the goals and aims of specified curricula. However, I personally find that these curricular requirements do not interfere with the actual organisational structure and running of my classroom. They are, essentially, forms of accountability.

What occurs as science then begins first with me the teacher. Furthermore, how my plans, beliefs and intentions are executed is determined, primarily, by the classroom context at any one given time. As a consequence, a variety of curriculum orientations is emphasised within my planning. How these plans, beliefs and intentions translate in practice will now be examined. What follows, are examples of **planned** science activities and a discussion of their relationship to particular orientations. I start with the Unit on Air.

I began the Unit on Air with a collection of items connected with air and air experiments. These included: a model kite, a toy boomerang, a paper airplane, a wind-up bird, a parachute, a balloon, a candle, a ping-pong ball, a tire, tissue paper, cups, anemometer, suction cups, plunger, plastic tubing, pictures of hot air balloons, lungs and fish, an air pump, straws and plastic bags. Each item, I told the children, had something to do with helping us understand some interesting things about Air. It would help us understand a little more about something that is all around us and that is

invisible: Air.

I began my first lesson by picking-up various objects and asking: "What has this got to do with Air?" If I was met with puzzled faces or silence I would do a simple demonstration with the object. For example, when I picked-up a jar and placed my hand over the mouth, I asked: "Is there anything in the jar?" Most responded that Air was *trapped* in the jar. Or, when picking-up a plastic bag and receiving no response, I moved it through the air quickly so that it expanded, I asked: "Why does it fill out?" Some children suggested that it was the wind, to which I replied: "What is wind?" The response that it was moving air seemed the majority opinion. Picking-up a candle I asked: "What has this to do with Air?". Some were not sure while others suggested that air helped a candle burn. I therefore lit the candle and placed a jar over it asking the children to predict what would happen and why. The conclusion was that it went out because "the candle used-up all the air". I suggested, that to burn things we needed to have air, and in particular, a special part of the air called oxygen. At this point some of the children made the connection between lack of air(oxygen) and putting out of fires. Many knew the phrase, "Stop, drop and roll". That a fire can be extinguished by smothering the flames.

Generally, students tried to make appropriate connections between the objects and their relationship to air. For example, one student, noticing the Kleenex and plastic cup, said he knew of an experiment with these two things. He explained that if you placed the tissue in the bottom of the cup and then turned the cup over and pushed it down into some water, the tissue would remain dry. I had him demonstrate this *trick* which many of the children were familiar with. I then asked why the Kleenex remained dry? The majority of explanations included the concept of trapping a bubble of air-it was this bubble that stopped the water getting in. I later encouraged all the children to complete

the experiment themselves. In addition, I explained, with various books and diagrams, that this idea of trapping air was first used in early diving bells. However, not all explanations and connections were as direct and relevant as this example. For example, one student, picking-up an anemometer and spinning the cups, suggested that if you placed magnets on each cup, each cup would try to catch the other and would, therefore, keep spinning. Which, if true, would demolish Newtonian Physics. However, the concept of applying some knowledge concerning magnets was implied within this explanation. Unfortunately, I did nothing to further explore this idea.

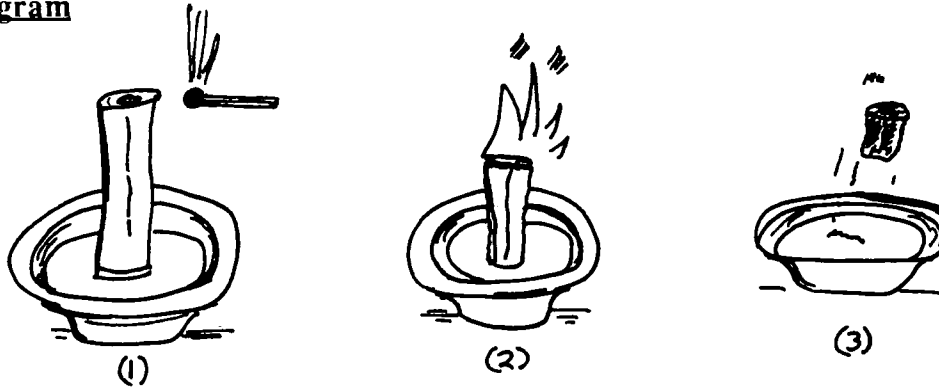
By beginning in this manner I was deriving, somewhat crudely, some information about the children's knowledge concerning Air. By the end of the introductory double period I felt that the children knew, or were aware of, the following:

- 1) Air was invisible and all around us.
- 2) Air can take up space.
- 3) Air is connected with breathing and burning.
- 4) Hot air rises.
- 5) Air can help things fly.

From this information, I began to organise a variety of experiments that would further extend their understanding as well as introduce new concepts e.g. air pressure. What follows, are two detailed examinations of experiments within the Unit on Air.

**Hot air rising: the case of the rising tissue paper experiment.**

**Diagram**



The correct (scientific) explanation: The tube causes a column of hot air to form inside the column. Since warm air rises, this column of superheated air will pull up the lightweight ash. Rising warm air is called a convection current. The "lifting power" of the small amount of hot air you have created is not very strong. That is why you have to use extremely lightweight paper.

The correct (teacher) explanation: Hot air is lighter than normal or cold air. Because it is lighter it will rise.

For a teacher, the concept of hot air rising is important in relation to explaining a variety of phenomena within a child's world: heating of homes, weather and hot air balloons- to name but a few. I knew, from discussions with the children, that they were familiar with the experiment of a tinfoil-spiral turning over a heated candle, the action of convection currents.

I decided, therefore, to try an experiment that I had found in a book called: "Bet You Can: Science Possibilities To Fool You." Before demonstrating it to the students I first made sure that it

worked! After considerable experimentation with size and type of tissue paper and, I might add, a lingering phosphorescent smell of spent matches, I achieved success! A blackened tube of tissue paper rose, Phoenix-like and dramatically, into the air! Very excited and pleased with my perseverance, I endeavoured to repeat the experiment. Unfortunately, I couldn't do it. (This is not the first time that suggestions in science books have failed to replicate themselves!) However, because I so enjoyed the final result I decided to risk it with my students.

I began the demonstration by telling my students that I had found a "really neat" experiment that showed how hot air rises, but that unfortunately, I had only been able to make it work once. I then proceeded to tell the students about where I had obtained the idea, and my numerous failed attempts at achieving the required result. My demonstration became a narrative, as I constantly folded and lit numerous tubes of tissue paper. Both the content and manner of presentation seemed to capture the students' interest for I persevered for approximately forty minutes before the final effect was achieved! Presumably my animated description of the final moment had created an audience's desire for the story's climax. For, throughout the demonstration, I was encouraged to constantly "Try it again". I was also encouraged to try a variety of things: different sizes and colour of paper; to light the tube at different points and to try more than one match. There were also appeals as to why it wasn't working, which encouraged yet further suggestions. I had, not only eager audience participation, but also eager applications of many aspects of the processes of science: hypothesising, collecting data and analysing. The narrative of events was also aided by an incident that mirrored, in a less dramatic manner, the final desired result.

Because of numerous unsuccessful attempts the demonstration table had become covered in the ash of numerous burnt tissue paper tubes. This ash was extremely light, and on one occasion the



stirred ash caught in the convection current of a lighted match. Quickly seizing upon the moment I *followed* the ash with the burning match. The children watched as the gossamer-grey fleck of ash rose upward. One student viewed this event as being similar to burnt paper rising above a fire. A second, to paper swirling around on a hot day. While a third, wondered if this was how hot air balloons worked? This mini-event and accompanying student comments seemed to sustain the desire for the narrative's climax. Finally, the desired result *was* replicated. And the effect was satisfying and dramatic, with numerous "Oohs" and "Ahs", similar to that accompanying an explosion of fireworks in the night sky. Jennifer happily concluded, "At least it worked once."

But, the *story* didn't end there. For many students it had only just begun. Lee wanted to know if he could use the same idea to enable himself to fly. "I could somehow build a fire under myself." Naive, obviously dangerous, but not dissimilar to the hoped for conquest of air predicted and imagined by 17th century balloonists. Paul wanted to place a fire in a glass jar and suspend, by string, a brown paper bag over the rising hot air. Michael wanted to use manila tag. Another student wanted to try steam as opposed to hot air. Having understood that hot air rises, these students looked for practical applications. However, as in many classroom stories, the predictions and hypotheses of the students' imaginations were to remain just as such, for we returned to our desks to look in our textbooks at similar and further examples of hot air rising. How quick is the desire within us to move from the exploratory to the expository (note Water, Candle and Jar Experiment.)

The narrative mode is an important means by which students can acquire and understand scientific concepts and knowledge. "Hot air rising" is an example of using the narrative mode in describing and explaining a scientific event. The demonstration was successful, I believe, precisely because it

was conveyed in the preferred mode of learning for young children, the narrative mode. Anecdote and story enable children to breakdown those barriers that exist between school knowledge and everyday language, as well as fact and fiction. Moffett (1968) makes precisely this point:

*"Whereas adults differentiate their thought into specialised kinds of discourse such as narrative, generalisation and theory, children must for a long time make narrative do for all. They alter themselves almost entirely through stories-real or invented- and they apprehend what others say through story (p.19)"*

This concept of *storying* is, personally, not new. However, the realisation of its importance in presenting teacher knowledge, is new. Previously I have only sensed intuitively its power and importance. For example, when describing the rudiments of the digestive system, I have told, graphically and dramatically, the journey of a MacDonald's hamburger from beginning to end! The suggestion, in all of this, is that for children science remains a story . That narrative approaches and presentations are as important as applications of concepts and the scientific method. As Wells(1986) suggests: "stories have a role in education that goes far beyond their contribution to the acquisition of literacy "(p.195). Wells concludes:

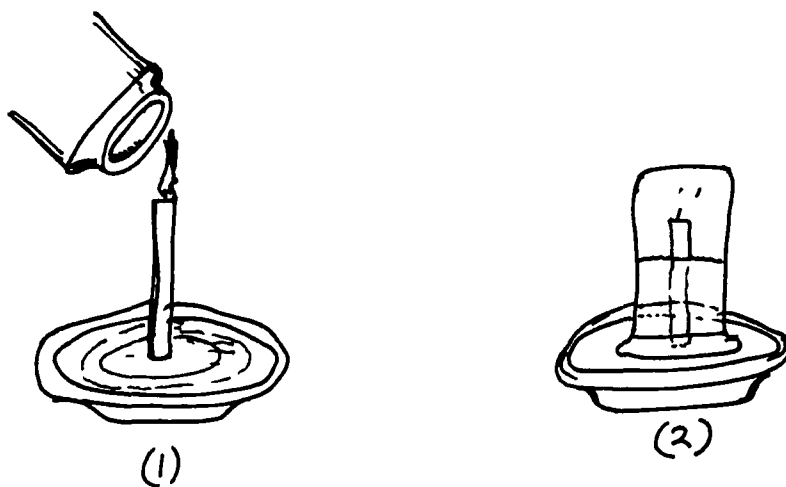
*When storying becomes overt and is given expression in words, the resulting stories are one of the most effective ways of making one's own interpretation of events and ideas available to others. Through the exchange of stories, therefore, teachers and students can share their understandings of a topic and bring their mental models of the world into closer alignment. In this sense, stories and storying are relevant in all areas of the curriculum (p.194).*

Should this be surprising? For science itself can be understood as a story of fact and fiction. The story of our Universe, from Ptolemy to Steven Hawkins, is just such a story. The nature of which has very little to do with curricular models or the scientific method. The scientific questions of our Universe are just as deeply entwined with culture, faith, religion and poetry, as with theories and the scientific method.

*What is geology but a vast story which geologists have been composing and revising throughout the existence of their subject.....How do we understand fetal development except as a fundamental story in which sperm and ovum triumph at the denouement of parturition. Every chemical reaction is a story compressed into the straitjacket of an equation. Every car speeds down the road by virtue of that well-known engineer's yarn called the Otto cycle (Rosen: quoted by Wells(1986), p.205).*

### THE WATER, CANDLE AND JAR EXPERIMENT

Diagram



A correct (scientific) explanation: The jar, when placed over the burning candle, traps a pocket of air. The oxygen in the air pocket can only sustain the burning candle for so long. When the candle stops burning an empty space, not a vacuum, is created within the upturned jar. This empty space

*lowers the air pressure within the jar. Air on the outside of the jar, which is at a higher pressure presses down on the water to fill the empty space and equalise the air pressure within the jar. Since the air is prevented from entering the jar by the water, the water is pressed-down to fill the empty space. Thus, a rising of water is noted within the jar.*

*A correct (teacher) explanation:* *A candle needs air to burn. When the candle goes out some of the air has been used up in the jar. There's an empty space in the jar. Air around the jar tries to fill the space but the water stops it, so the air presses on the water making it rise inside the jar.*

I introduced the above experiment for two reasons. First, it incorporated in its understanding three important scientific concepts previously discussed by the students: air presses; air fills spaces and air (oxygen) is required if something is to burn. Second, the experiment was an interesting and, I felt, exciting hands-on experience. I initially introduced the experiment as a classroom demonstration. Later, the students, in groups of four and five, repeated it themselves.

I began my demonstration by simply asking students to watch what happens and to tell me what they saw. At this stage I offered no explanation or suggestion of *what* was to happen, other than that the experiment would help us understand more about Air. I did not anticipate that the children would deductively derive from their previous conceptual knowledge the *correct* explanation but I fully intended that I would give a *correct* explanation, but only after a variety of observations, predictions and hypotheses had been given by the children through *exploratory talk* (Britton, 1970). The sense and direction of this *exploratory talk* would inform and influence the nature of the *correct* final explanation.

Classroom experience led me to anticipate a wide range of ideas about the content and nature of

what was under observation. I also knew, from *Child Science* research, that these initial and exploratory views would be both enduring and influential in relation to children's scientific understanding. For example, in a previous study of Grade 6 student's work on Electricity, *Words, Meanings and Concepts* (1986), I recorded and commented upon the following incident (pgs. 31-32):

**"Exchange#6**

*Students working on what is called a "Ferry"*

*A Ferry is a device that will carry an electric charge from one point to another. In this case, the "ferry" is a can standing on a piece of wax, next to another can, from which hangs, by a piece of cord, a thread on which is fixed a thumb-tack. A charge touching the can should cause the tack to move back and forth.*

*The student's had been experimenting with this device for sometime when I asked why the tack moved. This is one student's reply:*

*S. Well ... I think that maybe like water...it's conducting it.. it's conducting electricity through here... here like...this paraffin wax is a generator and the wood on it...comes up through here...be sort of like vibrating because of the vibrations coming from the electricity...and the paraffin wax is um...has sort of stuff...this stuff and that stuff connected will make an electric force...it's sort of making it go back and forth...and when it goes too close[ the tack to the tin]...it goes back.*

\*\*\*\*\*

The student is exploring, through his own language, an attempt to formulate reasons as to why the "Ferry" works. There is a recognition on his part of a possible number of causes and connections. What appears initially as perhaps meaningless is in fact a verbal rough-draft. As later class work followed, K. wrote a description of this experiment. The written response had greater clarity and supported an accurate diagram. The student has formulated knowledge from previous experiences: scientific concepts are being evolved from "*a mediated attitude towards its object*" (Vygotsky 1962). As Harlen(1986) further comments:

*"Such influences[ children's initial ideas ] can be readily seen in the different observations which children make of the same event. Consider, for example, a group of eight-year-olds who were asked by their teacher to watch carefully as two stones were put into two identical jars each half-full of water and to say what differences they noticed. The teacher hoped they would immediately mention the difference in the water levels in the two jars. Instead the children talked about the different sizes of bubbles rising, the change in colour of the stones, and how, after immersion, each looked to be different in size from before. What was most obvious to the teacher, and was there to be observed by the children , was not mentioned. The difference in water levels was a significant observation to the teacher, sharpened by her expectation, but the same expectation was not focusing the children's observations (pgs. 32-33)*

The problem of children's own ideas and observations being at variance with the teacher's is not a purely elementary-aged one. As Driver(1983) explains in relation to adolescent students:

*Such ideas are often readily suggested by pupils and it is not surprising that in many cases they do not correspond with the accepted answer. Within the limits of the pupil's experience the suggestion may be quite reasonable. Faced with a novel phenomenon, pupils are searching to find familiar events to which they can relate this new experience. They try to interpret the unfamiliar by analogy with familiar experiences(p.24).*

In both the demonstration and the group experiments the children did not focus upon the rising water but upon: the candle going out, condensation on the sides of the jar, smoke and the effects of lighting matches. I offered interested children explanations as to these observed events. So that, in the case of water forming on the inside of the jar, I reminded the children of previous

experiments and explanations concerning condensation and water in the air. Having, hopefully, satisfied these student observations, I then redirected their attention to the water rising in the jar, which *some* had observed alongside the other observations. After noting water level changes in small groups, unusual explanations and observations abounded:

*"The candle sucks up the water."(animism)*

*"Smoke gets underneath the water making it come up. When it hits the top it comes down."*

*"Like a pot, when water is in it and you put it on a fire and it gets really hot and starts bubbling and water in the jar starts rising."*

*"When candle goes out only little bits of air left and steam comes up when candle goes out and water rises."*

*"Fire pulls up the water."*

I did not consider these explanations as naive views or misconceptions of a scientifically immature mind but, rather, genuine attempts to explain, on the basis of experience, what was happening. For example, the idea of the water being "*sucked*" or "*pulled*" up, is a very accurate description of the manner in which the water rises in the jar after the candle has gone out. The water *does* appear to be "*sucked*" up, rather than pushed by the invisible air. What I did was give credence to their explanations. They were not summarily dismissed. In this, there is the belief (and it is a belief), that children may possibly engage in the correct explanation or at least eventually incorporate the correct explanation into their conceptual thinking. And, more importantly, be more inclined to risk an explanation or interpretation of events.

There were, however, attempts at correct explanations:

*"Little spaces, air trying to get in. Empty spaces [after candle has gone out] and air tries to push in."*

*"Air tries to get in . Air outside pushes water down."*

I repeated this experiment some five months later, curious to note any changes. I discovered that only a few children offered an explanation that accorded with the correct one. All remembered the experiment and what to do. Many also remembered that it was connected with our topic on Air. In the case of one student the connection between this experiment and evaporation was made again.

*"It's making heat ...I don't know...when there's heat the water evaporates... it rises.."*

The suggestion being, possibly, that evaporation serves as a suitable mechanism by which to explain the rising of water inside the jar. If this is true, then this is less a misconception and more an attempt to apply an acquired concept in a new situation. A similar application of a previously acquired concept is suggested in this child's answer:

*"Hot air rises..pushes up the jar... and the water comes in."*

The heat from the candle causing the jar to rise, and thus allowing water to pour in, is a plausible explanation. Furthermore, the response, *"Air is pushing to get the fire"*, suggests, in an abbreviated form, considerable similarity to the correct explanation, in that, outside air is trying to replace the space created by the burning of oxygen inside the jar.

On reflection, it would appear that I quite doggedly pursued this experiment as a way of somehow reviewing or bringing together a variety of concepts. For example, the children engaged in this particular experiment individually and in groups three times! The candle going out because of lack



of air and the remaining observations should, probably, have sufficed. Even with the knowledge, experience and study into children's scientific understanding and use of language, the "teacher" in me prevailed. While accepting *exploratory ideas* and *verbal rough drafts* I still persisted, in this incident, in trying to *make* the children understand *my* explanation! This is not unusual. Rosen(1984) records a similar example of "conventional pedagogic necessity."

A seven year-old child was describing a bird's nest he had found in the school grounds. The child concludes with a description of the recently hatched chicks:

*"...they all went down off each other and put their heads down ...so I couldn't see them except for their wings. They all had like stripes going down them.. and they are black, brown and white ...and they had little wings about this big.."*

Rosen records at this point the teacher's verbal intervention:

*T. How big's that?*

*Brain: Ooh about...em..don't know really.*

*T: Can you say how many inches?*

*B: I can't remember how big they were.*

*T: How many inches would that be?*

*B: Er about...about...on top of their head they had all fur sticking up.*

Rosen comments perceptively on this exchange thus:

*I chose this snippet of a transcript because I have indicated this is a classroom where children are given every encouragement to seize upon the spontaneous, where the sparse traditional tale is told and children read books not "readers". Yet in so favourable an atmosphere as this, a teacher positively talented at releasing the children's narrative competence, still has flowing in her veins the last dregs of conventional pedagogic necessity. "How many inches?" displaces her customary eager complicity (pgs. 18-19).*

The desire, therefore, to transfer knowledge is strong within teachers. It is not only a matter of bridging gaps between, as Barnes describes, *action knowledge* and *school knowledge*, through, amongst other things, *exploratory talk* and *verbal rough drafts*. But, also one of balancing the appropriateness of this curricular activity in the light of children's understanding.

*"In other words, to be able to use information obtained by others, to benefit from the reading of textbooks and other references, the individual must have a conceptual structure and a means of communication that enable him to interpret the information as though he had obtained it himself" (Science in the Schools: Scientific Literacy, 1983, p. 38)*

This experiment, therefore, is an example of the application of two curricular orientations: Language-across-the-Curriculum and Child Science. There is a sense, sometimes, that the acceptance of children's linguistic approximations and naive concepts, leads to a kind of teaching that is perhaps too tentative. The desire, however, to have children acquire knowledge at any cost is as equally strong. Rosen's example of "conventional pedagogic necessity" clearly illustrates this. The key, in applying in practice the principles of various curricular orientations is balance. Balance, between transferring content knowledge, while at the same time respecting the nature of

the learner to whom this knowledge is being transferred.

I will continue the examination of the Unit on Air by looking at various examples of integration within this unit.

### **Examples of "Integration" within the Unit on Air**

In the Unit on Air, a key objective was to have children acquire specific scientific knowledge about the air around them. This knowledge was primarily described within conceptual terms (Appendix 3). However, if the content webbing of this plan is reexamined( Document #1: Appendix 4), it will be seen that there are numerous opportunities for "integrating" other scientific knowledge. For example, I outline the possibility of examining such traditional branches of science as: aeronautics(FLIGHT); meteorology(WEATHER); physiology(BREATHING); biology(PLANTS and BREATHING) and environmental studies(POLLUTION). Most of these are, of course, adult conceptions and would not be introduced as such. However, the point is that the central scientific concept, the nature of AIR, can enhance the study of widely related scientific concepts. It is equally understood, within such planning, that not necessarily all proposed connections would be explored. Although, in the case of the topic AIR, I found that by the end of the year many of these other connections had been examined. For example, how other members of the animal kingdom such as insects, fish and amphibians breathe was examined in the context of pond and "bug" studies. While pollution, particularly air pollution, was examined in relation to the environment. Furthermore, aspects of weather were connected with examining snow and temperature and trying to understand why the north of Canada had a different climate from the south. Of course, whether the students perceived or consciously understood these connections is a matter of conjecture.

Personally, I find that broad conceptual headings help my planning as well as providing numerous reference points. For example an examination of the lungs helps in the study of the heart and the circulatory system. There is a case to be argued, I believe, that "integration" is valuable when the central focus is a fundamental natural concept. Such umbrella terms can often lead to fruitful science work for a year.

Within the Unit on Air, let me explore in more depth one particular connection, that of breathing. How we breathe and the potential health problems that can interfere with this provide fertile ground for examining important health concepts as well as scientific concepts. This particular avenue of exploration was further enhanced by having in the class a severe asthmatic and a child who was acutely bronchitic. Both, used various inhalers and medication to relieve their problems. I begin, therefore, with their stories and problems.

Over a period of two to three lessons children shared stories of problems in which breathing was important. They shared a wide variety of situations related to breathing:

- 1)the problem of smoking and its consequences-related in anecdotes about parents, relatives, friends and TV programs. (I also, personally related how I became a non-smoker after many years of cigarette smoking ).
- 2)the need to keep the air passage open as an important First Aid concept.
- 3) a wide variety of anecdotes, real and imagined, concerning suffocating, choking, breathlessness and swimming underwater.
- 4)observations concerning people carrying little air cylinders around with them, oxygen masks and collection boxes showing children suffering from cystic fibrosis.

These *stories* emphasised, to the children, just how important the act of breathing was.

Essentially, breathing was life. As a consequence of these stories I determined two things. One, to teach in a little more detail about the lungs. Two, to introduce an expert, the health nurse, to help explain and answer some of the children's questions that had arisen from these discussions and anecdotes. First, teaching about the lungs.

I began by describing pictorially, how the lungs worked using a variety of books and posters. I then made a simple model of how our lungs work. This model was derived from the excellent science series by David Suzuki, "Looking at the body"(pgs. 62-63).

As a model of just how our lungs worked, I found it an excellent teaching tool. It was also one which the children could manipulate freely. An explanation of how the model works is quoted in full:

*The bottle is like your chest, and the balloon across the bottom of the bottle is like your diaphragm. The balloon inside the bottle is like one of your lungs, and the straw is like the bronchial tube that leads to your lungs. When you push up on the " diaphragm" your balloon lung shrinks and air is sucked into the "lung" and fills it (p.63).*

This is similar to what happens when you breathe.

The addition of the health nurse added considerable background to the ways in which various diseases effect the lungs. She also brought in real lungs, one healthy and one that was diseased.

Children are fascinated( aren't we all?) by the examination of real organs. So often the size of these critical organs takes them by surprise. The introduction of an *expert* into this Unit added, I believe, to the children's knowledge. In this example, the health nurse responded to a wide and varied number of questions concerning the operation of the lungs. In addition, she was given the opportunity to promote and encourage healthy habits.

"*Integration*", that is genuine and authentic in its connectedness, will often, I believe, direct the curricular agenda along in all kinds of connected ways. For example, the discussions and anecdotes concerning breathing, created a debate concerning how long one can stay under water? Just how long can a human being hold their breath for? How long can one live without air? This lead the class to the library and the Guinness Book of Records , synchronised swimmers, pearl divers and individual claims of prowess in holding one's breath. As a teacher, I may choose to either ignore or utilise these *teachable moments*. I had not intended to necessarily explore lung capacity but I had now created such an opportunity. The context, I felt, was an appropriate one. I therefore introduced the children to the following experiment. I use with caution the word experiment. This was rather a *demonstration* , for what was to be examined and understood was already known. Furthermore, it was not so much a *demonstration* of how much air your lungs can hold but rather how much air one can exhale. For the purpose of this example I used exhalation as an appropriate measure of lung capacity.

The demonstration requires a large plastic container, one that has about a 4L capacity. The children fill this container with 500ml. of water at a time regularly marking off the side. When the jug is full it is inverted so as not to lose its contents and placed in a large sink. A piece of plastic tubing is then inserted in the child's mouth with the other end placed in the jar. The child takes a deep

breathe and exhales. The air that is breathed out bubbles into the jug. Water is forced out of the jug. Looking at the markings on the side children can calculate how much they have exhaled. This can be used as a measure of their lung capacity.

The demonstration emphasised aspects of science that are valued within the orientation *science as process* : fairness and measurement. To make the demonstration fair children were not allowed to exhale continually, for as they quickly discovered it rapidly lowered the water level in the jar. Only one continuous exhalation was permitted. There were also discussions over how many tries one could have-the best of three was determined as the fairest. The demand for fairness was partly created by a desire to prevent cheating as well as a competitive desire to discover the person with the largest lungs! The resolution of cheating allowed me to introduce the idea of fairness. The need for fairness in science demonstrations is an aspect of the orientation *science as process* . Recording the results graphically enabled us to determine the child with the largest breath and, possibly, greatest lung capacity. Recording results is a further aspect of *science as process* . There was also some degree of measuring and mathematics involved.

This, then, is one example of "*integration within a traditional subject boundary*". Given an initially broad but critical concept such as Air, the opportunities for connections will, I believe, flow in genuinely productive routes. Preliminary discussions and question by the children themselves often determines these productive routes. Openness on the part of the teacher is also very important in this respect. A relevant scientific context and the opportunity to share anecdotal information concerning it, provides a rich and fertile background for varied science work.

### Science within a theme.

I continue with examples from a theme on "Giants". As I have previously described (pg.37), my science teaching was planned either as separate Units or was "integrated" within themes. These are examples of "*cross-curricular or inter-disciplinary integration*".

In this theme, I examine giants both real and imagined. I also look at the opposite of *giant things* in terms of the very small. Within this theme there are considerable opportunities to develop and explore science. What follows is a description of activities that arose in connection with the theme "Giants" and, I believe, their related scientific merits.

### Whales

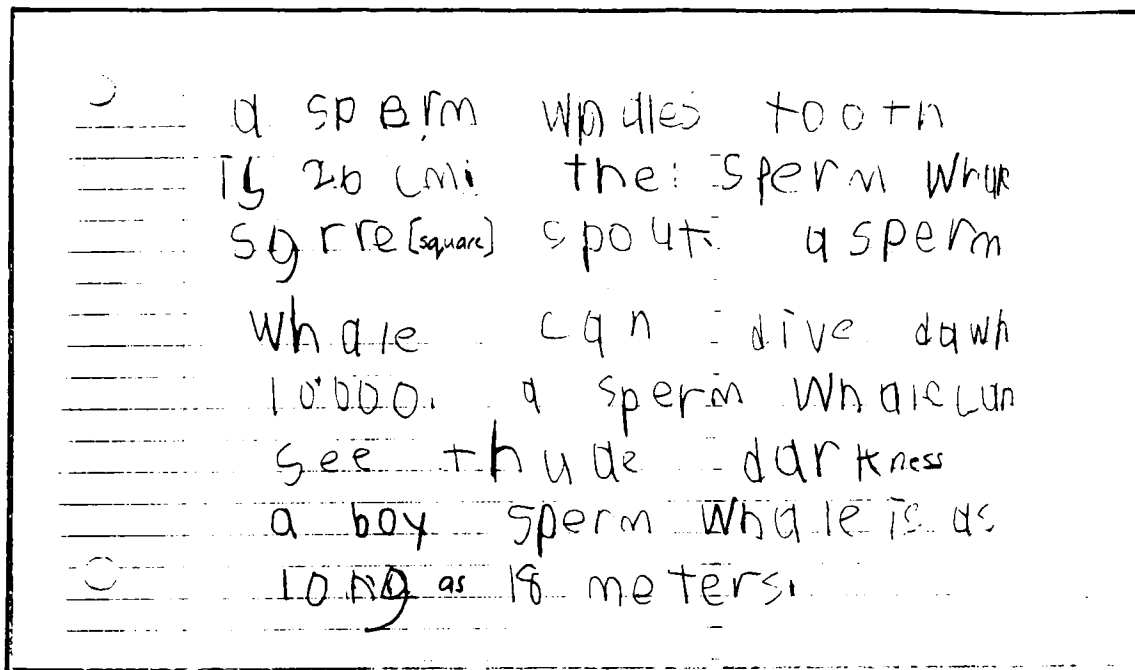
I presented knowledge about whales in a variety of ways: films, videos, film strips, books, magazines, personal anecdotes, music and stories. Children added to this knowledge base with stories, books and models brought from home. Furthermore, children were encouraged to respond to this scientific content in a variety of ways. For example, some children chose plasticene as a way of demonstrating knowledge about whales. Some, preferred to paint pictures, while others chose to respond in writing.

### Christopher and Trevor's response: Sperm Whales

In the class both children had become fascinated by a particular book on Giant animals. The book was noted, especially, for its scaled illustrations of numerous giant animals. These illustrations



unfolded from the book in the manner of a concertina. For Christopher and Trevor a fascination for the picture of a Sperm Whale descending the ocean depths in pursuit of giant squid became an abiding interest. I therefore encouraged them to *research* the Sperm Whale or do a painting. Research is understood as "finding out" or "what can you remember." They both chose to paint. When they had finished the painting, I again suggested that they may want to write about the painting. Working co-operatively, Christopher recorded their information while Trevor read it out from a variety of books.



A sperm whale's tooth is 26cm. The sperm whale [has] square snout. A sperm whale can dive down 10 000. A sperm whale can see through darkness. A boy sperm whale is as long as 18 meters.

This is information that was important for Chris and Trevor. Throughout the morning they both discussed and reexamined books; talked to other children about what they were writing and took pleasure in being involved in the assignment. How do I know? From excited parental response during an open house we held to conclude the theme! These facts, as written, represent the final product. I did little else to change the facts other than to help it make sense with the addition of one or two words. The application of this knowledge was revealed a few days later, when a colleague brought into the class a whale tooth and some whale "ears". It was suggested by some children that the whale tooth must belong to a Sperm Whale. Christopher immediately picked up the tooth and measured it, declaring that since it was much less than 26cms. long it could be that of a Sperm Whale!

Amanda's response.

Amanda chose to respond, within her writing/journal time, to create her own book on Whales. Amanda wrote in her journal and then typed into the computer the following information:

*When whales sleep they float.*

*Killer whales chase blue whales for their blubber.*

*People kill the blue whale for their blubber. For lamps and lots of other things.*

*Whales can stay under water for sixty minutes.*

*There are seventeen different kinds of whales.*

*The Blogo is endangered. The Beluga is white.*

*Some killer whales are not all tame.*

*Stop killing whales please.*

*Whales are nice.*

*It takes eleven months for a whale to be born. You hite whales when big boats come along.*

*Do you know what you are dowing.*

*you can pet whales.*

*Their is one whale thay is not tame it is the killer whale.*

*You can wach and swim with whales.*

*You seen the whales now it 's are tern kids tern.*

*There are lots of porsts [posters]and films.*

*If you look in your school libarey or publick libarey you can look at books.*

*If you sell bluber you can get money.*

*Whales eat krill and fish.*

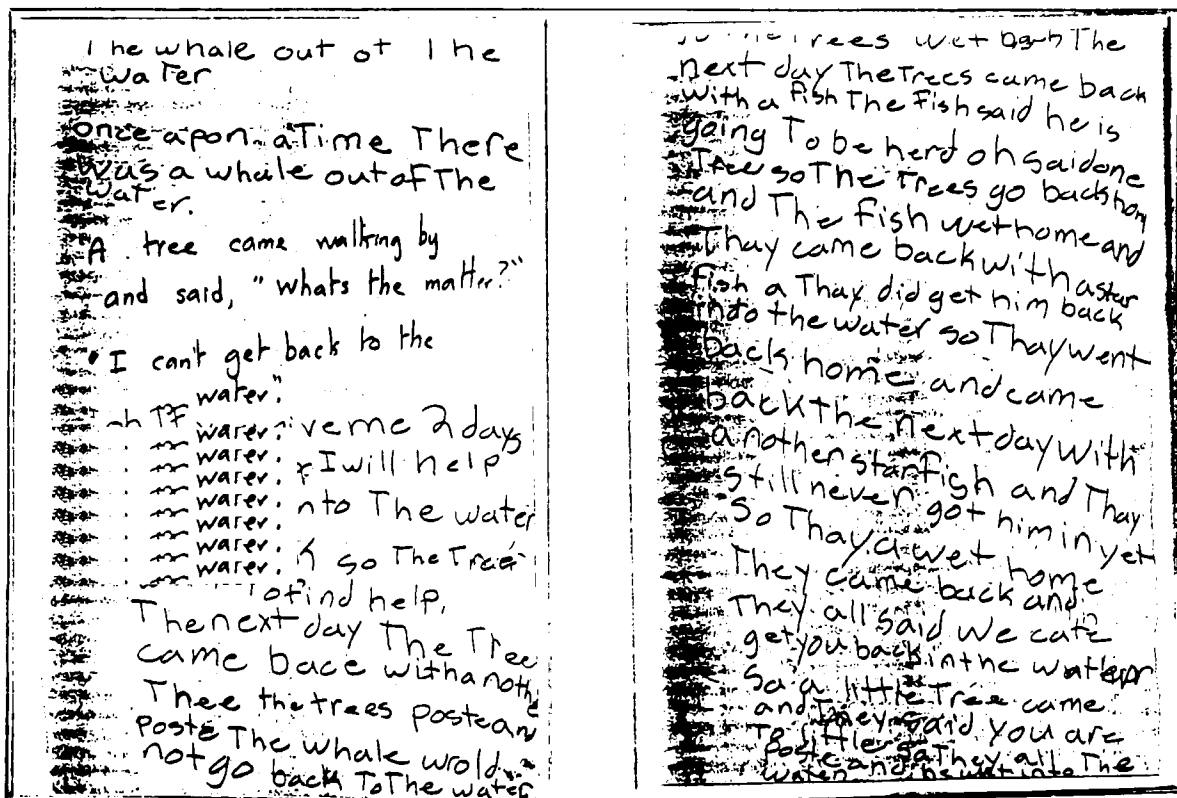
*krill is little pease of meats.*

The information is a varied list of whale facts remembered from films, found in books and gleaned from discussions in the class. When Amanda had completed this list I tried to help her organise it into headings. However, she found this difficult. The list, therefore, remained a list. Gathering, collecting and typing had, for Amanda, been enough. In the case of the sentence, "*There are seventeen different kinds of whales,*" I remember Amanda counting the whales on the class poster and then going to the school librarian to check whether this was accurate. As such, this piece of writing represents a considerable body of information in relation to whales. It also has that genuine quality of not being transcribed or copied from books: "*krill is little pease of meats*", "*There are lots of porsts [posters]and films,*" and "*Whales can stay under water for sixty minutes*". There is also the narrative voice of films: "*You seen the whales now it 's are tern kids* " and "*Do you know what you are dowing*". Amanda has independently recorded in her own words all that she considers valuable in relation to whales. The sentences represent what Amanda has considered worthy of recording as well as indicating where she has obtained that information. Knowledge recorded and presented in this manner is, I believe, of greater significance than that of copying a list of teacher-made notes. For example, krill is described as "*little pease of meats*". This is an accurate approximation, for Amanda, both linguistically and conceptually, of what krill is. I have

not supplemented her definition with an adult one because, I believe, these approximations to be the groundwork of conceptual development. This is a *spontaneous concept* spiralling its way to a *scientific concept* (Vygotsky, 1962). This is *action knowledge* approximating *school knowledge* (Barnes, 1976).

Brooke's response.

Brooke's response illustrates that, when given a choice of ways in which to respond, teachers must be prepared to allow them. In this example, Brooke chose to respond with a play. The play was centred on the factual information of Whales sometimes beaching themselves. This fact had been presented in class through a variety of stories as well as a film. This fact became the central problem of the play. However, the play also followed the fairy-tale sequence of Tolstoy's "The Enormous Turnip", a story both I and the children had read and explored through drama and readers theatre. We had also discussed in class the sequential nature of other fairy tales such as "The Gingerbread Boy" and the "Golden Goose". Brooke, therefore, borrowed a familiar literary form to describe an important scientific fact about whales. Brooke not only wrote the play but she also produced it, correcting her original text as she organised the play. The text is presented in its original form. The text shows the addition of my writing during a conference of the text.



Brooke's response is science within a Language-across-the-Curriculum orientation. Brooke is not only writing to learn, but she is also learning to write. Factual knowledge is manipulated within a familiar form or genre. This example illustrates Britton's(1970) description of writing within an expressive mode.

### Mathew's Response

For the final example of responses to Whales, I refer to my journal entry, and quote in full:

*Mathew had shied away from previous experiences in Art but today, with plasticine he made the most fantastic Blue Whale. Unlike other children he took a large lump of blue plasticine and produced a carefully modelled replica of a picture on the wall. In detail it was remarkable. The blow-hole had a white plasticine plume-the fins and tail were remarkably accurate. But there was also a killer whale attacking - this was no mere fantasy. We had seen a film of a [blue]whale in which Killer Whales attacked. Mathew had taken about eighty minutes over this model. It revealed, for me, considerable observation to detail-very careful working out-and remembering of details from a film.*

How does this relate to science? Observing and recording do not necessarily have to be seen only in terms of measurement and writing. Modelling, an artistic response, is as equally valid a scientific response. In the real world of science, models, drawings and diagrams are valuable interpretative tools by which to understand and interpret the natural know world. Art and science have always been closely related, except of course in mandated curricula!

### Growth

Within the context of the theme "Giants", I emphasise two broadly contrasting ideas: largeness and smallness; both of which are made applicable to a wide range of activities. In relation to smallness, for example, I bring into the class a variety of magnifying lenses, microscopes and prepared slides of interesting things. The children are shown how to use a microscope and encouraged to use their magnifying lenses to explore their environment. This free exploration can often produce interesting avenues of scientific exploration. The following vignette is an example of just such an exploration.

As a part of my science work I try to use the environment near the school. We are surrounded by Boreal Forest which, especially in the Fall, is full of various mushrooms and fungi. I therefore had the children go on a nature walk to collect as wide a variety of mushrooms, toadstools and fungi as possible. From this collection we discussed what kinds of plants they were and how they grew. In trying to understand how they grew I collected information from the children on how they believed other plants to grow. When we compared this information to mushrooms and toadstools very little matched. A particular problem was: where are the seeds? I therefore conducted for the children a simple demonstration on how mushrooms "spread their seeds". By placing a mushroom cap on a piece of blotting paper and leaving it overnight a fine dust is left behind. This "dust" is of course spores or, as I told the children, thousands of very tiny seeds- so tiny that we could only really see them under a microscope. These spores could be blown by the wind and grow in a special way. I illustrated this with a particular book "Mushrooms and Toadstools" a *Macdonald Starters Series*. It was at this point that I saw a very useful connection between examining spores and microbes. I therefore planned a mini-unit to explore this idea further. To help in my planning I used a useful book entitled "Lots of Rot" by Vicki Cobb (1981).

I began by telling the children that there are other "*spores*" in the air that can grow. To show that there are other kinds of "*spores*" we created a mould garden. This essentially meant collecting a variety of food items and allowing them to decay (rot). As the children observed this decay they began to notice moulds growing on the apples, cheese and bread. How these moulds grew now became the centre of discussions. To help understand this problem I used some simple experiments from Cobb's book. These experiments suggested the placing of equal amounts of similar food in different places- dry, wet and cold for example. We concluded, from these simple experiments, that there must be very small *things* (organisms) in the air that, when left alone and given the right conditions, will grow. These organisms we call microbes. The children then studied microbes as germs and diseases in their Health books. They saw a film on how there are *good germs* and *bad germs*. We also saw an animated film on how white blood cells "*attack*" germs and how antibodies are created.

The concluding activity, again used the expertise of the health nurse. The health nurse was first impressed by the students' knowledge in response to her questions on ways in which germs and diseases can be spread. As a demonstration she had one child apply a special liquid to his hands such, that when examined under ultra-violet light, bacteria showed as pink blotches-even after he had washed his hands! At the end of the lesson we examined other children and discovered that they also had pink marks! These could only have been picked-up from contact with the original student or from places he had touched. It was a very dramatic demonstration of how germs and diseases spread. I concluded the theme by reading about the life and work of Louis Pasteur, and examining ways, both past and present, of preventing food from becoming "bad".

Although, originating within a theme, the instructional approach of this science example reflects the

approach of a *school science* curriculum orientation. The science is teacher-centred rather than child-centred. Care had been given to appropriate materials and activities by which to acquire understanding. In a sense, this example illustrates the way in which various curricular orientations can operate within various contexts. The key is selecting what is appropriate.

The Unit on Air and the theme "Giants" emphasises the applicability and value of integrated science. In stressing the connectedness of knowledge, especially scientific knowledge, Integration encourages risk-taking and experimentation within class science.

### A Unit on Magnets Planning

As an elementary teacher, I have found that children retain an abiding interest and curiosity in exploring the properties of magnets. I intended, therefore, within my science teaching to utilise this natural curiosity. Fortunately, this natural curiosity for magnets had already been stimulated by the introduction, a week prior to the unit, of two large magnets into the class by Michael. The unit began, therefore, within the context of student interest, which is precisely how I intended to begin the Unit. If the magnet had not been introduced, I would have introduced one myself, to create and activate student interest and comment.

The Unit on magnets I planned would be derived from the children's questions, ideas and interests, working in small groups. The choice of instructional approach was determined by two things. First, the nature of the materials. Magnets need manipulation and exploration: small group activities, therefore, seemed appropriate. Second, the classroom context played an important role



in determining the choice of instructional approach. At the time of the Unit on magnets our class theme was "Pirates". This particular theme was an instructionally teacher-centred one. Many of the activities associated with this theme were whole-class ones. I felt comfortable, therefore, in pursuing a more open-ended approach in my science teaching.

In Part One of the study, I described my classroom context as one guided by "Whole Language " principles. These principles, I believe, are enacted in a wide variety of activities. More importantly, they are enacted in a rhythmical sense (Whitehead,1929). That is, the instructional approaches range from the routine to the teachable moment. The physical and intellectual demands of operating within this context are great. I therefore, personally try to manipulate this, so that the day was balanced between unstructured and structured learning situations.

### **Beginning the Unit**

I began the Unit by first asking the children what they already knew about magnets. Second, what further information they would like to discover in relation to magnets ( Document #9, Appendix 3). Responses to the first question were:

- 1) magnets pick-up metal (*recognition of an important property of metal*)
- 2) some kinds of metals, not all metals can be picked-up by magnets (*considerable discussion and disagreement accompanied this statement*)
- 3) magnets can push together (*recognition of concept of attraction*)
- 4) some stick to your fridge (*awareness of a variety of everyday uses*)
- 5) found in many shapes and sizes
- 6) used to keep cupboard doors shut
- 7) some screwdrivers and scissors are magnetic ( *the usefulness of this was accompanied by a*

*variety of personal anecdotes)*

8) magnets have poles- they have a north and south (*familiarity with an important quality of magnets*)

Responses to the second question were:

- 1) How much can a magnet lift?
- 2) How big is the biggest magnet?
- 3) How do magnets work-how do they pick -up things?
- 4) Why are some shaped like horseshoes?
- 5) Can you make a magnet?
- 6) Can things be moved by magnets?
- 7) What do we use magnets for?
- 8) Are there magnets in rocks- is the earth a magnet?
- 9) Did they have magnets in the past?

The children's questions and interests provided me with the source of directions and interests for the Unit. My curriculum or teacher agenda was *modified* by the children. I prefer the word *modified*, for in this example many of the interests and questions were anticipated from past experiences with children and magnets. However, this is not to suggest that the request for student questions and interest was a meaningless exercise. The key is that my instructional agenda should be negotiable. It is the teacher trying to satisfy the children's questions rather than the children trying to satisfy the teacher's questions. This can be examined in relation to how the Unit progressed.

I begin, with the example of the controversy over whether magnets attract *different* metals. An important concept in relation to magnetism. I had the children sort through a container of numerous items-magnetic and non-magnetic. It was not the children's suggestion, but rather mine. On reflection, I perhaps should have encouraged *them* to provide the *experiment*.

In sorting through this container, the children *discovered* that there *were* a number of materials that magnets did not pick-up, many of which were metallic. There was no direct instruction on how these materials should be sorted(*classified*) but the children tended to sort them into two piles. These piles were designated a variety of names, but each corresponded to the concept of magnetic and non-magnetic. Some children did further *reclassify* these materials into wood, plastic, glass, etc.

In identifying these piles I began to introduce the terminology of magnetic and non-magnetic. I did not displace or discourage the children's own everyday terminology, although I found, and this is partly reflected in the children's written responses(pgs.77-82), a growing use of more scientific terminology. I shared additional information during these group activities. For example, I *told* the children that many of these metals that were magnetic, were made up of special metals, in particular, steel and iron. The question then arose as to why there were differences? Why *do* some metals(in particular iron and steel) have the quality of being magnetic?

In the context of this activity, therefore, *some* children had raised one of their own questions: how *do* magnets work? Certainly, as a teacher, I would have wanted to explore this question, but its exploration is more meaningful when pursued within an actual context in relation to a child's

question. The curriculum is being *negotiated* but in a *guided* way.

How do magnets work? More importantly, how does one explain this? An adult explanation would include the nature of negative and positive particles and their alignment and composition within the molecular structure of materials. However, can such concepts be reduced to simplified terms that can equate with a child's understanding? Furthermore, is it necessary to do so?

In this example, I did not respond by avoiding the question but by answering in the following manner: *I suggested that to the best of my knowledge metals are made-up of numerous molecules, each one, in a way, being a separate magnet. These mini- magnets can either be all jumbled-up or neatly organised. Those that are jumbled-up will be non-magnetic while those which are orderly will be magnetic.*

As I discuss in *"Incidental science"* (p.83), the role of an explanation is more than mere words. Children constantly ask questions and are more likely to continue to ask them(I believe) if we respond in genuine and authentic ways; as if they are equals in the enterprise of acquiring knowledge. It is not our role to assume that explanations only be given if they approximate with our notions of what a child can or cannot understand. The key is that within a meaningful context, children desire adult responses as to why the world is the way it is. We can equally reply, that we do not know. Better still, we can suggest that we will find out and try to return with an explanation. Or, that there *is* no reasonable explanation! However, this is not to suggest that factual knowledge, of the definitional textbook kind, can appropriately be presented in chunks, reminiscent of Dicken's Mr. Gradgrind in *Bleak House*. Children seek, demand answers to the

way the world is. Explanations are authentically given in response to genuine inquiries not as detached chunks of knowledge. They are explanations within meaningful contexts.

The free exploration of various magnetic and non-magnetic materials had answered two of the children's questions. The children had determined that "*not all metals can be picked-up by magnets*". Furthermore, in exploring this *controversy*, they had also learned about "*how magnets work*".

The nature and composition of magnetic materials led, naturally, to the question of the existence of magnets in rocks. I therefore introduced the children to a lodestone, a natural magnet called *magnetite*. Immediately, the children wanted to test its magnetism by checking on its ability to pick-up various metallic materials. Numerous questions followed concerning this material: where is it found? who found it? where did you get it? is it in the soil around us? is this what magnets are made from? The children's natural curiosity and the opportunity to handle a few pieces of magnetite allowed me to discuss and explain a great deal about magnets. I was also aided by the children bringing in various books from home. These gave good illustrations of how magnets are made. I also told the children a Greek legend of how magnetite was discovered. I further extended the narrative of the lodestone by describing its use as a simple compass, especially by the Vikings. Considerable fascination was evidenced towards the lodestone, but the children's curiosity did not end there. A variety of student initiated ideas followed.

*Could it lose its magnetism?* Many children already knew that magnets "*lose their power*" when constantly being dropped. Why not drop it therefore, and see if it can pick-up as many paper-clips

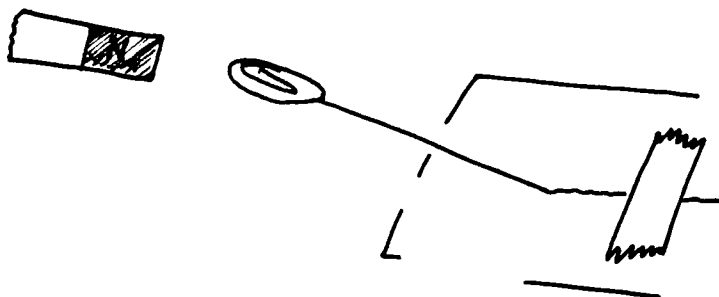
as before. A simple, but fair test of the hypothesis. Unfortunately, the lodestone would only hold a few paper clips. Furthermore, its magnetic strength was very varied over its surface. We were, therefore, unable to conclusively answer the question.

*If it was used as a compass does it have a north and south? How would we know?* One student suggested that we use magnets that we already have, hang the lodestone from a string and see if the stone moves away or towards the pole that was facing it. The formulation of a hypothesis based on the application of knowledge acquired by exploring the poles of magnets! It does have poles but it was not an easy experiment to detect. Neither did it perform very well as a compass, causing speculation on its use as an ancient direction finder.

The two previous examples demonstrate that given an interesting context children will naturally satisfy those curricular aspects of *process science*, the application of the *scientific method*. The key word is naturally for in the lodestone example I did not apply any special terminology to reinforce the thinking practices of the children, nor did I think it necessary to do so. Why label what occurs naturally, possibly instinctively and intuitively? We had, in relation to individual children, real questions and problems.

As the children were encouraged to freely manipulate magnets, they began to explore the strengths of various magnets. The children had great delight in placing large magnets under wooden desks and sliding paper-clips along their surfaces! They also freely explored other materials and possibilities. These *free* explorations provided further ways of measuring a magnet's strength! For example, the children quite spontaneously tested their magnets' strength, in a variety of ways:

hanging paper-clips from them, seeing if they could move paper clips through various materials, constantly testing the magnet's strength and deriving alternative ways in which strengths could be measured. For example, in the following diagram, a magnet's strength was determined by its ability to suspend a paper clip.



The original questions and interests of the children provided numerous opportunities to explore the nature of magnets. However, their original questions also provided me with some insight into other aspects of their scientific knowledge. For example, there were no questions concerning electromagnetism and magnetic fields. I therefore introduced the children to the making of some simple electromagnets, using nails and coils of copper wire, and a few simple teacher demonstrations of magnetic fields, using iron filings. From these activities, a variety of student questions were generated.

One student wondered if an electromagnet had a magnetic field and, if so, was it different from that of a magnet? The answer to her question was easily sought by finding out, which she did. She proceeded to set-up her electromagnet in such a way as to allow a piece of paper to cover the experiment. She then sprinkled some iron filings over the paper. After a variety of attempts, she created a field which she thought would satisfactorily enable her to compare it to that of a bar magnet. Throughout her experimentations, various children made comments and suggestions:

what if you put both under the paper? look what happens when you bring a bar magnet closer? In an experimentally playful manner she and many students proceeded in a manner that equated with the scientific method (*science as process*). I further extended the concept of electromagnetism by bringing in toy electric motors and some electric bells, offering explanations on how they worked. I further encouraged the children to see where, in their homes, magnets and electromagnets were used.

### Concluding the Unit on Magnets

The children concluded the Unit on magnets by responding in two ways: through writing and drawings. In respect of the written responses, my only request was that they write about something they enjoyed doing with magnets or electromagnetism. For the drawings, I encouraged the children to record accurately experiments that they had done.

The written examples illustrate considerable writing confidence. The children are comfortable and in control of their subject matter. This confidence and control is illustrated in many ways. First, there is variety. There are no uniformly copied teacher notes. For example, many children chose to describe the behaviour of magnetic poles, but each choose his or her own words to describe that phenomenon. The vocabulary of magnetic attraction and repulsion is approximated by such everyday words as : *stick to; push away; come together; go apart; they want to meet, pulling and pushing*. Christina describes the phenomenon with complex sentences that have a mature clarity about them:



## The Magnet

A magnet can pick up things that are metal. A magnet has a north side and a south side. If you put the north side of one magnet to the north side of another magnet they will go apart. If you put the north side of one magnet to the south side of another magnet they go together. If you bang a magnet all of the magnetism comes out and it won't work anymore. You can make a magnet by sliding a screw on a magnet.

In contrast, Louise chooses a more expressive mode, finding magnetic attraction analogous to an "attack."

When the magnet is hanging to the south end it likes the north end, they attack. But when you put south to south or north to north they push away. When you put a thin piece of wire around a big battery on both ends. Then wrap something metal. Leave it in for a minute or so. Then when you take it out it will be a electro-magnet.

While Mathew and Aeron, in two, clear, simple sentences encapsulate the behaviour of magnetic poles.

If you get two magnets and you stick north and south together. If you turn them opposite they'll go a way.

Aeron  
North to North and South to South making the magnet move. South to North and North to South pulls the magnet.

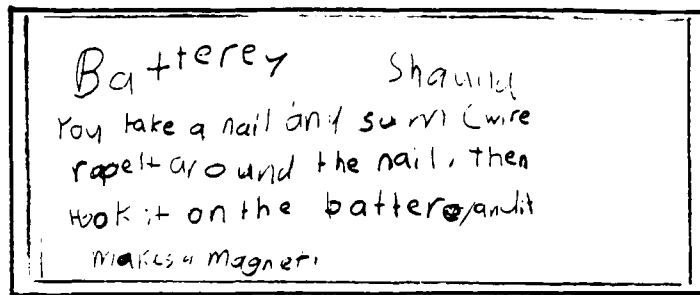
Second, there is confidence in the control of explanations. There is also the continued variety. This is evidenced in the following examples by Nathan and Tyler of how an electro- magnet works. Nathan confidently elaborates from "First you find.....". To conclude: "And you have a magnet [electromagnet] ". While Tyler concludes, somewhat tentatively: "and try to pike it up now you have a magte". Both writers have also chosen to describe the *terminals* of a battery as "a black thing" or "little knobs".

# How To Make A Magte

First "you find the thing; you need, A nail, wire, and A big batterye. Then you wrap the wire around the nail. You put one end of the wire to a black thing on the batterye and the other end of the wire to the other black thing. Then you get a piece of, metel you leave it on for an hour. And you have a magnet.

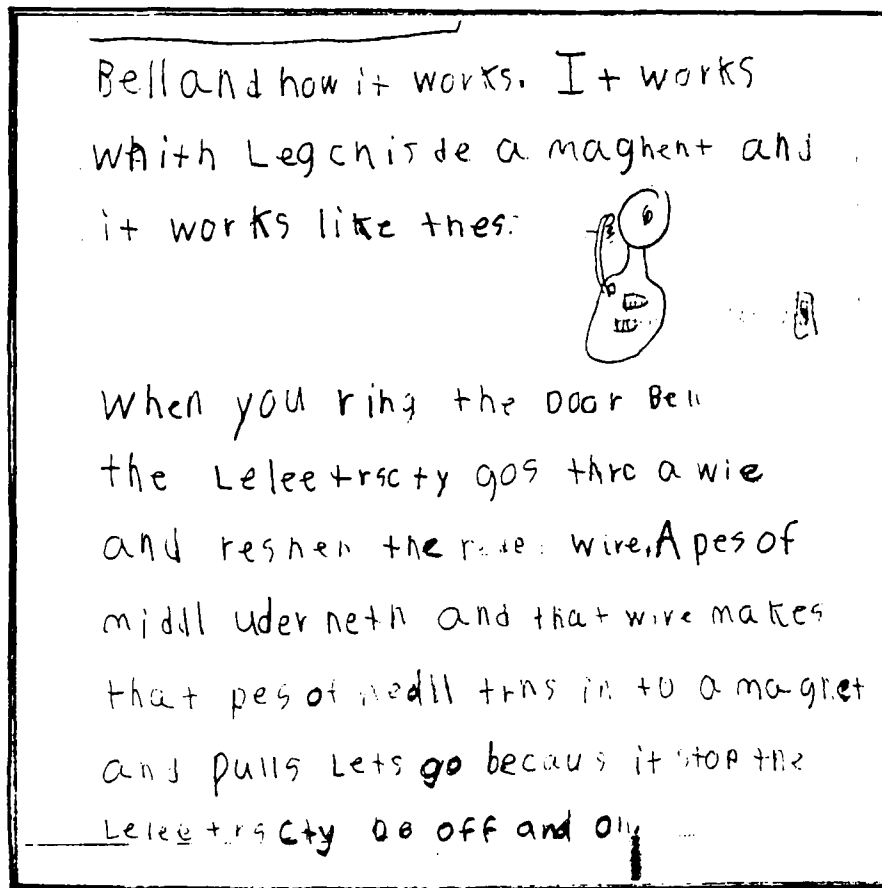
How it works  
You get a batter, and some wire and you put the wire n between the little knobs then you close them and and you wrap the wire around a nail. you wait while and get a paper clip and try to pike it up now you have a magte.

Shauna's explanation, in contrast, is glaringly cryptic.



A writer's confidence can also be determined by their ability to logically order difficult material.

Brad, trying to describe how an electric bell works is such an example.



As is Jennifer, making an electromagnet.

How to make a electro-magnet.  
 You get a battery, a nail and some wire.  
 You wrap some wire around the nail and  
 then you put the ends of the wire on  
 the battery if you take the nail  
 away you should end up with a  
 magnetic nail.

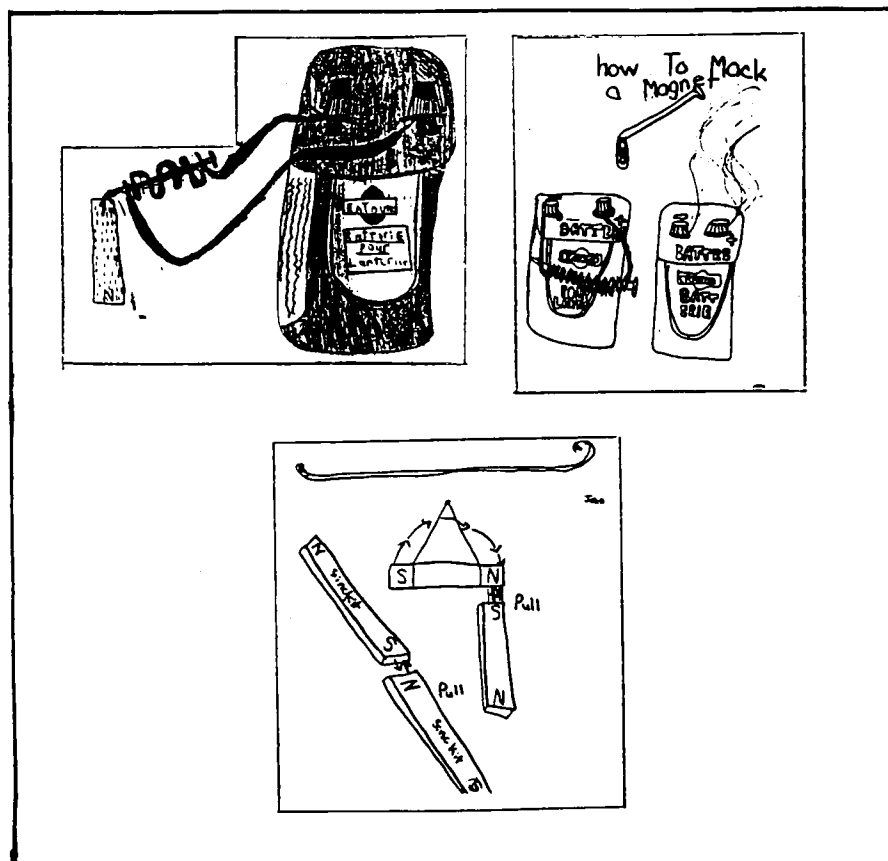
And Amanda, describing how to demonstrate a magnetic field.

Magnetic field  
 You need a magnet, a peice  
 of paper and Iron filings.  
 Put the magnet down.  
 Then put the paper on  
 top of the magnet. Now  
 you have the shape of  
 the magnet you used.  
 You also have a magnetic field

Third, there is a tentativeness, in many of the written examples, that suggests an honesty of scientific observations. In Jennifer's example, we read: "*you should end -up with a magnetic nail*". Does the tentative *should* suggest an incomplete or unsuccessful experiment?

The use of writing to express understanding of this topic emphasises an LAC orientation. This is "writing to learn". There is an acceptance, on my part, of approximations in both terminology and understanding. Still, key concepts and understanding concerning magnets are found within the wide variety of written responses. There is no standardised format, thus creating uniformity and denying individual response. Children, I believe, given such opportunities to express themselves in writing, begin to bridge that gap between "school knowledge" and "action knowledge". These examples, like their talk, are "first drafts" towards scientific understanding. Language expressed, through talk and writing, is experience and understanding possessed.

Finally, the ability to record in writing is not the only way in which the scientific world records events and observations. The use of diagrams and models in expressing understanding is also very important. I conclude, therefore, with a collage of diagrams that demonstrates, I believe, both understanding and careful observation of magnets and electromagnets.



### **The story of "Incidental science"**

Within this study I have made reference to the term "*incidental science*". The term is one which I have *invented* to incorporate a variety of classroom incidents that do not easily *fit* the broader categories of planned science activities. Neither do these incidents neatly fit within various curriculum orientations. When applying the word "*incidental*", the emphasis is upon its connotation of occurring without intention or calculation. "*Incidental*" does not imply easily dismissed, for these recorded incidents are highly valued for their *scientific* content. What then is "*incidental science*"?

One, the activity, incident or question is *scientific* in content. That is, there exists a recognised explanation(s) for describing the occurrence. Two, the activity, incident or question is initiated by the child. Three, the activity, incident or question is not necessarily dependent upon a specific scientific context. These incidents occur at any time or place. Four, they seek an answer from the teacher: they demand an explanation. Five, they can become mini-science lessons. "*Incidental science*" is, in a sense, a "teachable moment" of a scientific kind! A brief, preliminary example, that occurred while writing this section, may further illustrate the nature of these incidents.

During a class writing time, a discussion arose over an incident that had occurred at recess. One child had spoken of having had her hair "pulled out by its roots". Her friend remarked that you cannot have your hair "pulled out by its roots!" The controversy was, eventually, brought to my attention possibly for resolution. The controversy really revolved around the word "roots". The friend, it appeared, saw the "roots" of hair as being similar to that of a plant's roots- a network of roots spreading under the scalp. To remove hair from the scalp, in such a case, would be both

painful and bloody! Stopping what I was doing, I quickly found in their health textbooks, a diagram of the skin showing a cross section of skin. I then explained how hair roots were arranged within the follicles of the skin. I also pulled a few strands of my own hair, to illustrate how easy it was to "have your hair pulled!" This is the nature of "incidental science".

The examples that follow were collected over a period of three months as personal anecdotal records. They are not examined in chronological order, neither do they exhaust all the possibilities that arose.

#### Example 1

One morning, Paul brought in a glass jar that contained an egg that had been sitting in vinegar for a long time. The vinegar, acting as a mild acid, had dissolved the shell so that the membrane remained in tact. This jelly-like object floated precariously within its off-white fluid like some primeval fetus. The jar contained the product of an experiment that the children were familiar with. In their previous class, their teacher had used this experiment as an example of the way in which acids may attack a tooth's enamel. A reasonably effective analogy. After the children's initial curiosity had been satisfied by this laboratory-like specimen, one of the children remarked that it was a very big egg. "No", replied another, "its just the water making it bigger". "No, its the glass," replied another. What the children were observing was the way in which objects can be magnified by a liquid. Noting the children's interest I quickly found a glass jar and repeated this phenomenon with a pencil and a coin. The result is *illusory* - but now I was being asked why? Why *is* the pencil bigger? Why does the pencil appear to be broken? Why does the coin look like it's not on the bottom? I noticed that children began dipping in their own pencils checking the



point at which this occurred. I also showed how a drop of water on a piece of paper magnified the letters underneath. At this point it became necessary to offer an explanation.

What the children had been observing was an important aspect of a branch of physics called optics, in particular the nature of refraction and magnification. Experience has taught me that optical effects are difficult to explain to young children. For example, the concept of light travelling in lines as rays is difficult to comprehend when light is more easily understood as a medium filling a room. Furthermore, many children also have difficulty with the idea that we see things because of light *entering* the eye. Children have a general impression of something going *out* from the eyes when they see objects. As adults, we *may* comprehend the nature of refraction and images, in the following manner:

*First we see objects because our eye receives the light rays they give off. The light rays form a widening beam of light from each spot on the object. Our eye is able to tell in what direction the object lies because it is able, in effect, to trace back these rays in a straight line, and we infer that the object must be where they originate from. But the surface of water or glass is able to bend light rays. When our eye receives these rays, it processes them in the same way, and they seem to come from a different spot from their real image. We "see" the image. We also see images by tracing back reflected rays. The actual rays can be seen more easily through glass.*

The children's questions and curiosity demanded an explanation. However, I did not offer an explanation in adult terms of refraction and images, although I did mention that this is what scientists have called this *trick* of the eyes. And we can observe it as a *trick of the eyes* because the pencil is not *really* bent, and from some angles the illusion disappears. What I suggested, therefore, was something like this:

*The water, the light and the jar, together, play a trick with the light that our eyes pick-up , so that the pencil appears to bend and the coin in the jar appears to float.*

I extended my explanation, of light *playing tricks*, by describing the way, on hot days, waves of heat can make things "float". We call these tricks of light *mirages*. With this explanation a number of students offered anecdotes of experiencing such a phenomena.

In the case of drops of water acting as magnifiers, I kept my explanation to the idea that water in bubble shapes uses light to make objects appear bigger. An adult explanation might be as follows:

*A lens bends light both as the light enters and again as it leaves. The material the lens is made of determines the angle at which the light bends. Reflected light spreading out from the object one is looking at hits the lens (in this case a water lens) and is bent back to your eye. Your eye sees the light as though it came on a straight line from the object, and it appears as though you are looking at a much larger object a comfortable distance away.*

In addition to my simplified explanation, I further told the children that the very first microscopes used by a scientist from Holland(Anton van Leeuwenhoek), hundreds of years ago, used the same idea. (In fact , if you punch a small hole in a piece of plastic and place a drop of water over it, you obtain an instrument not dissimilar to those early magnifiers.)

A few days later Andrea brought into the class another example of how to magnify objects. The magnifier was a plastic ice cream bucket over which was stretched a clear piece of plastic. Cut-away in the sides were two holes, large enough to allow a hand to hold an object underneath

the clear plastic. When water was poured onto the surface of the plastic, an object placed underneath, would appear larger. When asked as to where she had obtained this idea, she replied that she had seen it in one of her books at home.

### Example 2

Jennifer had become fascinated with optical illusions in a book she had been reading; the book had a wide variety of examples. "Why", she asked, "do they make your eyes funny. How do they work?"

Again, an adult scientific explanation could be very complex. Although, as grandparents and parents can attest, young children will often listen to quite complex explanations in complex language if the explainer is a trusted friend, and the explanation is in response to their question. In this example, I wasn't sure myself, and said so. I promised to see if I could find a suitable explanation. Eventually, I did find something suitable. The explanation I used was derived from a book called Scienceworks: An Ontario Science Centre book of Experiments (1984). I quote the explanation in full. It was this explanation that, in so many words, I offered Jennifer.

*Just as you had to learn to read- to make sense out of squiggles on paper- so you had to learn to see- to make sense out of rays of light hitting your eyes. Once your brain has learned the "rules" of seeing..it applies those rules to interpret everything you look at. But when an object or a drawing breaks the rules, or when it could be interpreted in different ways, your brain may give you wrong or confusing information, and that's what we call an optical illusion (p.60).*

Example 3

During a shared reading time Darcy read out from his journal some of the things that had interested him concerning dinosaurs. In reading out his story he described how dinosaurs became extinct. In his case, he explained that the weather changed- resulting in it becoming too cold for the dinosaurs. They therefore died out. A heated discussion now took place concerning these ideas. "Why are they not around today? I read it was a large meteor that caused all the problems?" The children were engaging in genuine dialogue. Such interrogative dialogue over assigned meaning makes possible new knowledge that expands individual experience. The discussion became quite sophisticated in its vocabulary and concepts, a reflection of interest in dinosaurs at this age, as well as the influence of television programs and visits to the Tyrrell Museum. I did not suggest that any of these ideas - scientists call them theories - was wrong, they are ways of trying to explain what might happen. In such cases, the teacher's role is that of facilitator and resource person. One, further example may illustrate this. One day, in response to a student's hiccups, a child asked how do you get hiccups? Controversy arose, in this example, not over the correct explanation, but rather over the correct possible cure! A variety of explanations, possibly superstitions, were offered as to how to cure hiccups: holding your breath, placing a paper-bag over your head and, leaning back with your fingers in your ears, with your mouth open, and to have someone pour water down your throat!

But controversies can also occur when supposedly conflicting concepts are applied in similar situations. For example, we blow on a candle to extinguish it and blow on a fire to help it burn. How can similar actions produce differing results?. This particular controversy arose in connection with the Unit on Air. This is how I explained it. You need three ingredients to start a fire: heat, oxygen and fuel. The fuel can be wood, a candle, certain chemicals, paper, or anything

that burns. When you strike a match, friction produces heat. (Friction is easily demonstrated by rubbing the hands together). The heat causes oxygen in the air to combine with chemicals on the tip of the match to produce fire. You can put the fire out if you take away one of the three ingredients. You can make the fire bigger if you add fuel or oxygen. By blowing hard on a candle flame, heat is removed. The fire goes out. By blowing gently on a larger flame, oxygen is added to the fire. If a strong wind blows it might remove heat from the flame. Then it would go out.

#### Example 4

During class, there is a sharing time each day, when children bring items that they feel are important. One day, Nathan brought in a tea-towel on which there were numerous pictures of hummingbirds. Nathan first explained where he had obtained it and then proceeded to give additional information on how small they were. This prompted a great deal of discussion about hummingbirds. I myself, shared some anecdotal information. Questions of size arose. I gave a rough, diagrammatic representation of how large the eggs were in comparison to an ostrich. The interest carried over, with one student going to the library, where the librarian found a poster with additional information on hummingbirds. The poster provided further discussion concerning their diet, speed and travels.

#### Example 5

During my Unit on Space, I read the children Tomi Ungerer's (1967) *Moon Man*. The story tells of how the man in the moon, anxious to enjoy the pleasures of Earth, journey's to Earth. Unfortunately, he is met with hostility and intolerance. Trying to return to the moon he enlists the help of an old scientist. After I had read the book, I asked the children whether they thought the

pictures of the scientist were accurate? (Ungerer's scientist is possessed of all the stereotypical attributes of a scientist: thick glasses, beard, eccentric, isolated, etc.). My question was met with all the stereotypical characterisations one could expect. Initially, I was concerned. On reflection, however, considering the influence of films and TV, why would they think otherwise. Where in their experience would they have met a working scientist? From where, would the children derive a non-stereotypical view of a scientist who, coincidentally, was always associated with a male? What the incident reminded me of was to try, if possible, to challenge at every opportunity these closely held views of what a scientist does. How, precisely, to challenge these views, remains an intriguing question.

Throughout this study, I have suggested that children's questions and interest, even within **planned** science activities, provide numerous opportunities and avenues for science. For children, however, curiosity and questions about the world do not remain within the constraints of a particular subject domain. "Incidental science" demonstrates that such possibilities for science exist outside the planned curriculum. This is, I believe, equally true of the whole curriculum. Children will often bring in items that demand an answer or promote questions. Children, who are encouraged to bring in objects and ask questions will, especially if they are met with equal interest and curiosity, act as scientists. Listening to children's questions shows the wide range of experiences and concerns they have about the world. Dialoguing with children further extends those possibilities.

## CONCLUSION

*Children are infinitely credulous. My Lisa was a dull child, but even so she came up with things that pleased or startled one. "Are there dragons?" she asked. I said that there were not. "Have there ever been?" I said all the evidence was to the contrary. "But if there is a word dragon," she said, "there once must have been dragons."*

*Precisely. The power of language. Preserving the ephemeral; giving form to dreams, permanence to sparks of sunlight.*

Penelope Lively, *Moon Tiger*, 1987, p.9.

*Elementary science should provide children opportunities to extend their curiosity and to learn about the natural world through a series of planned learning experiences. By offering a diversity of interesting and challenging experiences the science program will involve children directly in personal rather than vicarious learning (Alberta Elementary Science Curriculum (1983), p.1).*

Within this study, through selected personal insights and examples, I have attempted to illustrate and understand the nature of teaching and learning science in one grade three classroom. First, I began with a review of various prescribed curricular orientations related to science and learning. Second, I described the specific instructional context within which these orientations operated, specifically, I described this as a "Whole Language " one. Third, I selected a variety of scientific events and topics which occurred within a specific time period: September-December. Each of these selected descriptive examples illustrates various aspects of science teaching within my class.

There is a temptation in this study to ask, initially, whether my science teaching reflected any specific curricular orientation? Originally, I had thought that classroom examples might possibly match each of the orientations described. However, as I began to manipulate data into a readable

narrative I began to discover that, in practice, my science teaching and children's responses were a complex inter-relationship of many orientations. Certainly, there is a preference for *Integration* and *Language-across-the-Curriculum* (LAC) orientations. For throughout the study, the role of language in learning science is expected, anticipated and sought within all the topics of work examined: I appear to encourage oral language that is colloquial, informal and that approximates to that of adult/ textbook registers. The same expectation is true of written responses. There is also a desire to encourage anecdotal and narrative forms of knowing. In describing and explaining scientific phenomena, children appear to prefer the narrative mode. Furthermore, because of the nature of language, the acquisition of scientific knowledge is viewed as a tentative process. That is, knowing begins first with the children's personal knowledge and experiences. Ultimately, this implies respect for the natural language of children. I appear to believe, in both theory and practice, that children should gain access to scientific knowledge in the same manner as one would propose to encourage the development of literacy or numeracy. *Integration* and *LAC*, therefore, are orientations that are clearly emphasised in the study.

When planning for science, however, I am aware of the need to impart some scientific knowledge, generally in the form of key scientific concepts that I believe are accessible to children of this age. In this, I adopt *school science* and *child science* orientations. The desire to impart some scientific knowledge is, clearly, a strongly held belief. However, the acquisition of this knowledge is not through didactic, transmission methods of teaching. The lack of emphasis upon a textbook within my class, illustrates this point. Scientific knowledge is acquired while paying attention to those principles underlying *Integration* and *Language-across-the-Curriculum* orientations. That learning involves and occurs through talking and writing, and that language use contributes to cognitive development. *Child science* is further implemented by encouraging student questions and recognising and accepting naive views.



If there is any one orientation that is under-emphasised, it is that of *science as process*. Is this due to misunderstanding or prejudice? Certainly, I find the philosophical and historical arguments weak for this orientation. More importantly, however, I find the instructional practices associated with this particular orientation questionable. One does not teach the *processes of science*, rather one creates meaningful opportunities within which these processes may occur and be observed by the teacher and students. For children will, when given such opportunities, naturally wish to draw conclusions, experiment, hypothesise, question, etc. - just as they would in any given situation. The key elements of *process science* (inquiry) are adult descriptions of how, possibly, we come to organise *some* aspects of our knowledge. I note, that in the 1989 February survey of elementary science teachers ( Science Bulletin:Vol.1, Issue 2, 1989), respondents expressed " *a need for assistance in using the inquiry(process) approach to teach science*". Is this "need" a silent recognition, on the part of some teachers, of the non-teachability of these processes? That is, rhetorically, we may, as teachers, pay lip-service to the terminology, while in practice recognise the difficulties of its application.

Science is not unique among the school subjects that use rational arguments and critical thinking skills. Understanding and explaining the world is as much a linguistic and moral imperative as a scientific one. Process skills cannot account for what is authentic to science alone as a subject or discipline. For example, measuring, is this a mathematical or scientific process? How do we measure in a scientific manner? Not, I suggest, in isolation, but rather as a means by which to understand a meaningful context created by a meaningful question. For example, when dissecting a Moose heart in connection with work on the heart, the children observed a difference in the thickness of the two chamber muscle walls. We measured just how different, and for good reason, because the role of each chamber requires a different sized muscle. Just as in the human heart.

Finally, process skills cannot be organised into a developmental hierarchy-so that hypothesising is more appropriate to Division 111 students than Division 1 students, a suggestion proposed by B.Galbraith(1983) in "Science Process Skills and the Alberta Science Curriculum". What we know of language and learning suggests we have been constructing our worlds in precisely this manner(process) from birth. Stated crudely, a constructivist view of Kellyan origin would propose that we are constantly hypothesising, observing, predicting, etc. The process skills are already there! It's very presumptuous, therefore, to suggest that they can be taught.

There is, of course, science that occurs outside the parameters of specific curricular orientations. *Incidental science* is an example of this. The occurrence of *incidental science* is, I believe, a reflection of my classroom context, which I have described as a "Whole Language" one. Within this context children are encouraged to question, bring in interesting objects, and pursue their interests. Science is not confined to a specific time slot but is assumed to occur at any time within class. Furthermore, my own interest in science and desire to explain children's questions is an additional factor in creating *incidental science*.

The teaching and learning of science within my class is, therefore, reflective of a variety of curricular orientations. As I plan for science I emphasise: *school science* , *child science* and *integration* . However, the execution of these plans emphasises a *Language-across-the-Curriculum* orientation. In addition, it appears my classroom context creates opportunities for *incidental science* . This is not to suggest that such science is the exclusive preserve of "Whole Language" classes. What kind of science, therefore, has occurred within my classroom during this period of investigation? I propose the following as a list of distinguishing features:

- 1) children have been encouraged to gain scientific knowledge (AIR, MAGNETS, LUNGS, and GIANTS)
- 2) children have been encouraged to investigate their own interests (GIANTS and INCIDENTAL SCIENCE)
- 3) children have been encouraged to plan, investigate and communicate results in a variety of ways (MAGNETS, GIANTS and AIR)
- 4) children have been encouraged to observe, classify, record, test, design experiments and draw conclusions (AIR, MAGNETS, HOT AIR RISING and GERMS)
- 5) children have taken responsibility for investigations (GERMS, GIANTS, AIR and MAGNETS)
- 6) children have related their work to everyday experiences (AIR, MAGNETS and INCIDENTAL SCIENCE).
- 7) children have enjoyed themselves, and shown curiosity and ingenuity (AIR, MAGNETS and INCIDENTAL SCIENCE).
- 8) children have made use of the immediate environment (GERMS)
- 9) children used everyday language as the accepted mode of communication and understanding
- 10) science work has been integrated
- 11) science has been of personal interest and curiosity to me as a teacher.

Essentially, these aspects of classroom work compare favourably with the philosophical intent of the Alberta Science Curriculum(1982,p.3.). Coincidentally, recent British National Curriculum (1989) guidelines for Primary Science, correspond to my outline of distinguishing features. The one exception being that of the inquiry process emphasis. In a sense, therefore, I have been teaching *the curriculum* !

However, there are some important and essential differences. First, I retain a broader view of what science *is* than that found presently in the prescribed Alberta Program of Studies. In a sense, I view anything in the natural world as worthy of legitimate scientific study. Furthermore, many aspects of the Health curriculum are included under the heading science. In some respects, my personal view of appropriate science for young children could easily be encapsulated within the term : Nature Study. Second, there is an emphasis upon language: that scientific knowledge is acquired and understood through language, both spoken and written. The relationship between scientific understanding and language is an important one. Unfortunately, it is a relationship that is never fully described in the present Alberta Elementary Science Curriculum.

My study, I suggest, views the teaching and learning of science as one that I propose to call Primary Science. That is, science that is appropriate for children aged 5-11. Primary science, I suggest, is broad in content, although not so broad as to make science unrecognisable from other curriculum content. Primary science, therefore, should concern itself with broad themes within the natural world, that is, with what is immediate, observable and meaningful to children. In this sense, Primary Science has much in common with what is traditionally described as "Nature Study". Weather and Growth would, for example, be appropriate themes to explore. Furthermore, this content should encourage the acquiring of some simple scientific facts as well as the encouragement of student questions and interests. However, the manipulation of this content should also take account of the nature of language and learning of children of this age. For the relationship between language and learning is, I believe, central to the acquisition of scientific knowledge.

*The important feature of education[for some] becomes saying the right words, not learning how to use one's own words. In such circumstances*

*the "language" of science remains for many students a set of foreign words, dead as Latin, to be memorised from a book. It is not the constructive speech of a vital culture. Students then regard "definition" as a chain of words that bonds one to "truth" and "reality"; if one link is forgotten, the whole chain of understanding is broken. They have no sense of words as spider webs that catch meaning in their sticky strands; no experience of words as an approximate schematic of conceptual understanding; no notion that meaning is recomposed in each new personal performance on the public instrument of language (Connolly,1989,p.7).*

### Afterword

#### Ramblings on the Cinderella of the Elementary Curriculum:

##### Science

Having spent some time reflecting on the nature of elementary science teaching, it is appropriate, I feel, that I indulge myself in some further thoughts concerning the teaching and learning of science. I end this study, therefore, with first an outline of what I would like as a science curriculum. Second I review a series of questions that need further study, as well as a few personal recommendations for continued research and personal examination.

It must be stated very clearly that when dealing with science as a school subject, *school science*, we are dealing with science that is very different from science as practised by the majority of scientists in the scientific community. This is as true of applied sciences as of theoretical sciences. We may also add that *school science*, especially at the elementary level, is even further distanced from the daily practice of science by adults. This is not an issue unless it is proposed that school science should in some measure try to emulate this scientific community. If it were a desirable goal then one would need to address issues wider than those of *school science*. There would first have

to be a consensus on precisely how this scientific community operates. I would suggest, that both a cursory reading of the History and Philosophy of Science would fail to produce such a consensus. *School science* at the elementary level should, I believe, concern itself with other less lofty but important goals.

One, it should give children access to scientific knowledge in the same manner as one would propose to encourage and develop literacy or numeracy. Children should gain access to this knowledge in a variety of ways, so that their lives are enriched in meaningfully intellectual and emotional ways. This entails grounding our instructional practices in what we know about children and learning and in identifying what is authentic to science. The first requirement is true of all school subjects, the second asks that we identify *what* is science? Rhetorically, I would propose a conceptual response. So, one first derives a set of guiding principles from accepted views of children and learning. Next, a broad and meaningful content is determined, worthy of being engaged in and responded to. Such content is available in any broadly based review of international curricula. The route has been travelled many times! Finally, appropriate and meaningful ways are determined by which content and learning may be practised in the classroom. What is an appropriate classroom context within which science may take place? What are the necessary ingredients?

Two, it should desire to create curiosity, wonder and respect for the nature of our world for both children and teachers. Science plays a vital role in satisfying such a desire.

Three, it should preserve a role for scientific knowledge in the education of the young. At present

numerous misconceptions abound concerning science and "Whole Language" or "Integration". So much so, that science often becomes relegated and diminished to the point of unrecognisability.

I would argue, therefore, for a two-part written curriculum. Part One would contain an informative/critical review of ideas and theories related to elementary science teaching and learning. From this review would be derived guiding principles to inform instructional practices. Part Two would suggest a recommended elementary content a little more specific, although broader, than at present. From this, individual schools may derive an appropriate curriculum. Hopefully, such a curriculum would enable teachers to examine the duplication of topics. For example, how would Space, Dinosaurs, Water, Air, Flotation or Fire be differentiated within a school. How might we expect Water to be treated at kindergarten and then at grade six? In what way may we distinguish them?

Accompanying this curriculum would be a resource handbook, giving example activities, resources, advice and the adult scientific explanations of everyday phenomena. One of the greatest complaints against elementary science teaching is lack of confidence in teacher knowledge or expertise. Teachers themselves often avoid science through feeling inadequate about their own knowledge. To accompany this curriculum, there must be considerable in-service. No curriculum can ever satisfy every need or requirement. But there is a need to create a dynamic, exciting curriculum that will challenge teachers and revive and promote interest in science. Such a curriculum is possible.

In consideration of this *imaginary* curriculum there exist other concerns, many of which have not

been examined within this study:

- 1) How *do* we pursue student questions? How is science genuinely derived from children's interests?
- 2) The appropriateness and conduct of experiments within elementary science.
- 3) The use of film and T.V. in developing scientific knowledge.
- 4) The relationship between science and other curricula- especially Health.
- 5) Science and girls. Considerable research suggests that science, as presently taught and developed, is weak in satisfying female needs. What can an elementary curriculum do to promote girls and science?
- 6) Resources. What resources are needed to develop science in schools? This does not imply ideal resources, but a minimum base by which to conduct science. What are worthwhile texts? I would argue that there are a wide variety of excellent texts on the market at present more suitable than many classroom textbooks.
- 7) Financial allocations within school budgets. How can science be protected?
- 8) Science Fairs: what kind of science do they encourage and develop in schools?
- 9) Computers and science?
- 10) How appropriate are concerns with technology and science within an elementary curriculum? How do we equally concern ourselves with Environmental Sciences.
- 11) What of the history of science? How can we tell the stories of the past? How can we tell the stories of Canadian scientists?
- 12) Evaluation- both provincially and at school level- what is appropriate?

Finally, there are two areas of interest that, hopefully, will provide continued study and interest. First, there is the question of *science as process*. Essentially, this will become a more theoretical



question, involving the philosophical questions of the nature of method, ideology, applicability and generalisability: ultimately, certainty versus tentativeness. Second, the role of narrative language, storytelling, in the acquisition and understanding of scientific knowledge.

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### **Appendix 1**

Personal guiding principles by which long range plans are organised.

We use language to enable us to do the following things (amongst others):

explain	manipulate	observe
investigate	construct	create
hypothesise	question	estimate
compare	plan	express
master	classify	write
listen	speak	imagine

Teachers, like good parents, create opportunities for the above by :

- a) structuring the environment
- b) facilitating the learning
- c) supporting the children

Teachers incorporate the following essentials in activities ( integrated and thematic) that demand:

- a) daily reading(not only literature) to teacher, oneself and others
- b) daily writing for a variety of purposes and audiences
- c) familiar language and learning experiences ( meaningful contexts)
- d) extended literature across the curriculum
- e) sensible and appropriate strategy lessons- specific teaching
- f) use of community expertise



Further principles by which to guide the development of language rich classrooms

Since language is primarily communication, function takes precedent over form.

Since language is central to learning, language will operate across the curriculum.

Themes provide the context and focus for many of the elementary activities. At all times the inter-relationship of speaking, listening, viewing, reading and writing takes place.

Further guiding principles

Language develops primarily through its purposeful use.

Language involves and occurs through talking and writing.

Language use contributes to cognitive development.

Children will understand and remember only what they have the opportunity to talk and write about.

Children learn to read and listen beyond mere word recognition only if they regularly practice expressing their own meanings in speech and writing to themselves and others.

Children learn only if knowledge is defined in action as dialogue or conversation between teacher and student, student and student, student and the text, student and the world.

Further guiding principles derived from NAEYC position statement for 5-8 year olds.

(*Young Children* . January 1988: pgs.64-84).

"The relevant principle of instruction is that teachers of young children must always be cognizant of the whole child."

"The relevant principle of instruction is that throughout the primary grades the curriculum should be integrated."

"....primary aged children should be engaged in active, rather than passive activities."

"....the content of the curriculum should be engaging, meaningful and relevant to the children."

"....when schools unduly rely on competition and comparison among children, they hasten the process of childrens' own social comparisons, lessen childrens' optimism about their own abilities and school in general and stifle motivation to learn."

"....curriculum and teaching methods should be designed so that children not only acquire knowledge and skills, but they also acquire the disposition or inclination to use them."

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## Appendix 2

### Language and learning: a brief synopsis of the work of Barnes and Vygotsky

The questions of conceptual understanding and the difficulty of accommodating prior knowledge is intimately related to the role of language in instruction and thought. Barnes (1976) has described this gap as one between "school knowledge" and "action knowledge". Vygotsky(1962), in respect of conceptual understanding, as one between "spontaneous concepts " and "scientific concepts". These definitions are not presented as dichotomies, but represent a continuum along which students make an educational journey. Research suggests that both linguistically and conceptually this is not an easy journey neither is it necessarily one that all students will make or should make.

Barnes(1976) argues that it is important that teachers direct their attention to that Ausubellian relationship between what the learner knows already and the new system being presented to him.

*To learn is to develop a relationship between them [prior knowledge and school knowledge] and this can only be done by the learner himself.....This is why pupil's talk is important ,in that it is a major means by which learners explore the relationship between what they already know, and new observations or interpretations which they meet (p.81).*

The central problem of teaching and particularly science teaching therefore, is how to present adult scientific conceptions to children so that they do not become merely memorised and fragmented pieces of knowledge. Barnes quotes Piaget on this central problem.

*In some cases, what is transmitted by instruction is well assimilated by the child because it represents an extension of some*

*spontaneous constructions of his own. In such cases his development is accelerated. But in other cases the gifts of instruction are presented too soon or too late, or in a manner that precludes assimilation because it does not fit with the child's spontaneous constructions. Then the child's development is impeded, or even deflected into barrenness, as so often happens in the teaching of the exact sciences. Therefore I believe...that new concepts, even at school level, are always acquired through adult didactic intervention. This may occur, but there is a much more productive form of instruction: the so called 'active' schools endeavour to create situations that, while not 'spontaneous' in themselves, evoke spontaneous elaboration on the part of the child, if one manages both to spark his interest and to present the problem in such a way that it corresponds to the structures he has already (p.81).*

Learning is viewed by Barnes very similarly to Piaget, that is, in terms of transformations, as occurring not only in interaction with new sense data but also through communication with others. Barnes therefore emphasises the centrality of pupil's talk, particularly "exploratory talk", in the learning process. Barnes states:

*.....whenever school learning goes beyond meaningless rote, we can take it that a child has some kind of relationship between what he knows already and what the school has presented (p.23).*

Language then, not only provides a framework or structure for experience, but is itself one of the most important instruments for learning. Talk facilitates our organisation and interpretation of particular events and their incorporation into our world view. We talk, and in so doing we relate an event to our prior experiences and make sense of it. In the process of talking we are mirroring our

thoughts, we are Barnes states, not only receiving knowledge, but remaking it for ourselves (p.20).

*The very act of verbalising new knowledge often requires a reorganisation of the old and the new together(p.113).*

Talk that allows one to work ones way into a problem, to mirror thought and reshape it, is what Barnes terms "exploratory talk". It is characterised by frequent hesitations, rephrasings, false starts and changes of direction (p.28). Barnes would argue that "exploratory talk' is essential whenever the learner wants to take an active part in learning and to bring what he learns into interaction with that view of the world on which his actions are based(p.23). Furthermore, "exploratory talk" sustains open enquiry. Barnes suggests that the learner takes more responsibility for formulating and evaluating explanatory hypotheses when he is allowed to control his own language strategies and think aloud. It becomes of prime importance therefore, that "the learners have an opportunity to talk with others in order to go back over experiences and represent it to themselves"(p.30).

Martin (1971) reiterates this view by further suggesting that children need opportunities to talk through their understanding, to hear and "kick around " other points of view. This is best done using a flexible "expressive language"(Britton:Language and Learning) in the context of genuine communication with a sympathetic and interested audience.

*We can't really be said to know something until we've made it part of our own way of thinking and explored its implications ...Often this involves shaking-up and reorganising a whole system of ideas by which we explain the world to ourselves(p.12).*

Language, particularly "exploratory talk", enters the curriculum through the classroom communication system as devised by the teacher and through the individual child's strategies for learning. Whether the child is allowed to play an active part in the formulation of his knowledge will depend, according to Barnes, upon the intentions and expectations the teacher brings to the class and the patterns of communication established by the teacher. In developing this model of communication and curriculum, Barnes makes distinctions between:

- 1) the transmission vs. the interpretation of knowledge
- 2) the assessment vs. the understanding of student interpretations
- 3) the presentation vs. the sharing of knowledge
- 4) final draft speech vs. exploratory speech.

Knowledge, Communication and Learning-A Hypothetical Model

<u>The teacher's view of knowledge</u>		<u>Kind of learning encouraged</u>	
<u>Classroom Communication System</u>			
Teacher's Role		Pupil's Role	
Public discipline	----- Transmission -----	Presentation	----- Boundaried
	(Assessment	(Final Draft)	(School Knowledge)
	Predominates)		
Knower's ability-----	Negotiations-----	Collaboration-----	Related to everyday
to Interpret	(Reply Predominates)	(Exploratory)	(Action
Knowledge)			

(Barnes, 1976,p.146)

Barnes states that "the teacher's implicit view of knowledge and his responsibility for it carried implications for the social order... and for the learning behaviour open to his students"(p.126). He

further states, "A view of knowledge is likely to carry with it a view of classroom communication and of the roles of the teacher and pupil in formulating that knowledge" (p.139). Barnes is therefore concerned with the teacher's "responsiveness to the learners view of what is required"(79). In thinking that knowledge is "out-there", we have a tendency to assume as teachers that we can give knowledge purely by telling.

*Getting knowledge from "out there " to in "in here" is something for the child himself to do: the art of teaching is knowing how to help him do it(p.82).*

It is at this point that Barnes makes his distinction between "school knowledge" and "action knowledge".

*School knowledge is the knowledge which someone else presents to us .We partly grasp it , enough to answer the teacher's questions to do exercises, or to answer examination questions, but it remains someone else's knowledge, not ours (p.81).*

"Action knowledge" is the children's use of language to make knowledge their own. It is "action knowledge" that becomes for Barnes "exploratory talk", whilst "school knowledge" is identified with teacher talk , described by Barnes as "final draft". A teacher's view of knowledge, Barnes states, falls along a continuum from interpretation to transmission.

The interpretation teacher views knowledge as resulting from the child's active participation in the

assimilation and accommodation of experience. Exploratory talk, as improvisation accompanying the rearrangement of one's own thoughts, follows as the most appropriate tool for learning. Barnes further believes that the exploratory mode is more likely to be encouraged where a teacher's replies imply acceptance and understanding, if not agreement, and where the teacher and learner are in a collaborative relationship. This is teaching for assimilation rather than accommodation.

The transmission teacher, conversely, visualises knowledge as a body of accumulated learning outside the child which must be transmitted to him. Following from this, the teacher's role in assessing the amount of knowledge transmitted is emphasised, which consequently encourages the student to present his learning in a prematurely formal, complete "final draft" form. Knowledge, parcelled as standard science or teacher's science becomes a form of "cultural transmission".

The interpretative teacher makes allowances for "action knowledge", the transmission teacher ignores this and emphasises "school knowledge". A classroom dialogue in which sharing predominates over presenting, on which the teacher replies rather than assesses, encourages pupils when they talk and write to bring out existing knowledge to be reshaped by new points of view presented to them (p.111). If the pupil perceives the teacher as primarily concerned with assessment, he may present a facade, concentrating on external display rather than the exploratory talk requisite to relating new knowledge to old in formulating meaning. Barnes cautions, however, that:

*To advocate an interpretation view of education is to argue that teachers should never present knowledge to their pupils, but rather to imply that certain patterns of communication should follow the presentation as pupils negotiate their own ways of grasping the knowledge presented (p.149).*



Barnes further states that "Demands for final drafts prematurely is asking the child to arrive without having travelled"(p.118). Barnes therefore draws this important conclusion:

*This is why I have emphasised that through language children can come to terms with new knowledge and relate to it what they already know. But this takes time: children need time to assimilate what they are learning by talking and writing about it in relation to what they know already. Too many classrooms ask children to relate strange information only to other strange information : the conversation is carried out in terms of what the teacher knows, while the child's other experiences-in and out of school -are excluded. This prevents the children from engaging in significant recording of their experiences (p.85).*

Vygotsky(1962) argues that conceptual thinking and the ability to handle concepts is not identical with the ability to handle language or to express those concepts in language.

*The adolescent will form and use a concept quite correctly in concrete situations, but will find it strangely difficult to express that concept in words, and the verbal definition will in most cases be much narrower than might have been expected from the way in which he used the concept...this confirms the assumption that concepts evolve in ways differing from deliberate conscious elaboration of experience in logical terms. Analysis of reality with the help of concepts precedes analysis of the concepts themselves(p.70).*

Vygotsky's point demonstrates the fact that the growth of language and the growth of conceptual thinking are far from being identical. Word meanings evolve, concepts develop in a kind of

hermeneutic spiral or growing web: word/concept building upon concept/word based upon experience, use, and intellectual and linguistic maturity. We must expect no short-cuts, assume that our teaching is only a part of the continuum of the "spiral" or "web" of the child's language experience- and hope that these experiences are as wide and as concrete as possible. We must therefore help students develop breadth of knowledge and experience, linguistically and experientially, before requiring definitions.

Vygotsky also makes an important distinction between two kinds of concepts: scientific and spontaneous. In his discussion of the relationship between thought and language, Vygotsky likens each to a vine originating from a separate source but becoming so intertwined that in the adult they are inseparable.

Spontaneous concepts constitute the informal knowledge that a child holds of the world and how it works. This prior knowledge is a product of efforts to make sense of the environment, tempered and manipulated through interactions with parents, peers, television, and other influences; it is influenced by language, by culture, and by other individuals. Spontaneous concepts are acquired in a rather haphazard way. Children do not, for example, set out to learn of the Earth as a cosmic body. The children's senses reveal a flat Earth, but they also see in photographs from space that it is round.

Scientific concepts represents that formal body of knowledge approved by the consensus of respected adults who are usually older and more highly regarded than the student. Scientific concepts are consciously learned, whereas spontaneous concepts we pick up automatically in the

course of living. The latter being a more systematic knowledge originating from adult instruction the former being "the child's ideas of reality developed mainly through his own mental efforts"(Vygotsky,1962,p.84). Scientific concepts depend upon verbal intervention, whereas spontaneous concepts depend upon contact with reality. Scientific concepts provide systematic, general structures, whereas spontaneous concepts provide the substance of experience which can make the scientific concepts more meaningful.

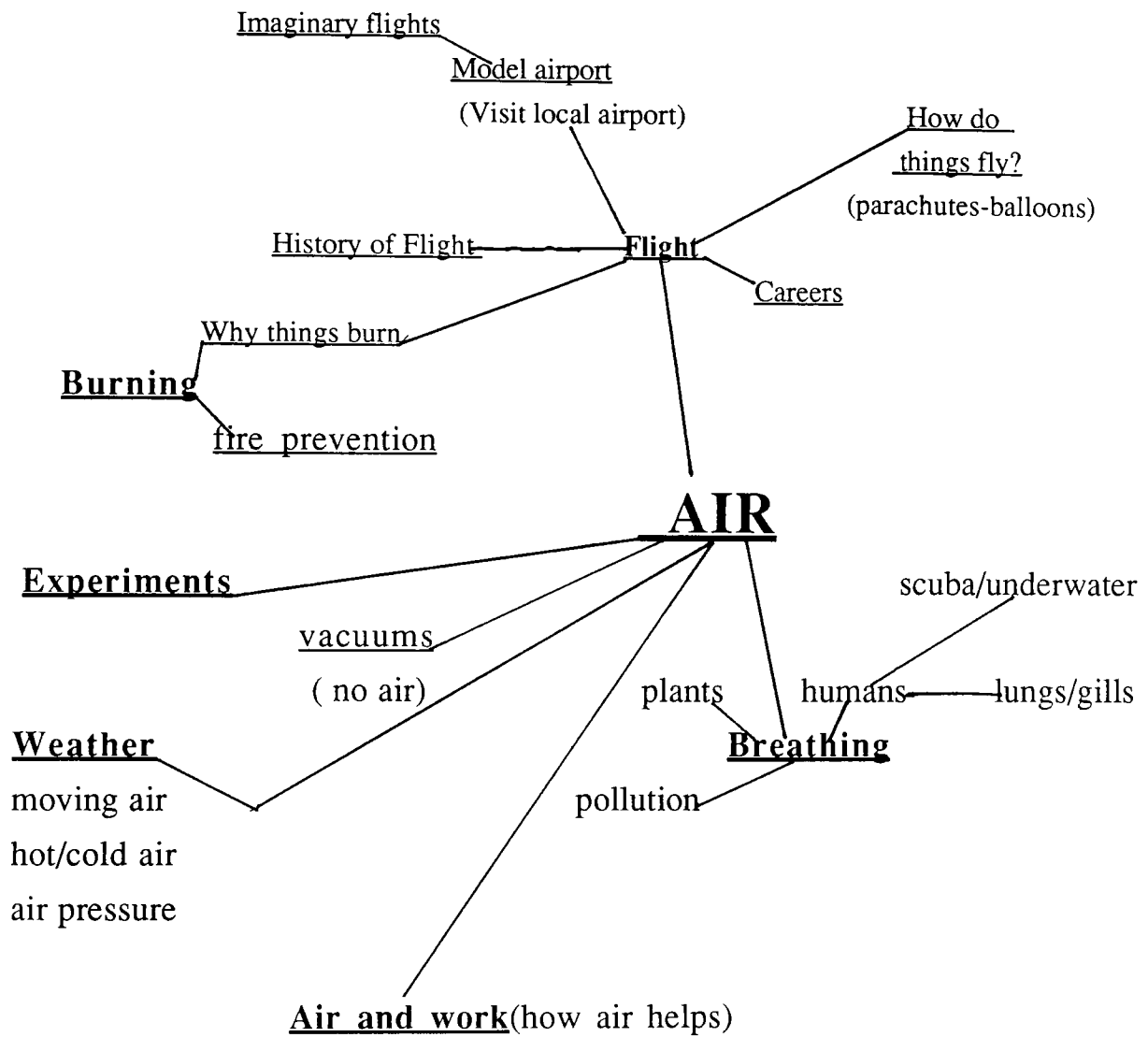
*The child becomes conscious of his spontaneous concepts relatively late; the ability to define them in words , to operate them at all appears long after he has acquired the concepts...The development of a scientific ...starts its life in the child's mind at the level that his spontaneous concepts reach only later...The inception of a spontaneous concept can usually be traced to a face-to-face meeting with a concrete situation,while a scientific concept involves from the first a"mediated" attitude towards its objective"(p.108) .*  
*"In working its slow way upwards ,an everyday concept clears a path for the scientific concept and its downward development. ...Scientific concepts grow down through spontaneous concepts, spontaneous concepts grow upwards through scientific concepts(p.109).*

Vygotsky stresses the importance of instruction in modelling and thereby influencing a more advanced structure of thought, instruction which "marches ahead of development and leads it....aimed not so much at the ripe as the ripening functions"(p.104). The introduction of scientific concepts therefore through instruction can provide the child with a classification system to which he can relate his personal experiences and from which he can gradually transform and organise his spontaneous concepts towards higher developmental levels.

The acquisition of concepts involves therefore, from a Vygotskian perspective, more than just getting some words to say. It means acquiring an interconnected set of words, and making connections between the meanings of these new words and other meanings which you already have. More than verbal definitions are needed if we want to help pupils master new concepts; we have to pave the way if new learning is to fit into existing frameworks. This can be done only by drawing out relevant spontaneous concepts and using them to help meet new scientific concepts half way. Since "...thought is not merely expressed in words; it comes into existence through them" (Vygotsky, 1962, p. 125), it follows that there are some kinds of information that children can gain through talk with adults, particularly concepts involving abstract qualities and relationships. Thus, the role of the teacher and language in bridging that gap between what is known and what is new; between "school knowledge" and "action knowledge", becomes vital in the development of conceptual understanding.

**Appendix 3****Document #1**

Unit plan map of science connected with concept of air.



**Document #2****Unit title: Air(experiments)- a separate science unit****Concepts**

When air is warmed it expands.

Warm air expands - occupies more space and rises.

Air contains moisture or water vapour.

Air can push on things.

**Objectives.**

See pages 2-3 of curriculum guide.

**Resources/materials.**

Attached experiment sheets.

Science Textbook: Addison Wesley pgs.88-103.

Films: CAMS(MP 3501): Learning about Air.

**Methods and Activities.**

Students may conduct experiments individually, as a group or at a learning centre.

Experiments may be conducted as class demonstrations.

**Evaluation.**

Paper and pencil.

Multiple choice.

Completed work.

**Document #3****Key scientific concepts about air and how they satisfy core curriculum requirements**

Core curriculum requires investigation of Matter and Energy

Air is matter: it has mass and takes up space.

Some relevant concepts for teaching about Air. Those marked with a \* are very appropriate for grade three students.

Air exerts pressure.\*

When air is warmed it expands.\*

Warm air exerts less pressure than cool air.

A given volume of cold air weighs more than the same volume of warm air(warm air is "lighter").

Air flows from areas of higher pressure to areas of lower pressure.

The earth is heated by radiant energy from the land.

Air is heated by contact with the land or sea.\*

Land heats and cools faster than water.

Warm air expands, occupies more space and rises.\*

Cooler air contracts(is more dense) and descends.\*

Air contains moisture or water vapour.\*

Warm air has greater moisture holding capacity than cool air.\*

**Document #4**

**Brief outline of classroom plans for health unit within topic AIR.**

The air we breath-science/health connections.

Week 1: How do we breath? Where does our air come from? Show simple model of the lungs.  
How long can you hold your breath for? Design an experiment to help you.

Week 2: How do animals breath? Do insects have lungs? How does a fish breath? Do plants  
breath?

Week 3: Explore in what ways we pollute our Air.

Week 4: What if we had lungs and gills- how would our lives be different?



**Document #5****Demonstrations and experiments****Week 1: Air exists/ Air is all around us.**

Move hands through the air, what do you feel? Pull a plastic bag through the air, what do I catch?

Light a candle and put a jar over it. Why does the candle go out? Make a mural of all things found in the Air. Make and experiment with parachutes and paper helicopters.

**Week 2: Air presses and pushes.**

Explore suction cups. A leak proof bottle! Pushing a stretched plastic bag down into a container and trying to pull it out. Breaking a ruler held down by a sheet of newspaper! Filling a cup with water, placing a card over the surface, inverting and watching to see if the water pours out!

**Week 3: Compressed air-lifting things up.**

Visit local garage for examples of compressed air usage.

**Week 4: Warm and cold air experiments- examples from prescribed textbook.****Week 5: Air contains water.** Simple experiments connected with evaporation and condensation.**Week 6: How do things fly?**

Making, designing and modelling paper airplanes.

**Document #6**

Introductory activities related to Unit on Air- activities that encourage questions, demonstrate prior knowledge and act as starting points.

**Make a collection related to Air: make a class collection.**

Vacuum cleaner Bicycle pump Syringe Straws Feather Pictures of things that fly etc.

Brainstorm with the children other objects that they think are related to air. Encourage them to bring them in.

**How do we know air exists?**

Riddle: What is it I can't smell, see and fills empty spaces?

Balance an inflated balloon and a deflated balloon. Why does the inflated balloon have a greater mass?

**Atmosphere**

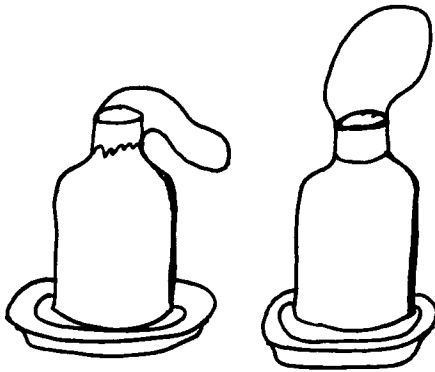
Why do astronauts need spacesuits?

Why do divers need aqua-lungs?

Why do mountain climbers need oxygen?

Document #7ExperimentsWhen air is warmed it expands.

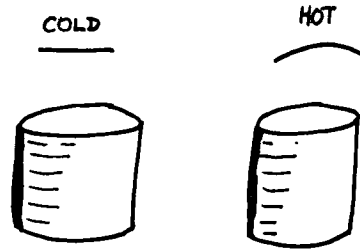
(1)



a) cold-no change

b) add hot water-balloon will inflate

(2)



a) fill water(cold) to level

b) pour in hot water-level  
will expandc) place ice-cubes in water  
level will "contract".(3) Warm air expands, occupies more space and rises.

Make a simple windmill-hold over an exposed light-bulb and it will turn.

Try near a refrigerator. At the bottom you will get a down-draught, cold air "sinks". That's why your feet get cold when you raid the fridge!

4) Air can push on things. Why does a suction cap stick?

**Document #8**

What children knew about magnets when asked(October 26th. 1988).

Pick-up metal

Pick-up old cars

Pick-up some kinds of metals not all metals

Some stick to your fridge

All sizes and shapes

Cupboard doors-keep them shut

Screwdrivers and scissors can be magnets

They have poles and forces

Magnets can stick together

What children wanted to find out about magnets.

How much can a magnet lift?

How big is the biggest magnet?

How can magnets pick-up metal-how do they work?

Why are some shaped like horseshoes?

Can you make a magnet?

How do magnets get made?

Why do we need magnets?