

**THE REAL WORLD OF ELEMENTARY SCIENCE**

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## ABSTRACT

Science as an elementary school subject is often unsatisfactory from both the teachers' and the students' perspectives. This paper outlines a year-long qualitative study of two grade four classrooms in a rural Alberta school district, using classroom observation, interviews with teachers and students, and participation by the researcher in student activities and in teaching.

The study attempted to understand in a deep sense the real world of elementary science as experienced by both teachers and students, with a view to projecting how the teaching/learning situation could be improved.

From the data collected, four "surface" (easily-discerned) factors interfering with the teaching/learning situation emerged. They were that (a) teachers typically had inadequate background knowledge and experience with science, (b) teachers had scant understanding of appropriate pedagogy for teaching the subject, (c) teachers were unsure of student needs, abilities, and interests vis-a-vis the subject, and (d) materials and supplies were woefully inadequate. Pervading these factors was the problem of inadequate teacher time for preparation and presentation of good science lessons.

Two deeper themes emerged from the data as well. There was a fundamental misunderstanding among teachers

regarding the nature of science as a way of knowing and discovering rather than a fixed body of knowledge. Teachers also felt a deep fear of science, both as a school subject and as a general area.

The data also revealed that students did not like or dislike science per se, because they did not view science as being differentiated from other subjects. Rather, they liked or disliked whatever specific activities they were engaged in. They enjoyed process-oriented science because it tended to be more activity-based.

The study's major recommendation is that teacher in-service in science be structured so that teachers have an opportunity to do science process activities themselves, so that they can develop their own meanings of the material.

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## CHAPTER ONE

### INTRODUCTION

#### THE PROBLEM

By practical definition, an elementary generalist is a teacher who teaches all, or nearly all subject areas to his or her class. This tends to be the norm, especially in smaller schools. The generalist is therefore responsible for the whole gamut of the so-called 'core subjects': language arts, social studies, mathematics, physical education and science, but also for such complementary subjects as art, music, and health. This is indeed a wide and diverse range, and calls on the generalist to have a substantial repertoire of personal knowledge and skills not only in the content areas, but also in the pedagogical areas. While it might be argued that the level of content that most elementary subjects require is not very extensive, it is still true that most people have strengths and weaknesses, preferences, and varying levels of background in various subject areas.

Most teachers take the situation in stride, but there is one subject area that forms a glaring exception-- that of science. Over the last twelve years, in my role as first a school-based administrator, and now a central office administrator, I have had the opportunity to observe fifty or sixty elementary science classes. My general impression has been that, most of the time, science classes are dismally done. The tendency seems to be to present science as a knowledge-accretion activity having little connection to the real world of the student, and generating little excitement among teachers and students. In most of my classroom visits to elementary science classrooms, I had the distinct impression that both the teachers and the students were either bored or disinterested; I know that I usually was bored by what I saw. This feeling was borne out by a recent experience: I was invited to be an external evaluator, looking at the area of science, for a city school evaluation. I thought that I might see something different in a large urban school, but, although the school is in general an excellent one, with caring teachers and more than adequate resources, the science classes I observed were fact-based and dull.

My experience has been that the norm in the

humanities classes-- language arts and social studies-- is spirit and enthusiasm, and that math is generally at least competently taught. Why should science be the core subject that is the exception? What is there about science, or what is there about teachers of science, that makes it so?

#### THE PROBLEM IN THE CONTEXT OF RECENT HISTORY

It is not a recent phenomenon to bemoan the state of science teaching and learning in our public schools. An article written by Jacobson in the Journal of Research in Science Teaching is a case in point. In this article, the author "looks forward" to 1980 to a time when elementary teachers will have mastered the pedagogy of science, and will "...have a fine operational understanding of the broad generalizations of science,...will have a mental picture of man and the world that is generally consistent with that developed in the various sciences,...will have an understanding of the conceptual structure of science,...(and) have a particular interest in the relationships between science, technology, and society" (1968:74-75). It is apparent to this researcher that, ten years after Jacobson's 'target date', we are no

closer to this 'ideal' than when the article was written.

#### PURPOSE OF THE STUDY

Are the foregoing observations about science in the elementary grades accurate, and, if they are, why should it be so? The study described here was designed to address the general question of science as an elementary school subject. Specifically, I wanted to enter as much as I could into the real world of elementary school science, the reality for both the teacher and the student.

This study is part of a career-long interest in improving the quality of teacher-student interaction; this is also the focus of my Master of Education programme. The specific purpose is to broaden and deepen my understanding of the nature of science as a classroom experience for both students and teachers. The ultimate purpose is to help me be more effective as a provider of in-service assistance to teachers in the field. I believe that the only way that this can happen is if I understand as deeply as possible the lived experience of the real teacher and the real student in the real classroom, not some abstraction. Change "...is only possible...if the

animateurs can find ways of apprehending the teacher's daily life and the realities of the classroom" (Butt and Olson, 1983:90). My own experience in the field is too distant and too limited to generalize from.

#### IMPORTANCE OF THE STUDY TO THE RESEARCHER

The question might be asked if similar studies, like that undertaken on a large scale by the Science Council of Canada, would not serve my purpose just as well. I don't believe they would, because there is a fundamental difference between reading about an experience, and entering into it directly. Like the Science Council report, this study was grounded in the day-to-day reality of teachers and students of elementary science; its subject was the minutiae, the frustrations, the joys, the boredom, the discoveries. I hope the published results of this study are interesting and meaningful to others, and recreate the shared beliefs, practices, knowledge, and behaviours of the participants of the science classroom. However, these results are of secondary importance to me. The most important part has been the time spent immersing myself in the world of Elementary School science; this lived experience will help me

to provide meaningful assistance to these teachers in the future. "One of the incidental qualities of case studies is that they usually reveal that the person writing them is, to an extent, changed by doing the research..." (Walker, 1983:156). This experience of change has been real and profound for me.

#### IMPORTANCE OF THE SUBJECT OF THE STUDY

I consider science as a crucial subject, because, as Orpwood (1987:unpaginated) says, "...we live in a scientific and technological age and those of us who do not understand these areas of knowledge will be at the mercy of them rather than in control of them. Education in science and technology should help to equip us to take control of our own lives." Scientific literacy is just as important for today's students as linguistic literacy.

One has only to think of the major problems and questions facing our planet today to see how crucial scientific literacy will be for future generations--pollution and garbage in general which results in ozone depletion, the greenhouse effect, and acid rain, to name but a few side-effects; overpopulation and the diminishing amount of arable land; the inevitable disappearance

of fossil fuels; the breakthroughs in genetic engineering; and burgeoning technologies. Tomorrow's citizen must be equipped to make wise choices for his or her very existence will depend on these choices. The school science curriculum must be prepared to play an integral part in equipping future generations. So it is no idle threat or exaggeration to say that if we do not improve how science is taught and learned in our schools, we are placing our students at terrible risk of succumbing to the dangers mentioned above.

#### DELIMITATION OF THE STUDY

This study is concerned with the phenomenon of science as an elementary school subject as experienced by the teacher and by the student. The background questions are

1. How is science taught, and learned, in our elementary schools?
2. What concerns or problems do teachers and students have with the subject?, and
3. What can be done to help teachers and students be more comfortable with the subject?

In concentrating on the 'general', this study has tried

to avoid the 'specifics' of, for examples, particular teaching techniques, materials, courseware, classroom environments, or other such predetermined factors, except where these have arisen naturally from the collected data. There was no attempt to focus on the effects of planning, time-of-year, grade level, specific subject matter, and other similar considerations, in and of themselves.

Similarly, there was no attempt to examine children's qualitative understandings or misconceptions about science, nor measure student achievement in any way.

The study involved a year-long series of observations of, and interviews with teachers and students in two classrooms in one rural Southern Alberta jurisdiction.

#### LIMITATIONS OF THE STUDY

My nearly-quarter-century experience in education, spent in many different places and settings, assures me that the sites selected for this study are reasonably typical elementary classrooms. Obviously however, studying only two sites in one jurisdiction will

limit the kinds of generalizations and conclusions that can be drawn.

Another limitation is the particular situation of 'familiarity' and relationship between myself and the participants in the study. There is further detail about this later in the study.

## CHAPTER TWO

### REVIEW OF THE LITERATURE

#### EVIDENCE OF NEGATIVE ATTITUDES TOWARDS SCIENCE

I began my research by reviewing the literature dealing with attitudes towards science as a school subject, because one measure of the reality of a particular school subject is undeniably the attitudes towards it on the part of teachers and students. My assumption before I began this study was that attitude measurement was a necessary, and possibly sufficient indicator of reality.

That student and teacher attitudes towards science as a school subject and as a discipline are very negative is widely supported in the literature. A major concern is that attitudes are so low that the subject itself is in danger of disappearing entirely. Stake and Easley (1978) explain it by contending that science education is being displaced by an emphasis on the so-called basic skills of reading, writing and mathematics. Rowe envisions the real possibility of the subject disap-

pearing altogether from our programmes of study: "If there were such a thing as an 'endangered subjects' list, science would qualify for emergency help and protection" (1980:19). Manning, Esler, and Baird agree that "The amount, if not the quality, of science teaching is declining" (1982:40). The substantial Science Council of Canada Background Study 52 reports that in the elementary schools they studied, "...ten percent of the available time is allotted to the study of science...Unfortunately, a 'ten percent concern' is not likely to build teachers' confidence through experience, at least not in the short run, as the teaching of science in the early years is such a small part of the daily teaching load" (1984:17).

There has been extensive research and reporting of results on attitudes towards science as a school subject. Nor is this only a recent trend: Blosser (1984) reports that nearly 2 000 documents on attitudes relating to science education were available on the ERIC database. My own search had led me to many more recent than that, and also numerous journal articles, so one might be led to assume that attitudes to science is a well-researched topic that provides us with insight and understanding of the world of science as it exists in the classroom. But, as we shall see, this is not the case.

## VALUE AND APPLICABILITY OF ATTITUDE RESEARCH

Many of the documents that seemingly deal with attitudes towards science in reality deal with an entirely different topic-- "scientific attitudes", that is, approaches to solving problems, assessing ideas, and making decisions, e.g. Gauld (1982).

Even when those are set aside, there is a large body of documents dealing with results of very specific treatments. Some examples of these are: strategies to change negative attitudes towards science (Fraser-Abder, 1984; Ostlund, 1986), the differences in attitude brought about by the introduction of new curricula (Vanek and Montean, 1977; Kyle, 1986), teaching techniques (Johnson, Ryan, and Schroeder, 1974), new materials (Milson, 1979), attitude changes brought about by teacher inservice (Butts and Raun, 1967; Rennie et al., 1985), student age difference and attitude towards science (Ayers and Price, 1975; Stead et al., 1979), or even racial differences in attitude towards science (Stanback, 1981). Many studies (egs. Stead et al., 1979; Haladyna and Shaughnessy, 1981; Fisher and Fraser, 1983) suggest that teacher attitude and the learning environment have the greatest effect on student attitude, but there is a lack of clear

experimental evidence, for reasons dealt with later in this review. Many researchers suggest extensive longitudinal research of the OXOXOX... design be planned and carried out. (egs. Haladyna and Shaughnessy, 1981; Gauld and Hukins, 1980).

All of these studies deal with 'bits and pieces' of the reality of science, zooming in on one detail at a time but ignoring the whole. It is akin to studying one tree at a time, but being unaware of the forest.

#### PROBLEMS IN ATTITUDE RESEARCH

Haladyna and Shaughnessy, in their meta-analysis of research done thus far on science attitudes, found the field to be "disorganized and chaotic" because of poor statistical analysis, concerns over methodology, and disagreements about definitions. They give some recommendations regarding methodology of future research, but their most interesting recommendation-- their concluding statement-- suggests that research provide "...findings that are translatable to teachers in terms of modifying classroom practices and learning environments" (1980:23). This focus is completely lacking in almost all of the research on science attitude reviewed for this study.

For example, Crocker, et al. did long, carefully-constructed research with sixth-grade science classes in which the variable studied was the degree of teacher control. The researchers' stated "...ultimate aim...is to find main effects and interactions that are sufficiently generalizable to form the basis for decision making on grouping or on the matching of teaching styles to student characteristics." However, "if interaction effects are as context specific as the repeated treatments argument suggests, then such effects are of little value in practice" (1977:50, my emphasis).

The real problem with the work that has been done on measuring attitudes towards science education was revealed by Munby (1983) in his massive and comprehensive look at the instruments being used in research. Munby looked at 204 different examples of instruments, such as Semantic Differential, Projective, Likert-type Scales, Interest Inventories, and the like. He found serious problems with the validity, reliability, and even the accuracy of what these instruments seemed to be testing. He concluded that much research has to be done in the area of attitude measures themselves, before these measures can be confidently used in research about attitudes. He also concluded that many of the ambiguous and contradictory findings in science attitude research can be

attributed to poor data collection instruments. Page (1979) reinforces this conclusion by demonstrating that there are no adequate ways of assessing the validity of attitude scales. Schibeci (1983) agrees with Munby regarding the poor psychometric construction of attitude scales, and is further concerned with stability of attitudes. That is, attitude scales, if they indeed measure what they purport to measure, do so at a specific moment in time, but will these attitudes be the same an hour later, or a day later, or a month later-- this is something that has not been addressed in research. Similarly, Schibeci is concerned with the influence of non-school variables in assessing attitudes. For example, what influence will a fight at home have on an assessment instrument, as opposed to a recent field trip to a fun activity having some science base? Schibeci admits that the reason that this has not been researched is the inherent difficulty in separating these non-school variables from ones relating directly to science.

One of the greatest difficulties in assessing students' science attitude has been what Munby referred to as "the doctrine of immaculate perception" (1982:207). No matter how objective an objectively-scored attitude assessment purports to be, students will interpret the

items subjectively. It is not possible to take this subjectivity (therefore variability) into account. So, the attitude assessment remains a subjective one even though it is designed and scored as an objective one. Aikenhead (1985), attempting to take this problem into account, developed an instrument that required the student to write an 'argumentative response' to attitude questions, inferring attitude from opinion. This instrument, however, strayed into the area of cognition, which Munby (1983) criticizes as interfering with a clear understanding of attitude. Aikenhead suggests the development of an instrument that uses student-generated statements (from a large national sample) to create a multiple-choice attitude format. This kind of activity was opposed by Munby (1983) who indicated that we have altogether too many diverse instruments now, and that we need to research these before developing any others. Another problem is that this kind of instrument is geared only towards older students (junior and senior high school) and could not be easily used with elementary students. This is also the problem with most of the other attitude-measuring instruments that I came across in the literature (eg. Billeh and Zakhariades, 1975): they are designed for students in middle-school and up only, ignoring the primary students entirely.

Krockover and Malcolm (1978), recognizing the difficulty of using the traditional kinds of instruments with younger children, devised a variation of the Likert-type scale using 'happy-face, neutral-face, sad-face' indicators to investigate attitude changes when the SCIS program was introduced. Their results were ambiguous.

Harty, Anderson, and Enochs (1984) also report inconclusive results when Likert-type scales were used to measure student attitudes, for many of the same reasons covered above. They go on to suggest that the best way to conduct attitudinal research with young children is by using qualitative investigation. Stead et al. (1979) has made extensive use of verbatim transcripts of both teacher and student attitude statements, with valuable but fragmentary results. That is, there is no attempt at synthesis or conclusion with these statements. No trends or patterns are clearly established.

Besides Stead et al. (above), the only research I came across that dealt exclusively with attitudes of students towards science as a school subject was Lazarovitz, Baird, and Allman (1981). Using a number of quantitative attitude-gathering techniques, they concluded that there were five major reasons why students did not like science. They were: "I don't like the teacher and/or the

way he teaches." (33%); "Science is boring, not challenging, or not interesting." (23%); "I don't do well in science." (21%); "I don't like to do science activities." (17%); and "Science is not useful." (5%). These statements and percentages do little to help the researcher or practitioner understand what factors in the reality of the science classroom might lead to these attitudes. We need to understand the classroom phenomena that generate this boredom, this lack of motivation, and/or this distaste for the teacher and his pedagogy.

#### RESEARCH IMPLICATIONS

A number of things are clear from the above review. One, much of the research has had a very narrow focus, attempting to justify a particular program or technique or strategy, but ignoring the whole world of science as a school subject for children. Two, this research has had ambiguous, contradictory, perhaps even misleading results and conclusions. Three, the information gathering techniques and instruments used in past research on science attitude are, at best, questionable, and almost non-existent for younger children. Four, the

criticism and problems with quantitative instruments is confined almost exclusively to those used with the students, but not with the teachers. That is, there is a general satisfaction with instruments available to gather data on teacher attitude towards science, both as a classroom subject and as a discipline. However, attitude in and of itself is only a part of the teachers' total "world-view" of science, and limiting a study that is interested in the realities of lived experience to this one question seemed hopelessly inadequate.

The above would lead me to believe that, in order to obtain meaningful information about the students' real world of science, and not just this one focus on attitudes, a qualitative, descriptive research process would be the most valuable. Thus, the dual problem of questionable instruments in general, and the dearth of instruments for younger children in particular, would be avoided. The qualitative approach would also encourage a wider focus: the child-and-teacher-and-science in the real classroom, rather than some particular program or technique agenda. We need to look simultaneously at teachers' and students' lived-realities in science in order to find links and common themes, and to better understand.

## RESEARCH DIRECTIONS

Before embarking on this literature review, I wondered if the subject had not been 'researched-to-death', especially in light of the number of documents in both ERIC and in the journals. I now realize that it is an area crying out for a holistic, child-centered and teacher-centered research. We will never understand why attitudes towards science are as they are until we begin to understand the whole reality of science-in-the-classroom for both student and teacher. That is, concentrating on just attitude as a way of entering the world of science in the classroom is likely to lead to the same ambiguity and inconclusiveness as reported above. The research has to take a far broader view. Any research of this type that helps shed some light on this reality seems to me a worthwhile endeavour for the researcher, for, regardless of any 'conclusions' reached, there will have been a period of shared collegial experience.

## THEORY

Richard Butt (1981:89) asks "what are appropri-

ate or useful modes of inquiry" when seeking to effect classroom change to increase scientific literacy and/or improve the teaching of science. In reviewing the frameworks of theory dealing with educational reality, he concludes that "one of the main problems is we have great difficulty in putting policy into action...primarily because we do not understand the way our own reality base (the classroom and the school) works." He compares the "muddle" of education's "inappropriate empirical analytic work" to sociology's successful "low level functional theory," and concludes that "there is a case to be made for some good honest groping around in schools" (p. 90). He goes on to document a case study using a variety of qualitative methods, including observation in the classroom.

The kinds of questions this study seeks to answer are indeed "low level functional"-- what does a particular person in a particular role do under normal circumstances, what beliefs and backgrounds guide his or her practice, and what are the 'norms' of the situation? So, "groping around" in the actual setting of science classrooms, trying to understand the "what" before I seek the "why", would seem to be appropriate methodology.

Goetz and LeCompte (1984) formalize this "grop-

ing around" into an ethnographic approach, and suggest that this will provide the researcher with "a depth of understanding often lacking in other approaches to research." "The purpose of educational ethnography," according to Goetz and LeCompte, "is to provide rich, descriptive data about contexts, activities, and beliefs of participants in educational settings" (p. 17). Rather than trying to isolate specifics such as particular teaching methodologies, curricula, or materials, the kind of data that will result from this type of qualitative research "represents educational processes as they occur" (p. 17). These processes interest me in a general sense: "what does it mean to teach elementary-level science", rather than specifics such as topics studied, books used, or any particular approach.

#### CASE STUDIES-- ARGUMENTS PRO AND CON

Walker (1983), in giving "three good reasons for not doing case studies in curriculum research," describes some of the errors he has made, and some of the pitfalls of both observation in classrooms and interviewing teachers. He describes this type of qualitative research as being "an uncontrolled intervention in the lives of

others" (p. 156). Studies like this "give a distorted view of the world," and are "conservative...much like a photograph is conservative" (p. 160). He warns that the act of research like this "is to describe reality in order to create it" (p. 163). Despite the apparently negative nature of this journal article, the author concludes that he will continue to work in this type of research, having learned from, and continuing to learn from his errors. Articles such as this have useful advice for the neophyte researcher, not the least of which is to remember that such studies "tell a truth but not the truth." But any "truth" will do, as long as it is reasonably typical, if it leads to understanding.

Kemmis notes that "case study workers...must be prepared to meet demands for justification of their findings" (1980:96) and outlines, as does Walker, problems in doing this. He sees three particular problems that arise "whenever the attempt is made to set out a case and its justification" which he terms (1) the problem of transcendental justification (2) the problem of scientism, and (3) the problem of scepticism (pp. 117-118). The first involves the researcher's possible assertion that the theoretical terms or observation categories already exist, rather than being products of the context

of the case study. The second involves the possible belief on the part of the researcher that the products of the research are above critique. The third involves the tendency on the part of some readers to treat the provisional truths deriving from case studies as fabrications. Adding to the above problems are the necessary limits to the truth about any case. Kemmis (1980:121) lists the following limits:

- language and the imagination of the researcher
- interest
- relevance/utility
- perception of observer and participants
- cognition (what makes sense?)
- aesthetics of the report (what coheres? is fragmentary? can be accommodated?)
- prudence (what can be said or sought?)
- frameworks (theoretical, ethical, and ideological or the research, researcher, researched)

In the light of the foregoing, what arguments can be made **for** using a case study approach? For one thing, as Yin says, "...the case study contributes uniquely to our knowledge of individual, organizational, social, and political phenomena... , ...the distinctive need for case

studies arises out of the desire to understand complex social phenomena, (and) ...the case study allows an investigation to retain the holistic and meaningful characteristics of real life-events..." (1986:14). It has a "distinct advantage" as a method when "a 'how' or 'why' question is being asked about a contemporary set of events, over which the investigator has little or no control" (p. 20).

Stake (1980:73) puts it this way:

Case studies are likely to continue to be popular because of their style and to be useful for exploration for those who search for explanatory laws. And, moreover, because of the universality and importance of experiential understanding, and because of their compatibility with such understanding, case studies can be expected to continue to have an epistemological advantage over other inquiry methods as a basis for naturalistic generalization. ...this method has been tried and found to be a direct and satisfying way of adding to experience and improving understanding.

As my stated objectives for this study are "adding to experience and improving understanding", the case study method seems particularly suited.

#### QUALITATIVE VS QUANTITATIVE RESEARCH

For those who question the validity and useful-

ness of qualitative research in education, the same caveat (i.e. that it tells a truth but not *the* truth) must be applied to quantitative research as well. For example, the summary of the vast study by the National Assessment of Educational Progress called *The Science Report Card* (1986:132) finds that "most students...appear to be unenthusiastic about the value and personal relevance of their science learning, and their attitudes seem to decline as they progress through school." I, and most teachers I've talked to about science in the last few years, could have saved them the millions it cost to run that study! But, "there appear to be few consistent relationships between...reported attitudes and students' observed science proficiency..." and, "attitudinal questions reveal few consistent themes" (p. 132). The report suggests that the teaching of science is in a state of utter disaster. But how do these findings, as vague and inconclusive as they are, help us understand the world of the teacher who finds himself trying to teach science in the midst of this disaster? What do teachers feel about science? Are they aware of this vast disinterest among students of science? Does it alarm them? Do they care? If they care, do they feel helpless? What do students feel about science? Do teachers know why students feel this

way? Qualitative research of the case study design can help us begin to understand these themes, relationships, questions.

#### RELATED RESEARCH

I looked through the *Resources in Education Index* and *Current Index to Journals in Education* for the past ten years (under *Science Education Research*) to see if a study like the one described in this report has been done. I found that there has been some qualitative study of the science classroom. There have been case studies which target specific teacher behaviours, for example Cline (1986), who focussed on how a teacher selected "target students" to answer higher-level questions, and what the teacher's perceptions were in this regard.

The whole of the 1984 AETS Yearbook was devoted to qualitative studies, but focussed on specific curricular, material or procedural questions, eg. *Can Science Teachers Promote Gender Equity in the Classroom? How Two Teachers Do It*.

In *A Summary of Research in Science Education*, the periodical *Science Education* documents numerous case studies and other qualitative approaches in the section

"Teaching and Teacher", but again all of these focussed on specific questions such as teacher belief-bases or the perception-practice gap.

In his map for a meta-analysis of science education research, Anderson (1981) identifies the six areas into which the vast majority of current research could be grouped. They concern curricula, instructional systems, teaching techniques, teacher training, science teacher characteristics vis-a-vis student outcomes, and science student characteristics vis-a-vis student outcomes.

In other words, none of the research I could find was interested in pursuing the "low level functional," synoptic approach to the world of the science teacher that this paper reports. As valuable as all the research on specific questions undoubtedly is, it only provides fragmentary answers to my basic question, "what is the world of the science teacher and student really like, and why is it that way?"

## CHAPTER THREE

### METHODOLOGY AND PROCEDURE

#### DEVELOPMENT OF THE RESEARCH

As stated at the beginning of the previous chapter, I began my quest for understanding of the world of elementary school science by envisioning some sort of quantitative project involving attitudes. For example, in a proposal dated three years ago, I proposed to identify (a) what the attitudes of elementary grade children are towards science as a school subject, and as a general discipline, (b) what the attitudes of elementary school teachers are towards science as a school subject, and as a general discipline, and (c) if there is a relationship among these respective attitudes.

As reported in the previous chapter, my reading convinced me that this was not a potentially fruitful area for me, so I began to investigate other areas of quantitative research. But browsing through reports with

titles like *A Comparison of Structured and Unstructured Modes of Teaching Science Process Activities* (Crocker, Bartlett and Elliott, 1976), or *A comparative laboratory study of the effects of two teaching patterns on the behaviour of students in fifth grade science* (Shymansky and Matthews 1974), to give but two examples, soon showed me that another approach would be needed to satisfy me. These studies, while undoubtedly learned and useful in their own ways, were all concerned with specific aspects of the science classroom rather than a holistic approach.

The next step in my 'sorting-out' process was to propose what I thought was a qualitative project, using questionnaires for teachers and interviews for students, to involve a wide range of elementary classes in my home jurisdiction. I still at this time had a definite working hypothesis in mind, involving attitudes towards science. My problem was that I had a personal academic background in English Literature, with some smattering in the Physical Sciences, but with no background at all in the Social Science tradition of qualitative research. I decided to take the Qualitative Research (Education 5938) course as part of my program. At this point I was looking at a rather ambitious "Action Research" project involving not only the gathering of ethnographic data, but also the structuring of a complete "plan of action" to take the

teachers involved in the study to some point of improvement in their teaching of science. Dr. David Smith, who taught this course, helped me to realize how little I knew about the world of qualitative research, so I subsequently took a Qualitative Field Methods (Sociology 3120) course to get some practical, hands-on experience. Dr. Smith also forced me to clarify my thinking about what I wanted to discover, and helped me realize that I needed to do one thing at a time-- that a project to discover "the real world of elementary science" was valuable in and of itself, and that the action part of it should wait until after the ethnography was completed.

These courses, in introducing me to the world of qualitative research, convinced me that this was the 'way' that would satisfy my needs.

#### RESEARCH STYLE

The study described in this project is therefore qualitative in nature-- an ethnographic case study. Goetz and LeCompte (1984) tell us that the data resulting from educational ethnography depict the true processes of education-- that of the classroom. These processes are

examined in totality; they are not taken apart, isolated, fragmented. This is precisely the approach I was seeking.

The third volume of the Science Council Report advises that

...we find we must attend to how the subject of science fits into the working life of the science teacher. The case studies show that, in practice, teachers are concerned with maintaining their credibility, exerting their influence, gaining access to scarce resources, coping with conflicts between outside expectations and the realities of the classroom, coping with a lack of skill to teach science as innovators imagine it should be taught, fulfilling the expectations of authorities and resolving conflicts between students' interests and the demands of the subject. (p. 15)

Are these the concerns of teachers in my local area? Does a list of concerns express the reality of the science classroom for teachers? What consideration is given to the students? In other words, would studies such as these answer my research questions?

No, because "The work these teachers do is complex, and these studies are but preliminary glimpses of the science classroom" (p. 17). In order for me to make my own meaning of the situation, I had to do my own glimpsing.

## CASE STUDY METHODOLOGY VS THIS STUDY

Yin (1986:23) defines the case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." Case studies, by definition, do not have to be qualitative or participant-observation in nature, but this study is both, for reasons discussed elsewhere. They must involve one or more 'cases'; this study, although it involves two sites, is one case-- that of science teaching and learning in a middle elementary grade.

Generally, according to Yin (1986:23), the design of a case study requires that research questions be proposed, that tentative hypotheses be proposed, that the unit of analysis (i.e. what the 'case' is) be defined, that a method of linking data to hypotheses be proposed, and that criteria for interpreting the findings be elucidated. But, if the foregoing is taken as a test of admissibility, then this study would fail, as my original design had only two of the above five 'criteria' (research questions and unit of analysis). Yet, as Adelman, Jenkins, and Kemmis (1980:48) point out, "'Case

study' is not the name for a standard methodological package. Research methodology is not defining in case studies...." Their concept of a case study being "the study of an instance in action" (p. 49) is applicable here. The actual methodology used in this study, then, derives not from it being a case study, but rather from it being ethnographic participant-observation of a case.

#### SPECIFIC RESEARCH QUESTIONS

Besides the general question of "What is the world of elementary science like for the teacher and the student?", some of the specific questions that this study addresses are:

- (1) What do the teachers believe the purpose of science teaching is?
- (2) What are the teachers' "philosophies of science teaching"?
- (3) How do the teachers approach planning for the subject?
- (4) How important do the teachers believe the subject is?
- (5) How comfortable do they feel about it?
- (6) How meaningful and useful are the materials available to the teachers?
- (7) How do the teachers feel about the way students respond to the subject?

- (8) How meaningful and important is science in general in the teachers' lives?
- (9) How important do the students believe science is?
- (10) How meaningful is the subject in their lives?
- (11) Why do they think they are learning science?
- (12) How do they respond to science classes? Why?
- (13) What kind of classes would the teachers and the students like to have? Why?
- (14) Is there a difference in the way students and teachers view science? If so, why?

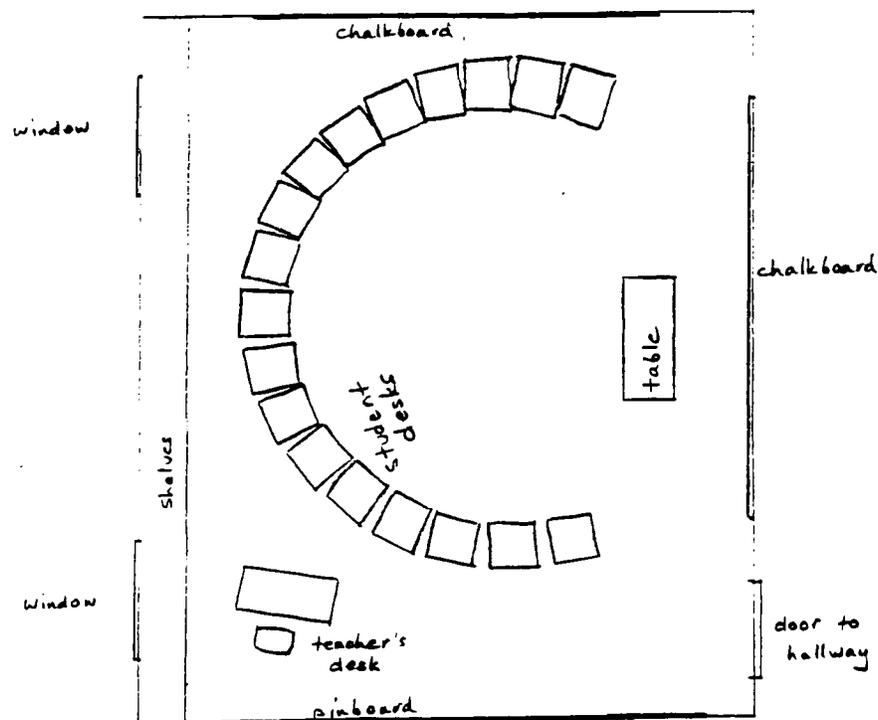
#### SITE AND SUBJECT SELECTION

Two grade four classrooms were chosen as data sites, with the consent of the School Board, the Principals of the two schools involved, and, most importantly, the teachers. They agreed to allow me both to observe their science classes, and to interview them. One teacher, Carol, is relatively new to teaching, although not a beginner, and the other, Alice, is close to retirement. I have good reason to believe that these classrooms are typical in many important ways, in terms of size, composition of students, availability of materials, teacher training and experience, socioeconomic mix, etc.

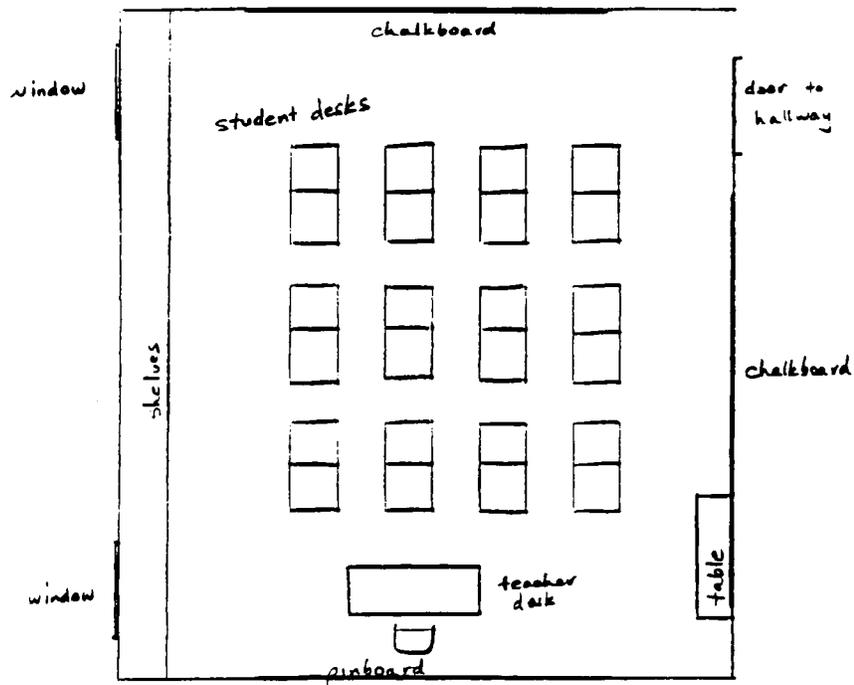
Carol's and Alice's classrooms are very much

alike in shape and size-- rectangular rooms about 31 feet long and 26 feet wide. Both have recently been painted off-white. The long outside walls in each room have a large rectangular window at each end, covered with ivory plastic vertical blinds. The full length of this wall has four-foot-high shelving units. Both rooms have recessed fluorescent lighting. The long inside wall, as well as one of the short walls in each room have green chalkboards with pinboard sections at each end; the other short wall has a large pinboard. The physical similarity of the two rooms is the result of both schools having been extensively upgraded within two years of each other.

What is different about each room is the way each teacher has arranged the students' desks, and their own desks. Carol's is arranged as follows:



While Alice's is arranged like this:



Some possible significance of this different arrangement is dealt with later in the study.

## ENTRY TO THE SITE

Since an understanding of the classroom process is what is desired, the classroom is the appropriate place to observe. As I mentioned before, I had obtained formal School Board approval when I first envisioned doing a study on elementary science. My relationship with both principals is such that, when I mentioned that I was interested in studying science, they both gave wholehearted support.

Lofland and Lofland (1984:25) advise the neophyte qualitative researcher to "...wherever possible...try to use *preexisting relations of trust* to remove barriers to entrance." The jurisdiction I work for is rather small, so staff tend to know each other on a personal as well as professional level, so I knew both teachers on a friendly basis. I had also worked with them on a number of professional development activities since assuming my Central Office role, and had developed a good collegial relationship: I knew them to be dedicated, caring teachers, and I hoped they recognized the contributions I have been trying to make.

When I first mentioned the possibility of doing a study of science in the classroom, even before I had

worked out the details in my own mind, a number of elementary teachers including the two eventual participants gave me some very positive feedback. They were interested in anything that could help them deal with science.

When I was a classroom teacher, I was involved, as the one being observed, in a study done by another graduate student. Even though I was quite self-confident, and reasonably satisfied that what went on in my classroom was good teaching, I remember being somewhat leery about the situation. Most teachers are simply not used to their 'territory' being invaded by others. Naturally, I assumed that my potential participants would feel the same apprehensions as I did, although we had been chatting informally, off-and-on for over a year as I tried to work out what I wanted to do. So, when I approached them with a *formal* request, I was careful with two issues. One, I made it clear that I would understand any reluctance to be involved, and that if they declined to participate it would not jeopardize the study as there were others I could ask. I insisted that they should only participate if they felt comfortable doing so. Two, I outlined in great detail what the conditions of participation were, and I emphasized their rights under the agreement. The agreement form is found in Appendix A.

I admit to being somewhat surprised by their

reaction, which was strikingly similar. Neither wanted to talk about the conditions of participation, or their rights, nor had they any questions or concerns. They both said, in effect, "Good! Let's do something about science! We need all the help we can get!" Still, I was always careful to ask if it was a 'good day' to come and observe or to chat, and was pleased that the feeling of trust was strong enough that they would occasionally indicate that, for whatever reason, it was not a 'good day'.

My role as Central Office administrator has to be taken into account in this study. In one sense, this role served to ease my entry to the site: teachers and students in our jurisdiction are familiar with me, and my presence in the hallways and classrooms did not elicit any undue reaction. Balanced against the ease of entry, however, was the interference that my 'normal role' produced. As part of the conditions of participation, I assured the teachers involved of the purpose of the research, and that they were in no way being evaluated in the sense that they are used to. However, I am sure that some of the responses to questions earlier in the study were 'conventional wisdom', or what they thought they *should* say. One specific example was Carol's answer to my word-association question, "What word would come into

your mind if I said science?" She answered, "I thought of inquiry.... but I'd say investigation." This is the 'right' answer in terms of contemporary pedagogy-- the "conventional wisdom"-- but I wonder how candid that answer was. I thought Alice's response of, "Oh!" was probably more heart-felt. Despite this, I was happy with the candour that developed through the course of the year. As the teachers saw that I was being non-judgmental in both the observations and the interviews, they became less concerned with appearing to be 'right'.

Another "mixed blessing" was that I was already quite familiar with the world of the classroom. I therefore had to work very hard to "...become explicitly aware of the things usually blocked out to avoid overload. Increasing...awareness does not come easily, for (I) must overcome years of selective inattention, tuning out, not seeing, not hearing" (Spradley, 1980:55). I am sure that I did not record some details, nor ask some questions, all because they seem too obvious.

#### THE METHOD

The two classrooms were observed for a total of twenty-three forty-minute science periods; a slightly

larger percentage in Alice's than in Carol's. Data was recorded using both written notetaking techniques such as teacher talk/student talk, activity summaries, and set-interval sampling, and some classes were recorded on tape. The techniques wherein I concentrated on one particular aspect of the class (for example, the ratio of teacher talk to student talk) were less satisfying in terms of data collection, although I am sure that even those contributed to my understanding of 'the big picture.' In hindsight, I should have used the cycle of preconference-observation-postconference more often, as it forces the observer to have a closer dialogue with the participating teacher about the classes themselves.

Besides a number of informal conversations with the teachers, four formal interviews each with them allowed me to experiment with a wide range of data gathering and feedback techniques, and allowed me to directly address some of the questions this study is interested in. The teachers were interviewed using overt taperecording, and some of the interviews were completely transcribed, and some were listened to and notes taken. The teachers were asked for comments on the some of the transcriptions of the interviews as well.

For both the formal interviews as well as the informal conversations, I used methodology suggested by

Spradley (1979) in The Ethnographic Interview. As a researcher with very little background in the Social Sciences, I found his structures and examples very useful. I tried to include as many of the types of ethnographic questions suggested by Spradley as possible. Some examples are: *Descriptive Questions* ("Think back and tell me what lesson you did in science...that you were the happiest with, that you thought was the best lesson you've done so far this year"), *Structural Questions* ("Would you say that science and other subjects like Language Arts, Social Studies and Math, are the same in some ways?"), and *Contrast Questions* ("How do you find teaching science different from teaching Language Arts or Math?"). Although I did not follow through on some of his techniques that I did not feel would yield valuable information in this context (making a taxonomic analysis, making a componential analysis), his book did give me sufficient background that I was able to obtain useful data.

I am indebted to the Qualitative Field Methods course that I took for helping me organize the "participant observation" part of this study, and also to methodology outlined by Spradley (1980). In many of the classes, I was a "passive" participant, simply sitting at the

back of the room, quietly jotting down notes, or watching, as the tape recorder made a record of what was said. In some classes I was an "active" participant, taking part in the hands-on activity with the students. In a few classes I was a "complete" participant, in the sense that I took over the role of the teacher, and although this was an artificial situation, gave me some very valuable insights.

#### DIFFICULTIES ENCOUNTERED IN THE RESEARCH

Time was my biggest obstacle. For example, I would have preferred to completely transcribe all of the interview and classroom recordings I made, but time did not permit this. I was amazed at how many hours it took to transcribe a half-hour interview; to do one forty-minute class took nearly four hours, and even then I abbreviated some things. I was fortunate enough to have some secretarial assistance to transcribe two of the interviews.

I was also hoping to be able to visit each classroom more than I did, but the specific times during which science was taught did not always correspond with time I had available. Although I felt that I visited

each room often enough to get the flavour of what happens in science classes, and obtain rich enough data to start discovering themes and patterns, there is always the feeling that something new and startling will happen when one is not there to see it.

Another difficulty concerned the teacher-participants. They went out of their way to be cooperative in terms of allowing me to visit and participate in their classes. They readily consented to be interviewed and often gave very candid answers to some probing questions. But they were reluctant to get involved in the 'making-sense-of-data' activities, beyond commenting on transcripts of interviews or lesson observation records. In an early version of the proposal for this research, I wrote that

I am hoping to have the teachers themselves help me make sense of (the data): code it and categorize in ways that are meaningful to them.

This did not happen. Part of the reason was pressure of time (again); the teachers were just too busy to give me more of their precious time than they already were giving. I can't help thinking that another part of the reason was my lack of research experience, knowing when to quit gathering and when to start organizing. I was so afraid that I did not have enough data that I almost ran

out of school year. I would be asking the participants to make sense out of raw ethnographic data at the worst time of the school year for any teacher-- near the end, when all manner of 'administrivia' must be completed.

Another difficulty was interviewing the students, which I deal with later in the study.

## CHAPTER FOUR

### OBSERVATIONAL DATA

#### INTRODUCTION

During informal feedback sessions and casual conversations, the teachers assisted me in "making sense" of the observation and interview data, in order to come up with a rudimentary "world picture" of the elementary science classroom. The conversations, interviews, and hands-on practice with students, doing experiments alongside them, helped me to see their perspective on this world. The teaching experiences I had gave me another window into the world.

#### GROUNDING THEORY-- A DEFINITION

The following sections deal with the data obtained from the year-long study, organized into hypotheses of how teachers and students live their lives in the elementary science classroom. These hypotheses are

grounded in the data, in the sense that Glaser and Strauss (1967) use the term; that is, they are discovered from the data. As Glaser and Strauss (1967:40) say

In the beginning, one's hypotheses may seem unrelated, but as categories and properties emerge, develop in abstraction, and become related, their accumulating interrelations form an integrated central theoretical framework-- *the core of emerging theory*. The core becomes a theoretical guide to the further collection and analysis of data.

This study's framework is in the form of a very elementary substantive theory (or, to use a more user-friendly term, conclusion) as to why science-the-subject is the way it is, and some projections about what might be done to change it.

#### EMERGING THEMES-- TEACHERS

As a result of my observations, discussions, "practica", and interviews, I came to understand something of the unease that these teachers feel in regards to science. Three 'levels' of themes emerged from the data. I have called these (a) surface themes, (b) a background theme, and (c) deeper themes; I do not wish this terminology to be interpreted as attaching relative importance to these themes, rather, this is simply how

they emerged. Each level is important in its own way.

## SURFACE THEMES

Four aspects of the teachers' professional world: (1) background knowledge and experience, (2) understanding of appropriate pedagogy, (3) perceptions of student needs and abilities vis-a-vis the curriculum, and (4) the quality of and access to available materials, are factors in how comfortable and successful teachers feel in regards to science.

### **1. Background knowledge and experience**

Both teachers were open and candid about their own lack of scientific background. Alice had no university science at all

(just) High School Chemistry and Biology--not Physics; we didn't have Physics then.... I don't feel as competent in science as in other areas, because I have to search for things, I don't understand things as well... I guess I'm not scientifically-minded.

and this lack of background poses very practical problems. For example, it is essential for her to choose activities

that I feel comfortable with. I want the ones that never fail. Because I find it

difficult to explain why some of these fail, so I like to be on safe ground with the children.

It is, of course, more difficult to explain why something *doesn't* work than it is to explain why it *does*. The 'correct' explanation can be found in any resource book-- no personal knowledge or background is needed-- but there may be a myriad of reasons, some of them technically obtuse, preventing the 'expected result' from happening. The less background knowledge the teacher has, the less likely he or she will have these explanations handy.

In another sense, it is correct to say that an experiment always 'works', that is, there is always a result, even if it is not the expected one. But teachers often assume that there should be only one 'possible' or 'correct' outcome. This ties in to a deeper theme that is dealt with later: the need for teachers of science to understand the nature of science as a mode of inquiry rather than a database of facts or series of 'right' answers.

This problem was very evident in one lesson that I observed, involving making rulers vibrate in order to make generalizations about sound. Alice very carefully followed the directions in the text, but the 'experiment' just would 'not work' the way it was 'supposed to', and

the teacher was at a loss to understand why. After a half hour of quite obvious frustration on the part of the teacher, and lots of 'twanging' rulers on the part of the students, the teacher's 'summation' was

Just remember this. We have different sounds depending on how many vibrations the ruler makes. When it was longer it made more and it was louder, like (names a student) said. And when we had the shorter end it made fewer. Fewer vibrations, so the sound is a different sound.

This is obviously an error of fact, and I could see that Alice was trying to work it out in her mind as she went along, but without success. This same lesson had quite a different effect on the students than it did on me-- although it took all of the professionalism I could muster not to jump up and say, "No, that's wrong!" (and lose the depth of trust that I had built up by never making a negative comment about a lesson), the students did not seem in the least perturbed at being confused. I refer back to this in a later section of this study.

Alice eventually gave up on this part of the lesson, and had the class go back to the textbook, to a different experiment. I would have liked to have had the opportunity to ask her to comment on this experience immediately afterwards, but time did not permit this. When I did broach the subject a few weeks later, she

admitted freely that the whole situation had bothered her.

**Alice:** I went back and read everything I could find about it.

**Interviewer:** If you had to do that lesson again, what would you do differently?

**Alice:** I think I'd quit (the activity) and try another day. Most activities I've done before, but not this one. I was getting the concepts mixed up in my mind.

It is my guess that the rulers wouldn't vibrate the way the text indicated because (1) many students had floppy plastic rulers that are unsuitable for the situation, and (2) those who had suitable rulers weren't holding them tightly enough against the desk. This relates to two other themes. The first, dealt with elsewhere in this section, is time spent on preparing for science: Alice had not tried the experiment herself before class. If she had, she would either have seen that it was not suitable, or she would have had a 'practiced' demonstration lesson ready. The second theme is science materials. Should a teacher have to rely on the vagaries of what particular type of ruler his or her students happen to have, or should there be suitable materials for these experiments on hand? This issue is further dealt with in aspect #4.

Alice was excited by an opportunity this year to have some Physics 30 students (my son was one of them) assist her in doing some electricity experiments. During

a formal interview she dwelt on the value that this 'extra body' had for helping in group work, but in informal conversations it became clear that she was very much aware that the Physics students were far more comfortable with the subject matter than she was.

Success in science, to Alice, is often expressed in terms of the success of the hands-on activities:

**Alice:** My favourite science lesson...might be once when we were making mud-pie mountains (for a unit on erosion) because everything worked well. Everything just seemed to fall into order. The experiments worked as they should.

**Interviewer:** The experiments worked as they should. That's important?

**Alice:** That's very important! Because then you don't have to explain the reasons why this may not have worked.

Carol also has little formal training in science,

except one course in introductory Biology...(which was)...just an extension of my High School Biology. I don't remember much.

She is also concerned that this lack of background means that students have to be kept away from using the Science Lab in the school. Not only is it not set up physically for her grade level students (the benches are too high, etc.) but also

I don't feel confident with the chemicals, etcetera. There have been some demonstrations set up there but most are done in the

classroom. A lot of it is my fault because I don't know what to do with it.

Alice said something strikingly similar when asked in an interview about the school's Science Lab. Not only is it "not well supplied" and "not conveniently located" but also

There are just too many things in there I don't want them involved in...acid or stuff...I'll let them go down there as they get older...with another teacher...probably in Junior High. I know some of the teachers have gone down there but I did a couple of times and I think I was... I fretted more about what there...well, maybe because they were so curious... I thought the lessons weren't as well-conducted as they could have been...working in the classroom, as they had been doing.

I did not observe a class of Carol's in which her lack of background, specifically, seemed to interfere with the flow of activities; it was only in what she told me both in the formal interviews and in the informal conversations that suggested that *she perceives* this is sometimes the case.

My reading suggests that this is neither a new nor a unique phenomenon: Washton (1961) describes 63% of a group of practicing teachers who were taking a graduate course in the pedagogy of elementary science as having only a junior-high level of science knowledge.

The Science Council of Canada Statistical Database (1984:39) reports that nearly three-quarters of the

elementary teachers surveyed had no university-level science, and that "there is an 80 per cent chance that a female teacher at the early-years level has not had any science since high school...."

## **2. Understanding of appropriate pedagogy**

Closely allied to the teachers' personal background and experience in the world of science, is their professional background in how to teach it. Carol has "no science methods courses at all, and Alice's "one course in Jr. E." (a two-year-after-High School teaching diploma that is no longer available) doesn't sound too promising. This is how Alice remembers the course:

She had rats running up her arm. This is how you handle a situation where you would have a hamster or a little white mouse. Let the kids look at it. I never did get to that stage because I don't like those little creatures.

Despite this lack of background, both teachers are acutely aware of the need to adopt a science-process approach to the subject, and are making every effort *they know how* to do this. Both talk at length of "trying to change", trying to effect, for example, a process-oriented electricity unit. Carol says,

I could have just stood up there and had the kids or told them (lectured). I wouldn't have done it that way but, mind you, some teachers do lecture-- this is electricity,

this is how it works...here are your notes, or here is the textbook, the chapter, read it and answer the questions. But that's not how you do it. You want them to investigate and figure it out for themselves. To guess and check it out. Maybe I am not as awful as I think sometimes. Maybe it's just I don't always know for sure what a science approach would be. Maybe I do it more than I think I do. I don't know that. I am not really a science person so maybe I'm not off-track as I think. Maybe we do more science process than I believe we do. I used to use the textbook quite a bit and used to lecture in a way, or have them do reports, and I don't think that reports is really science-- when you have a topic and go research it. That is more Social Studies again, when you research stuff. Rather than having them guess and investigate a little more. To me that is more science-- investigation, proving it, like manipulating it.

In this conversation, as at many other times during both formal interviews and casual conversations, I was being asked for feedback, for reassurance, for help, and it was quite a challenge to me not to be drawn into that mode. I felt that I would be sacrificing distance and objectivity if I was drawn into a role wherein I had to comment on the validity of any specific set of beliefs or actions on the part of these two teachers. I found it difficult, as this is one of my 'normal' roles; I believe that the teachers found it somewhat puzzling and frustrating.

Alice is just as aware of her struggle with pedagogy:

I sort of stick very close to the...science text books... I guess you might say I'm a science text book teacher... some chapters I almost know by heart. I'm trying to get what [an Alberta Education Science Consultant] wants us to do....

She is well aware that science is not

...book learned. That's not meaningful to (the students). I guess because it's such a hands-on world. They like that. They gain some knowledge and they can understand it. That's what I've learned-- the trend in teaching that is coming. It's not important to know specific science facts, it's to know how you come up with that generalization, and you sort of have to come around to that point. So if you can get them involved in something, they will probably remember something of it. They may have to go to a book and find a little bit more...I remember years ago, we learned everything in that book...that was the program. That's what we did...probably it's because that's what I did too, and you have to change, to fit the times.

Changing to fit the times is what these teachers want to do, but are unsure of how to go about it. When asked what would help her most in teaching science, Carol answered,

To see someone who knew what they were doing teach a unit-- see someone's unit or lesson plans. A model.

### **3. Perception of student needs, abilities, and interests**

One dichotomy that I noticed was between what teachers said was important for the students, and what

their actions and choices would seem to indicate. Not surprisingly, both teachers indicated that Language Arts was the most important subject for students, as the basis and foundation for all the others, but what was surprising was the contention that, for Carol, beyond Language Arts

Science has got to be top, or if not top has to be high up there. In today's society I think you have to have some science...

Alice also put Language Arts first, followed by Math,

then I would have to put science before Social Studies, because science tells you the modern world and they have to deal with scientific things.

Yet, when it came to timetabling, they 'allowed' science the minimum class time they could have. Alice had 150 minutes per week; Carol had 120 minutes per week. This is dealt with later in the section on time.

Another facet of this topic is the teachers' perceptions of what, in science, is appropriate for their students, and of interest to them. An interview with Carol dealt with this:

'Cause I wonder, do these kids really care what a series or parallel circuit is? Not really, you know. I kind of wonder, what's the point? Or, when we do friction. You know, what's the point? They're nine years

old. They could care less. Does it really apply to them? The stuff that I think they like best in science is the stuff they can apply to themselves more, they actually see some value. Like when we were doing electricity and I brought up the Christmas light thing--what do you do when you burn out a bulb. And they go, Oh wow! and they kind of got excited about the series and parallel. I find you've got to find comparisons like that or they could just care less. But you do that with everything, I guess. You've always got to relate it to them. To their background material or it's not relevant.

There are two different contradictions in the above example: the first concerning whether or not a grade four student would find series and parallel circuits interesting, and the second concerning whether or not science is different from other subjects in its need to be relevant to the students.

Alice also has some insights into what contributes to the students' interests:

**Alice:** Erosion wasn't as exciting.

**Interviewer:** Why not?

**Alice:** Maybe I'm not as interested in it.

**Interviewer:** I heard you say that (the students) don't like science as well as, for example, Social Studies.

**Alice:** Well, I don't think they do. It seems like you don't get the same response, and it could be me too. Maybe I'm just not as scientific. Because I really like Social Studies. Maybe it could be a feedback too... You can pass on vibes without even knowing it.

In many of the interviews and casual conversa-

tions, there was the belief stated that grade four students were "not ready" or "not mature enough" for the science curriculum. There seemed to be the belief that science could "come later", for example in Junior High. But just like in the question of relevance, there are obvious contradictions in statements about readiness. For example, in this interview with Carol:

**Interviewer:** When they're older, they're going to have science teachers?

**Carol:** Well, they do. They have specialists. And I think they're more ready for science too. People say, Nonsense! to that, like Baloney!...And that's true, because I know that (the students) do like (science). They like it when I do it in an investigative way.

**Interviewer:** Is what you're saying, they'd be ready for a different kind of science?

**Carol:** Perhaps, yes. Well, for sure, they get to use a lot more materials, you know, that's for sure, like the chemical side of it. But again, maybe I'm doing a better job than I think....

#### 4. Materials

My observations of classes and my conversations with teachers indicate very strongly that a perceived (a) shortage or lack of materials, (b) difficulties in obtaining them, (c) inappropriateness of them, and (d) mess or disruption associated with them, was a constant source of annoyance.

Texts are seen by both teachers as not being

useful for a variety of reasons. One is that they "know" that the course should not be fact- or text-based (although this concept does not seem to be very clear or internalized). Another is that the reading level of the available texts is perceived to be too difficult. Still another is that the hands-on activities in the text don't seem to work very well, especially when done by the students independently. Both teachers talk of a search for "things that work."

There was a litany of complaints that materials were not available, although this was often accompanied by the admission that these materials *could have been* available if the effort had been expended to get them, or if there was more certainty over what to have on hand:

**Interviewer:** What things interfere with (good science lessons)?

**Carol:** For something like when we did sound, it would be nice to have sound bells and tuning forks, so lack of materials, or the fact that I didn't know what to order or get a catalogue or figure out what we should order so we can have it. It's my fault too 'cause I didn't order this stuff when I should, probably.

**Interviewer:** Are you saying, maybe, you wouldn't know what to order?

**Carol:** Yes, I wouldn't know what to order. Exactly.

In stating "I wouldn't know what to order", Carol is demonstrating that two of the factors being

elaborated in this section are interwoven: materials and teachers' background knowledge, and these are combined with the pervasive element of lack of time.

However, both teachers agreed that materials were made available when requested ("We can get \$20 things easy enough"), and Alice was even quite happy to buy some of the materials herself to avoid the "bookwork", and that the library aide went out of her way to provide them with resources that they wanted. Facilities such as running water or extra storage space would be nice, and the opportunity to have, for example, a freshwater pond environment without running afoul of the janitor would be "A-1."

My exploration of the two classrooms, and observation of numerous classes revealed that there were far more materials around than these interviews and conversations might lead one to believe. For example, I watched Carol's class do a 'friction' experiment where each group had a full set of metric masses and a spring scale-- exactly what was needed to do the work. I know, too, that Alice's school has a wide variety of suitable materials, yet she contends that "our lab is not well supplied."

## CONCLUSIONS ABOUT THESE THEMES

I noted earlier that although I had termed the foregoing themes 'surface', I was in no way using this as a pejorative term. I wish to emphasize that the terminology does not mean that they are untrue, unimportant, or misleading, but merely that they are easily noted.

It seems unlikely that an elementary generalist can have an equal background in skills and knowledge in the diverse range of subjects that they are called on to teach. From my discussions with and observations of many elementary teachers over my career, I've concluded that science is the subject where few have any academic or professional training. For example, I did an informal survey of 31 elementary teachers in a local rural school district, and found that only 3 of them professed any background in, or personal interest in science, either as a school subject or in general terms. Many of these same teachers also admitted to "gaps" in a variety of other subjects as well, but the "gaps" tended to follow no pattern; science was the only subject where almost everyone had this lack.

This lack of background is not the only situation at work here, however. It is in part *responsible*

for, and in part just one factor in a larger condition. In order to enjoy comfort and success in their classes, teachers need to feel that their background is adequate, they need to be able to access appropriate pedagogical techniques, they need to feel that the curriculum requirements meet student needs and abilities, and they need to have access to appropriate materials and supplies. I sensed that these four factors "fed on" one another: that is, the lack of personal background (and interest in) the subject made it less likely that the teachers would actively seek out viable pedagogical techniques; their discomfort with the subject would translate into a perception that the students were also uncomfortable with it (the self-fulfilling prophesy); their lack of familiarity with (and interest in) the "tools" of the subject would feed a perception that materials and supplies were not suitable or not available.

It is my impression that the perceived lack of materials and supplies is a result of three factors. The first is an 'historical' one. In casual conversations, both teachers spoke of lack of co-operation from the previous science 'specialists' in both schools, especially when they were trying to follow a text-based approach, and wanted the exact materials specified (because they

didn't have the background knowledge necessary to deviate from the list). This lack of co-operation between Senior High School science specialists and the elementary generalists is not universal by any means; I have witnessed many instances of co-operation and have spoken to many elementary teachers who praise the efforts of their Senior High colleagues to help them with science. But where it does exist, it might be attributed to the widely different *cultures* of the subject-specialist, versus the generalist. Hargreaves (1986), in discussing middle schools, shows how different the perspectives are of specialists (who place a premium on the academic knowledge of the *subject*), from those of generalists (who place a premium on personal contact with the children over a range of subjects). This difference in culture might well interfere with a science specialist's ability and desire to provide collegial assistance-- materials, supplies, even suggestions for their use-- to a science-illiterate elementary teacher.

The second reason is the fact that the lab, where most of the supplies and materials are stored, is physically remote from their classrooms, being as it is in the High School section of the school. The third is a lack of familiarity with the materials due to both the

teachers' own lack of background in the subject. As one teacher mentioned one day in a casual conversation, "I wouldn't know it if I saw it."

Compounding all of the above is what the Science Council of Canada calls the "ten percent concern." That is, ten percent or less of the daily teaching load is science, yet its demands in terms of lesson and material preparation and knowledge far exceeds this time in relation to other subjects, partly because of the teachers' unfamiliarity with the subject and its requirements.

My findings as reported above are consistent with the Science Council of Canada Database (1984), which found that the top four areas cited by elementary teachers as being obstacles to achieving science objectives were (1) curriculum resources, (2) teacher's background and experience, (3) students' interests and abilities, and (4) physical facilities and equipment.

#### BACKGROUND THEME-- TIME

Pervading the 'surface' themes, in fact an "eminence grise" in all the data, was the problem of time. The demands on any elementary generalist's time are incredibly large, involving not only preparing for a wide range of classes, but also marking, playground supervi-

sion, preparing report cards, meeting with parents, attending staff meetings, coaching intramural teams, and other extracurricular activities. It is small wonder that, given the lack of personal and professional preparation in the subject, problems with materials, and questions about the value for their students, teachers give it short shrift both in teaching time and in planning time.

Despite the stated 'recognition' of the importance of science, there is a reluctance to give the subject any more than the minimum of class time. In fact, Carol reduced the amount of time devoted to science, and expresses fairly strong feelings about it:

I used to have four (forty-minute periods per week) but I didn't feel I needed it. I needed more for Math or Language Arts. You don't need four.... For me to try to do a better science program (it would take) a lot of prep time. I resent having to put so much prep (time) into my 120 minutes (per week of science). So for me it's "don't be stupid, and do this right, and put some time into it". But sometimes I resent that.

I resent it (but) I've decided it was science's turn this year.

The theme of 'resentment' towards science came through loud and clear in casual conversations with Carol, resentment at having a subject that takes less than 10% of her week's class time consume so much of her

available preparation time. Alice does not state the same feelings of resentment towards science; in casual conversations with her she admits that this is also, for her, science's turn to have a little more attention. She is coming to the end of her career, and wants to have science "in place," and "well done." Significantly, this is *after* she has spent considerable time coming to terms with Whole Language, Math Their Way, a new Social Studies curriculum, and Theme V (Human Sexuality) in Health. I got the impression, although it was never manifestly stated, that these other subjects had received the attention they did because of *external pressures*; that it was someone else's agenda-- either the Department's or Central Office's-- that set the priority. I know for a fact that there has *not* been a significant 'push' to change or improve science at the grassroots level in any local district that I am familiar with, despite the dire predictions in, for example, the Science Council of Canada report.

Planning time is also a problem: because the teachers are not comfortable with the hands-on experiments they might be expected to try them out themselves ahead of time. But as has been noted in the description of the vibrating ruler experiment, this wasn't always the case. In another class in this unit, Alice brought bot-

tles into class to have the students observe the change in pitch brought about by different amounts of water. The students were to (a) tap on the bottles and (b) blow across the bottles' mouths. Neither would 'work' because (a) the glass was the wrong type and wouldn't 'ring' and (b) the mouths were too wide to produce a sound.

I hasten to add here that the foregoing is not a criticism of the teachers, but rather a recognition of an important aspect of their lived realities. Neither teacher is lazy; both give more than full-time to her profession. Yet, there aren't enough hours in the day, and it is not a reasonable expectation for these teachers to create a meaningful science program for themselves, let alone their students, given the factors already discussed.

Carol's resentment about spending an inordinate amount of time on science is certainly understandable in the context of what she feels will give her, and her students, the most return for the finite amount of time there is available.

## DEEPER THEMES--

## (1) UNDERSTANDING THE NATURE OF SCIENCE

Underlying the five facets already cited is a deeper theme concerning the whole concept of science itself, as the teachers understand it. As a result of both personal and professional experience with science, it remains for them a dogma, a set of facts to be learned, rather than a process or way of knowing. Even when Carol was talking about classes that she was really proud of because they were hands-on, there were facts and concepts for the students to master at their core:

**Carol:** ...the hands-on material was pretty good. In the electricity I had them do a lot of things-- bulbs, wire, etc. and had them make a circuit and they had to figure out which end of the bulb went to which end of the battery-- had the students investigate this themselves. Worked quite well.

**Interviewer:** What I am hearing you say is what you liked about it was the fact that the students could do their own investigation and there'd be less input from you.

**Carol:** Like when we did insulators and conductors they just had to try it, complete the circuit and put stuff in between and then they had to arrive at the conclusion that stuff that is metal is a conductor and other stuff isn't, and be able to generalize and make definitions of what an insulator and conductor were. Things that they had to investigate. That is the kind of stuff I like to do.

They "had to arrive at the conclusion..." because that, for Carol and Alice, is what science is all about, even if the conclusion ("stuff that is metal is a conductor and other stuff isn't") is faulty.

Carol spoke about a new science theme that she would like to improve:

I know when I did my stars and space it was more of a fact kind of thing. We really didn't do a lot of what I think is science process skills. I found it difficult and maybe I just didn't try hard enough to make it more of a process oriented thing.

but her plans all boil down to what she considers the "stuff" of science, the facts:

I got Linda to order a book that helps you get out and find stuff and would have had lessons at home to identify stars and constellations and look at the colours of stars, notice how they move, why do they move...

When asked why it was difficult for her to "switch gears" to a science orientation, Carol answered

I think it is the, for instance the Language Arts, it's the brainstorming, being creative, writing a fiction kind of thing, but in science you have your facts, you have some information in front of you and you have to figure out how to investigate it and make guesses and prove them true or false.

The recurrent burden here concerns "conclusions", "identify", "information", "proof"-- terms that characterize science-as-fact, regardless of a veneer of hands-on

inquiry.

Similarly with Alice, when she says

It's not important to know specific science facts, it's to know how you come up with that generalization, and you sort of have to come around to that point. So if you can get them involved in something, they will probably remember something of it. They may have to go to a book and find a little bit more....

despite the assertion that "It's not important to know specific science facts...", her students are expected to "come around to that point," "remember something," "find out a little bit more." As I've indicated previously, it's important for her experiments to 'work' because she cannot explain why they might not, but also the purpose of the experiments is to illustrate or demonstrate science-as-fact:

I think I probably haven't done enough problem-solving from that approach. It's more or less just been a factual approach....going in factually and trying to come out with experiments, instead of going in with experiments and coming out with *factual* (my emphasis).

So her pedagogical shift is a surface one only. To her, the purpose of science process is "going in with experiments and coming out with factual."

Carol organized an experiment with her class in which students compared sliding friction, pulling weights with a spring scale, to rolling friction, pulling the

same weights over pencil-crayons used as roller bearings. After the experiment and subsequent discussion of applications of rolling friction (ball bearings in bicycle wheels, for example), the students were sent back to their desks to "write-up" the experiment.

But after all this hands-on and process, the activity culminated with the teacher question "What did you learn?", followed almost immediately by the teacher answer, "Things that roll have less friction; that's what you learned." And, at the end of the class period, after another hands-on activity, Carol wrote notes on the chalkboard, a list of facts about friction and lubricants, for the students to copy and complete.

But, after all, how could science be anything else but dogma or fact-accretion for the teachers, if that is how they learned it? The truism is no less true here: very often, teachers teach as they have been taught. As Alice says,

I remember years ago, we learned everything in that book... that was the program. That's what we did...probably it's because that's what I did too, and you have to change, to fit the times.

But asking teachers to "change to fit the times" seems futile here. If they haven't done science as inquiry themselves, if they don't have a clear handle on the nature of science itself, it seems unlikely that they can

model this science approach for their students. I believe that Carol intuitively knows this when, in reply to the question about what would help her most, she says, "a model."

## (2) FEAR OF SCIENCE

A second deeper theme emerging from the data is that the teachers have a fundamental fear of science itself. This fear manifests itself in several ways.

Because teachers have scant background in the subject, they no longer feel they have the same position of mastery or control when teaching science, as when teaching other subjects. Alice wants "to be on safe ground with the children" when doing the experiments because her concept of teaching is that the teacher is the dispenser of knowledge. It is somewhat like the old joke about how to teach a dog tricks: first you have to know more than the dog. When Alice's ruler-sound experiment didn't work, she "went back and read everything (she) could find about it" so that she would indeed know more than the students. Similarly she welcomed the Senior High Physics students into her class, admitting that they knew more about electricity than she did.

After an observation period in Carol's class, I wrote in my notes

While the students are working, the teacher asks me for help in writing out the science objectives. She says, "They keep coming out like Language Arts or Social Studies objectives. I have an idea of what I want to do, but does it fit with the curriculum objectives?" She seems to have an intuitive understanding of the student needs, but a great fear of the subject.

I puzzled over why I felt she feared science, but after subsequent conversations and interviews I think the key word is 'objectives.' She doesn't have a deep personal understanding of the objectives of science-- the "why are we doing this"-- so she falls back on what she does know well, the Language Arts and Social Studies objectives. So, Carol's fear of not having mastery or control is different from Alice's: whereas Alice fears not having "the knowledge," Carol fears not having "the method." When I asked her how she knew an activity was working well, she said.

I guess, Wayne, in science they are supposed to be curious, investigate, make a guess, see what happens, and draw a conclusion. I don't know if I am off-track with that but that is what I like to see them do. Like when we did electricity, instead of me saying this is the circuit, this is how you put it together, here's your stuff, make the light bulb light, and they have to figure it out and draw their pictures to show me.

Her knowledge of science-as-process is fuzzy; she knows

that and, as a dedicated teacher, she fears what she is doing is not the best. She wants to 'do it right' and kept seeking feedback (and approval) from me:

You want them to investigate and figure it out themselves. To guess and check it out. Maybe I am not as awful as I think sometimes. Maybe it's just I don't always know for sure what a science approach would be. Maybe I do it more than I think I do. I don't know that. I am not really a science person so maybe I'm not off-track as I think. Maybe we do more science process than I believe we do. I used to use the textbook quite a bit and used to lecture in a way or have them do reports and I don't think that reports is really science, when you have a topic and go research it. That is more Social Studies again, when you research stuff. Rather than having them guess and investigate a little more. To me, that is more science, investigation, proving it, like manipulating it. Did I answer anything?

She fears that her units on whales, having the students do research and presentations "isn't exactly science" because

what I think kids should do in science, they should come in and have all this stuff in front of them and I should pose a couple of questions to get them thinking and they should get at it and find the answers. And that's not always the way it goes.

This fear about method links back to the previous theme of science-as-dogma: her students would be expected to find **the** answers.

Another aspect of this fear of science is a fear of the potential dangers in the materials of the subject.

Carol doesn't "feel confident with the chemicals, etcetera;" Alice avoids the school's laboratory because "there are just too many things in there I don't want them involved in...acid or stuff," and she "fretted" about the dangers when her students did use the lab. There is also a revulsion towards some of the subject matter itself, as in Alice's memory of her science methods course, when the instructor "had rats running up her arm...I don't like those little creatures."

Science remains a mystery to the teachers, with little evidence of personal connectedness to their own lives. The only time that a teacher got in the least excited when talking about science was Carol's reference to her theme on endangered species. She is passionately interested in the topic, but she *fears it is not science!*

#### OTHER OBSERVATIONS

It was noted before that there was a difference in the way the two classrooms were arranged. Alice's was very much the traditional, teacher-at-the-front style, and this was reflected in the way she taught science. A typical class that involved student hands-on activities was still very much a teacher-directed situation. Alice would direct the class to turn to a particular page in

the text and often read through the activity with the class. She would write the outline of the experiment 'write-up' on the chalkboard, and closely direct the activities of the groups as they worked through the activities. The class summary was often her oral expectations of what the students' notebooks should contain.

Carol's classroom, on the other hand, was a much 'looser' arrangement, and this too was reflected in the way she taught science. A typical science class was one in which she gave general directions at the beginning, then went from group to group or individual to individual, depending on the activity, and gave help and answered questions. There was still, however, a tendency to "wrap up" lessons by having the students answer preset, note-style "experiment" write-ups.

These classroom organization styles are very much how these teachers approach all subject areas-- they are not differentiated for science. It is the way each teacher has developed a practical, workable style for herself, a style that fits with her background, personality, and experience of what works.

## THE TEACHING EXPERIENCE-- AN EXAMPLE

I asked each of the teachers to assign me lessons to teach, and to do it more or less at random. I wanted to get a closer 'inside' look at the situation. One of these experiences proved to be very significant, and gave me strong corroboration of the themes emerging from both the teacher and (as noted later) student data.

I received a fax from Carol on a Tuesday afternoon, assigning me a lesson to teach on Thursday of that week. I decided to taperecord my reactions to the assignment and my preparations for that lesson. I also asked Carol to observe and record her reactions to the class, and I would record mine later.

The following is a verbatim transcript of that tape.

It (the fax) says that it's for period 8 on Thursday, and that the objective from the Curriculum Guide, page 39, is that the students will trace the life-cycle of an organism and describe the special adaptive characteristics of each stage. Oh (...)! This is somewhat of a surprise to me. My reaction is one of a great deal of apprehension because I have some background in Physical Sciences and feel quite comfortable in electricity and sound and light, that sort of thing, and chemistry wouldn't be a problem for me either, but I didn't even take Biology in high school. My personal background is Physics and Chemistry, but no Biology at all, so what I know about the

life-cycle of organisms you can put in your hat. So I'm going to have to take a look at what kinds of resources are available and try to figure out what I'm going to do with the kids. This is somewhat of a humbling experience. The fax from Carol goes on to say that they have been using the text, chapter one, for this unit, and it includes several good pictures and illustrations of life-cycles. The class has covered three- and four-stage life-cycles by investigating the life-cycles of crickets, grasshoppers, flies, butterflies, wasps, bees, and mosquitoes. Carol goes on to say there's a need to draw out the fact that animals or organisms have different adaptations in various stages of their cycle. She says that I may need to review adaptation, and gives me the definition of it: the change in an animal that helps it to survive. That's how the class has defined it. Carol goes on to suggest that I could use Mayfly pictures on page 13 of the text. Obviously for some organisms, the next stage in a cycle means a completely different habitat and different characteristics are necessary. The students should be able to provide me with examples of adaptation specific to a stage in a cycle after they are given a few examples. She suggests a way of concluding is to give the class a choice of organisms that clearly must have adaptations to survive their cycle. She suggests having the class pick one, sketch the steps, and provide written explanations of the adaptations observed in each stage as appropriate and this should take the class about ten minutes.

My first reaction is to do a lesson-- this is a forty minute lesson-- based entirely on the pictures and the information in the text because for one thing I don't know anything beyond what is in the text on these adaptations or on this information. Since I've made such a strong pitch in the past for science as process this doesn't satisfy me...this does not make me feel as though I'd be doing what I say I believe in, so I'm taking a look at the Curriculum Guide, the actual Program of Studies part,

to see what they say about process skills in terms of adaptations. It says that "students will observe plant and animal characteristics and behaviours, and infer their adaptive function." So that's inference as a skill, besides observation. "They will classify adaptations as behavioural or structural," so, classification as a process. "They will trace the life-cycle of an organism and describe the special adaptive characteristics of each stage," which, I suppose, is what Carol has suggested I do. So this is a kind of process. And, "they will classify animals as predator or prey on the basis of their special adaptations." So classification is again a process skill that is involved here, with the knowledge of predator or prey being necessary. There is a comment on this page, 39 of the Curriculum Guide, that students should have the opportunity to make personal observations of life-cycles of organisms such as frogs, mealworms, or brine shrimp. Students should design an imaginary plant or animal which is adapted to a certain environment. I see this comment as being somewhat problematic...how do I allow students to have the opportunity to make personal observations of life-cycles? It would mean either some sort of field trip or bringing in the kinds of materials...having tadpoles turn into frogs in an aquarium, or having mealworms in the classroom go through their life-cycle, or brine shrimp. I could see where this might be part of a long-term planning objective, where they have this in the classroom but I'm unsure as how to do this in a single-shot kind of situation. I received this fax on Tuesday, and I've been giving it some thought; today is Wednesday, and I'm supposed to do this class tomorrow last period, so obviously, given all the other things that I have to do, I don't have the time to do this preparation, nor would I, off the top of my head, know where to look for the materials.

So I decided the next step would be to read through the Appendices in the Curriculum Guide which has an extensive discussion

of the process skills to see if I could get any hints to appropriate process skills to use with this particular lesson. The suggestion in the Program of Studies is to look at classification, observation, and inference, so I'll start with those things....

At this point, I spent about an hour reading through the process skill descriptions in the back of the Curriculum Guide. Although none of them directly related to my topic, or referred to it (and I freely admit to hoping that I would find a neatly organized discussion of how to teach the concept that I was assigned), the section on inference started me thinking that I could do an 'end-run' around the topic by concentrating on the skill of inference itself. The Curriculum Guide has a good suggestion on how to introduce and develop the concept of making inferences from observations, so I decided that I would "steal it", and start that way. I developed a lesson outline as follows:

- I. Review observation using the five senses.
- II. Give each group a sealed paper bag containing one or more objects, and have them record all observable characteristics.
- III. Have them decide what is in the bag.
- IV. Explain concept of inference, a plausible explanation of one or more observations. Emphasize uncertainty (I think a ... is in the bag)
- V. Observe and record characteristics of each stage in the life-cycle of mayflies, page 13 in text.
- VI. Infer from these observations how these characteristics are adaptations.

So, I prepared five paper bags with an assortment of objects inside, and rode off to meet my assignment.

I began the lesson by asking the students what the five senses were; they knew them, and I wrote them on the chalkboard. Then I asked them for examples of the kinds of information each of our senses could give us. They brainstormed some ideas, and although they were a little confused at times as to what constituted sensory data, had the basic idea. I then introduced the concept of inference, distinguishing it from observation. Our discussion took about ten minutes. Then I formed them into groups of four or five, and passed out the paper bags that I had prepared, cautioning them not to look inside (the tops were stapled). I instructed each group to record all the sensory data that they could about each bag and its unseen contents. This took them about five minutes, and they were quite excited about the task. Then, I asked each group to tell me their observations, and to make an inference as to what was inside. They were able to give me quite a range of observation data, and their inferences were amazingly accurate. It took almost twenty minutes to get through the five groups.

A little addition will indicate the fact that only about five minutes remained in the period at this time, so we weren't able to get very far with sections V and VI of my lesson outline before the bell rang.

What did this particular lesson teach me about the real world of elementary science? First, that students love to get involved with hands-on activities, and can work well in groups when the activities are prepared. That is hardly revolutionary: I have observed that during the entire year, and everything I have read about teaching the subject makes that point. However, it is infinitely more meaningful when one has actually done it oneself.

Second, I learned that students can work with the process skills such as observing, recording, and reporting. Up to that point, it had been theory for me.

Third, I learned that spending some time with the Curriculum Guide can be useful when one is desperate for an idea. The paper bag-hidden contents idea, as mentioned before, was 'lifted' right out of it.

Fourth, I learned what it is like to panic over a subject matter/materials 'vacuum'. I certainly wasn't unhappy to hear the bell ring at the end of the class, because I really had no idea how the last two parts of it would go. The students responded well to what I did get done, and Carol indicated that she thought the lesson went well. But, did I fulfill the objectives? Hardly, because I never got into life-cycles or adaptations, which is perhaps just as well. I could thereby avoid

making a fool of myself.

Fifth, I learned that one cannot rely on the textbook for help: there was nothing at all on adaptations in the text the class was using, very little useful material on life-cycles, and the suggested hands-on activity rather impractical for our part of the world. This activity involved attracting and capturing fruit-flies, which are rather rare on the dryland prairies, I would think.

My experiences, exemplified by the one reported above, corroborated both the "surface" and the deeper themes emerging from the teacher data.

My background knowledge and experience in Biology matches that of the average elementary science teacher-- essentially none. This certainly hindered me in that particular teaching assignment, so much so that I actually avoided doing what was assigned. I sidestepped it.

In terms of pedagogy, I asked myself the question on the reaction-tape, "how do I allow students to have the opportunity to make personal observations of life-cycles?" This is an excellent question, at the core of this subject area. I didn't have an answer to that question in the heat of the moment with the clock rapidly counting down towards the assigned lesson time. On lei-

surely reflection after the fact, I still don't have an answer.

I didn't have an opportunity to gauge student needs, abilities, and interests vis-a-vis life-cycles, simply because I didn't do the topic. The students were most definitely interested in the lesson I gave; they loved the challenge of the mystery-bags. And, as with all the other interactions with students I had during the year, they were involved, interested, and curious any time they had an opportunity to do science, as opposed to being told about science. I deal with this in greater depth in the section on students.

Materials were definitely a problem with regard to this assignment: not only did I have literally nothing with which to work (including the text), I wouldn't have known what was needed to do the lesson properly, ie. as process. Should I have had aquaria? ant colonies? bee-hives? Can one obtain pre-packaged sets of materials for this kind of topic? The phrase "I wouldn't know it if I saw it" took on a new meaning for me.

The pressures of time were also a big factor here. Although my normal time commitments are a little different than the front-line teachers such as Carol and Alice, this situation gave me another glimpse into their classroom realities. It took time to read the background

to the lesson, and time to prepare the materials. It would have taken even longer if I had persisted and actually attempted the assignment thoroughly. And, I was only doing one, isolated lesson in this instance; I didn't have to worry about the science classes before or after that one. Given my personal discomfort here with what I've called the "surface" themes, this background theme took on new meaning when viewed through the eyes of this experience.

The surface and background themes drawn from classroom observations and teacher interviews were just as valid and applicable to me when I was "in their shoes." But the deeper, interlinked themes suggested by teacher data also emerged from my teaching experience. Consider "understanding the nature of science." As mentioned before, I have a reasonable understanding of the physical sciences, enough to feel comfortable with them. Not so with the life sciences, however; I realize now that I feel distinctly uncomfortable with them. Until I had teaching experiences like the one outlined above, I had always felt that science processes should be transferable, adaptable, interchangeable, that the specific subject area shouldn't matter. If you could do it in one area, you could do it in any area. After all, I can read

faster and better than grade four students, so I can always assimilate any background information I need, regardless of the area of science-- or so I thought. Why then did I have a near-panic reaction when given the assignment? More telling, quoting again from the reaction-tape:

My first reaction is to do a lesson-- this is a forty minute lesson-- based entirely on the pictures and the information in the text because for one thing I don't know anything beyond what is in the text on these adaptations or on this information. Since I've made such a strong pitch in the past for science as process this doesn't satisfy me...this does not make me feel as though I'd be doing what I say I believe in...

So, I 'forced' myself to do a process lesson, not because it was natural or obvious, but because I'd made "such a strong pitch" for it, so it wouldn't be a case of "don't do what I do, do what I say."

Fear of science plays a part here as well. I was afraid to do the assignment as given; I admit that. I was so afraid I'd make a fool of myself by not knowing the topic that I avoided it altogether, effectively making sure that the lesson would run out of time before it got to a part I was afraid I couldn't handle.

My teaching experiences, if nothing else, taught me not to be so smug. It is far easier, I have found, to give advice and make suggestions to others than to one-

self. I think I can now better understand the source of the snide and uncomplimentary "definitions" of consultant that I have heard for years.

#### CONVERSATIONS WITH PRINCIPALS

The school-based administrators that I talked to expressed very much the same concerns as did the teachers, that science was the "worst" taught of the subjects because teachers were not prepared to teach it. They mentioned that teachers did get together on occasion to work on science long-range plans, but that this consisted mainly in taking the topic areas from the Course of Study, and dividing them up among the various grades. Alice's principal, who has a science background himself, had an interesting observation:

Teachers at the elementary level don't feel prepared to teach science because they are mostly women, and they have avoided taking science courses in their own education.

This comment would likely bring a howl of protest from some quarters as being sexist, but it is consistent with what I've seen both in this study and in general. It is also consistent with the literature, which clearly demonstrates that science is a male-dominated field in general (Handley and Morse, 1984; Hanson Frieze and Hatman Hanusa, 1984). There has also been much inves-

tigation of how and why females avoid science-related subjects in school, and how to address the problem (Hart Reyes and Padilla, 1985; Benbow and Stanley, 1984; DeBoer, 1984; Erickson and Erickson, 1984; Kahle, 1985, Kremer, 1984; Maehr, 1983; Manthorpe, 1987; Matyas, 1985; Ridley and Novak, 1983; Sadker and Sadker, 1985; Simpson and Oliver, 1985; Skolnick, Langbort, and Day, 1982; Stage, et al, 1985; Zerega and Walberg, 1984).

My own experience supports this as well. When I was in Senior High School, I was in a "streamed" class called 'Science I' in which the programme was heavily science/math oriented. There were 32 students in the class-- 30 boys and two girls. The girls, if they weren't taking the 'Commercial' (i.e. secretarial) stream or the 'Academic' (i.e. Latin) stream, generally took the 'Science II' stream, which substituted Biology for our Physics and Chemistry, and omitted the Trigonometry and Pre-Calculus. To have girls in a Science I class was regarded as somewhat of an oddity.

Years later, when I taught Physics 10, 20, and 30 in Alberta, I got the distinct impression that they were regarded by the students themselves as "boys'" courses, and there certainly tended to be more boys than girls registered.

The issue of gender is a definite factor in the problems with elementary school science, and relates to many of the surface and deeper themes emerging from the data. These are interlinked in the question of 'comfort' vis-a-vis science, which I deal with in Chapter Six.

#### GROUNDING HYPOTHESIS-- STUDENTS

My interviews with students, although they were not as comprehensively instructive as I hoped they would be, did give me some interesting insights into the world of science as lived by the student. Perhaps more experience in the techniques of interviewing children would have yielded more data, or perhaps the problems that my literature review revealed that others had had with younger children are universal and unsolvable. I found the students were at times reticent to the point of inarticulateness, yet on occasion made comments that showed amazing perception.

The following is the verbatim transcript of an interview with a student from Alice's class, a girl described by her teacher as "very bright", and who indeed performs well in all subject areas.

Interviewer: How about telling me something about what you've been doing in science this year, in general terms.

Mary: Well, we've been writing notes, like

on experiments, then writing the answers.

Interviewer: When you say experiments-- in what areas have you been doing experiments? Can you remember some of them?

Mary: Uh... (long pause)

Interviewer: What kinds of things have you done?

Mary: I can't remember.

Interviewer: Well, today you were doing solids, liquids, and gasses. Did you do anything on electricity this year?

Mary: Um...yup.

Interviewer: Can you remember anything about those?

Mary: No.

Interviewer: No? Not very much? When you're doing science, what do you like best?

Mary: I like to do the experiments.

Interviewer: What about the experiments? Anything in particular?

Mary: No.

Interviewer: What about today's class? You were doing some hands-on things; what did you like about that?

Mary: It's fun. (long pause)

Interviewer: That experiment today, what you were doing-- is there any way it could have been better? Is there anything that you would have liked to have done better?

Mary: No.

Interviewer: When you're in science class, what kinds of things don't you like?

Mary: Well, I don't like just sitting there listening to (the teacher) just talk.

Interviewer: You'd rather be doing the hands-on kinds of things?

Mary: Yes.

Interviewer: Do you do more of the "sitting and listening" or do you do more of the working on the experiments?

Mary: Sitting and listening.

Interviewer: You do more of that?

Mary: Yes.

Interviewer: What kinds of things have you been learning in science? What kinds of things can you remember?

Mary: (long pause)

Interviewer: Like in electricity, for example-- do

you feel you know more about electricity now than you did before?

Mary: Yes.

Interviewer: What kinds of things?

Mary: Like, to make a light flash when you put a battery and a light bulb together with wires.

Interviewer: Make it light up?

Mary: Yes.

Interviewer: Other things you've done-- I think you've done a unit on sound; what kinds of things can you remember about sound?

Mary: Like, you don't listen to everything at once, you just listen to one thing.

Interviewer: What kinds of things would you like to do in science that you haven't done yet?

Mary: Something in history, or something like that.

Interviewer: History of what, like scientists?

Mary: Yeah.

Interviewer: Any particular area?

Mary: It doesn't really matter.

Interviewer: Why would you be interested in history?

Mary: I like some things like they used to use, and stuff.

Interviewer: You don't do anything like that, then, in science?

Mary: No.

Interviewer: Anything else you'd be interested in doing that you haven't done?

Mary: No.

Interviewer: You have, what, four classes a week in science? What amount of time do you think you should be spending on the hands-on, the experiments?

Mary: Maybe ten or twenty minutes of each class.

Interviewer: So, you'd like to do something every day, then, of the hands-on?

Mary: Yeah.

Interviewer: Let's talk about science in more general terms for a moment. Why is science important?

Mary: 'Cause you learn stuff.

Interviewer: Why is it important to learn those

things?  
 Mary: So maybe you can get a job doing one of those things.  
 Interviewer: Jobs as a scientist, or something to do with science?  
 Mary: Un huh.  
 Interviewer: Are you interested in science like that?  
 Mary: I don't know.  
 Interviewer: You might be a chemist or an engineer or something like that?  
 Mary: Maybe  
 Interviewer: What else is important about science besides the possibility of a job?  
 Mary: (long pause)  
 Interviewer: Can't think of anything?  
 Mary: No.

Two themes occurred to me as a result of this interview. One, she likes the activity part of the science classes (which I expected), and, two, she doesn't make a clear distinction in her own mind between what an adult might call 'science,' and what might be called 'social studies': she is interested in the history, the 'human face' of science. I was surprised at this, and wondered if this might just be a particular interest of this student. But a similar theme appeared in an interview with Billy, from Carol's class:

Interviewer: If you had a choice, what topics would you study that you don't now study?  
 Billy: I would like to study the Government, like the Liberal leaders.  
 Interviewer: Would that be science?  
 Billy: No, that would be social studies, I guess.  
 Interviewer: What would you really like to know in science that you don't now know?  
 Billy: I would like to know about certain

people.  
 Interviewer: Do you mean scientists?  
 Billy: Yes. What I really liked was space. We learned about Challenger going up, and that teacher....(killed in the explosion).

On reflection, it is not surprising that students relate well to the human side of science rather than what might be termed 'content,' nor is it surprising that they confuse what they do in one subject for another. After all, their lives are not lived in such compartmentalized fashion. Both teachers do practice subject integration, and Carol does quite a lot of integrating social studies and science concepts, along with health and language arts, as in this three-way conversation between myself, Billy, and Patricia:

Interviewer: What can you remember about the kinds of things you've been doing in science?

Billy: We've done a lot of campaigns about saving endangered animals.

.....

At the very beginning of the year we kind of circled around people, and we did ourselves, and we did parts of our body and how to keep healthy, like toothbrushing. When we were in groups we played some games so we could remember all that stuff. Then we went on talking about animals, and people who are different from us. We did animals that were endangered or were extinct.

Patricia: We wrote letters to them.

Interviewer: Who did you write to?

Billy: I wrote to Iceland.

Patricia: I wrote to Iceland, too.

Interviewer: You wrote to countries?

Billy: The embassies.

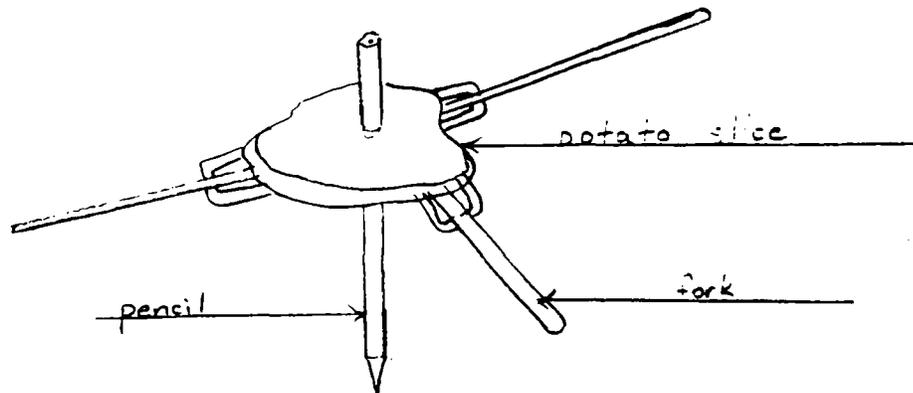
Patricia: Then I got a letter back, and it just said all these excuses, and it said, in different words, mind your own business.....

The students in both classes are interested and even excited by the hands-on, activity oriented classes, and it matters little to them if it is 'pure' science or if it is a mixture of subjects. They like to do; they most definitely do not like to just sit and listen. Although science for them does not exist as a clearly separate school subject-- and indeed why should it?-- they are quite prepared to enjoy any activity associated with it.

They are also quite unperturbed by lack of clarity or apparent lack of understanding of 'fact.' The lesson with the vibrating rulers referred to earlier in this study is a case in point. Alice and I were the only ones in the least disturbed by the ambiguity and the contradictions; the students' main-- or perhaps only-- concern was making sound by vibrating their rulers. They thought that was great fun.

I clearly remember another of Alice's classes that I participated in: the hands-on activity was trying to make a slice of potato, through which a pencil was pushed, stand up, by using forks as 'balancers' (the

object was to learn about the concept of centre-of-gravity). I worked as part of one group; no matter what we tried, we could not get the pencil to stand up on the sharpened end. Moving the forks around the edge of the potato slice just did not give us fine enough control over the balance. See the following illustration:



I remember getting quite frustrated by our lack of success, and was amazed that the others in the group were not frustrated at all. They were having fun trying! Another group actually got it to work, by turning the pencil upside-down, and balancing it on the blunt end. In doing so they were working with what might be called scientific intuition, just as valuable an experience as learning about centre-of-gravity.

It is beyond the scope or intent of this report to deal with the cognitive levels or abilities of elemen-

tary students vis-a-vis science. It is my contention, however, that such considerations are of minimal importance to the students. It has been my experience that they are happy doing that which is interesting and exciting, so it should be possible to capitalize on this in a science process program.

## CHAPTER FIVE

## DOCUMENTARY DATA

## ALBERTA EDUCATION CURRICULUM GUIDE

Before even looking at what to do about helping teachers improve the teaching of science in their classrooms, it is best to ask the question, "why do we teach science in our schools?" In the Curriculum Guide (1983), the Alberta Department of Education has outlined its philosophy of the elementary science program in terms of providing "...children opportunities to extend their curiosity and to learn about the natural world through a series of planned learning experiences." (page 1) It goes on to state that "the program should emphasize ways of gaining and processing information rather than learning information itself. Content serves as the context in which important skills and attitudes may be developed." (page 1) Further on, in italics, is the statement that "the teaching of science as inquiry is the basic instructional strategy recommended in the Alberta elementary science program of studies." (page 4) The Program of Studies, the legal, core prescriptive requirement, is

organized as follows: for each topic area, there are "boxes" with the headings *Subject Matter, Skills, Attitudes, Comments,* and *Possible Related Elective Topics*. In the *Subject Matter* box there is a short paragraph outlining the basic concepts to be covered, for example under "Sound", it states:

Sound is a form of energy produced by vibrating objects. Sound travels only through matter and in all directions from the source. Sound may be transmitted, reflected, or absorbed. Materials differ in their ability to transmit sound. The loudness of a sound decreases with the distance from the source. Sounds that are unpleasant because of loudness and other characteristics are termed noise.

There is then given a series of process skill statements relating to sound:

Students will:

- OBSERVE, DESCRIBE, and DEMONSTRATE conditions necessary to produce sound.
- IDENTIFY and CONTROL variables that cause changes in sound.
- OBSERVE and INFER that solids transmit sound better than liquids and gases.
- OBSERVE that sound becomes less audible as the distance from the source increases.
- DEMONSTRATE that materials vary in their ability to transmit, reflect, and absorb sound.
- DESCRIBE some of the possible effects that sound of various kinds has on people and their environment.

The bulk of the document deals with 'teacher helps' such as how to organize for instruction, how to

organize the classroom for science, how to evaluate, and appendices outlining the process skills in great detail, and equipment lists. This sounds like the 'ideal' Curriculum Guide, yet Carol's comment, when I asked what kind of documentation would help her, was

We need a Teacher Resource Manual like (the one for) Social Studies. They give you sample units and a whole lot of ideas. Even an idiot could teach it using that book. They could help us out a little!

So, regardless of what I think of the Curriculum Guide, the teachers-in-the-field seem to have little use for it. In another context, I 'introduced' this Curriculum Guide to a group of Hutterite Colony School teachers of whom I am in charge, and "walked" them through its contents. This is a group of seven teachers, some new to the profession and some with many years of experience, but not one of them had ever given more than a cursory glance to the Program of Studies part of the document, ignoring the process skills sections completely. After we spent half a day discussing the contents of the document, and brainstorming ideas of what a science long-range plan should contain in light of the Curriculum Guide, the group was able to start on a yearly plan based on science process and attitude objectives. So it does have its uses.

How is it that these teachers were now able to use a resource that was not 'accessible' to them before? The simple answer is that three enabling factors were provided. One, they were given the time to read through it, separated from all distractions and other pressures. Two, they were given "collegial space", the chance to work with peers, again with no distractions. Three, they were given an 'animateur', someone to help them focus, and guide their exploration. Taken together, they were conditions to provide meaning that was not there before-- not imposed, but developed. Carol, quite obviously, has not had the opportunity to develop meaning in relation to this document.

What the document does not contain, as I found to my chagrin when teaching the lesson on adaptations, is a series of sample types of lesson, as does the new Elementary Social Studies Teacher Resource Manual. I have been told that Alberta Education is working on a new Curriculum for Elementary Science, along with new resource materials. Perhaps these will address teachers' needs better than the present ones.

#### ACHIEVEMENT TEST IN SCIENCE

The Achievement Test given to grade six students

this year was in science, and it is instructive to examine what the Provincial Department of Education expects of its elementary students at the end of six years. There were sixty multiple-choice questions, on the following topics: Sources/forms of energy (6), Electricity (8), Light (3), States of Matter (12), Sound (1), Ecosystems (9), Animal adaptations/life cycles/behaviours (6), Plants (3), Earth Science (7), Human biology (2), The Language of Science (1), Magnetism (1), and The Universe (1). But more interesting than the topic areas was the content of the questions themselves. Forty percent of the questions (24 out of 60) called for the student to know one or more science facts (interestingly, one of the fact questions, number 9, contained a glaring error), while the rest called on the student to use science process, such as inferring, predicting, graphing, interpreting, and experimental design.

So, the majority of the questions support the science process approach, but I am left wondering about the forty percent of the questions that were content-oriented. I have on occasion, when talking to teachers about making their science courses process-oriented, been told that the students "have to know content." This is one more area of worry and confusion for the teachers.

## CHAPTER SIX

## WHAT I LEARNED FROM THE DATA

## ANSWERS TO QUESTIONS

I posed fourteen specific research questions at the beginning of this study. Some of the answers this study provided were expected, some were not. Specifically:

**(1) What do teachers believe the purpose of science teaching is? and (4) How important do the teachers believe the subject is?**

There is a somewhat fuzzy understanding that science is important to today's students. Carol, for example, is passionately devoted to saving endangered species, and sees the whole concept of ecology as important. But, beyond that, they were not able to articulate for me a purpose beyond the fact that it was a mandated subject. The amount of time devoted to science both in the timetable and in the teachers' planning time is a possible indication of the level of perceived importance, but time is a more complex aspect, as discussed else-

where.

**(2) What are the teachers' "philosophies of science teaching"?**

They want to teach science-as-process; they've been told they should. They don't know how to do this effectively, although they are trying; neither is there a support system that they can access to help them change.

There is a definite sense that many areas of science are beyond their students' present understanding and interests, as expressed in this interview with Carol:

...as they get older, science is more easily shown to be important to life in general, and they can see that it's got an effect. Like, when you're only nine... Like somebody asked me, why are you studying whales? Like, why aren't you fighting acid rain? and I thought, right!, you're nine years old, and you're going to worry about acid rain? Like, whales are something they can get excited about..... Whereas when they are in grade nine, ten, acid rain is something they can be concerned about, 'cause they can see what's going to happen. Whereas these kids, they wouldn't really have clue one.

This unease about the actual content is tied in with another very strong theme that emerged in my data: teachers do *what works for them*; given all the pressures and stresses of their professional lives, they have little other choice. Alice looks for experiments that always 'work,' Carol uses Social Studies-like structures

and topics, Alice creates a very teacher-controlled environment even when the students are doing hands-on investigations, Carol spends the minimum time possible on science....all of the foregoing help increase the teachers' 'comfort zone' in terms of the subject.

**(3) How do the teachers approach planning for the subject?**

Alice relies heavily on the text, and looks for activities that would fit into the specific areas. Carol sometimes tends to treat the subject as she would Social Studies, bringing a social-action problem-solving approach to bear. Both start with the content, and look for activities to teach and/or support this content.

**(6) How meaningful and useful are the materials available to the teachers?**

There is a dearth of materials, both textual and experimental, that teachers feel comfortable with. They both talk of a constant struggle to find things they can use. Much of the problem stems from their own lack of background in science, and a lack of time to obtain, adapt, or fashion suitable materials.

**(7) How do the teachers feel about the way students respond to science?**

Both teachers know that their students like

activity-oriented science, and are struggling to provide it. It is perhaps understandable that the teachers attribute to their students a frustration about the activities that I did not observe in the classrooms nor in the interviews. For example, Alice, when talking about the help she had from the Senior High Physics students during the year, said

they had it all hands-on because it was four (in each group) and I didn't have to go from (group to group)...usually we do it and we have the groups but I float and they get too frustrated by the time I get there, some of them, because somebody can't do it, but when they had that one (extra) body, the kids really enjoyed it.

It was my impression that it was the teachers (including me!) who got frustrated, not the students.

The teachers were quite aware that the students did not like the 'traditional' way that science was taught, and wanted to avoid it on that account.

**(8) How meaningful and important is science in general in the teachers' lives?**

As mentioned before, Carol is an environmentalist who cares about pollution and endangered species. There was no other data generated in this study that would indicate how meaningful and important science was to the teachers, although in hindsight I should have pursued this question more vigorously.

**(9) through (12) Importance, meaning, and response by students?**

These four questions all have the same answer: the students want to *do*. They don't much care what, why, or how, nor do they bother to differentiate science from other subjects. It is part of a world they view holistically. There is also a strong indication that meaningful science, for children, is science that will have a personal and social meaning for them; it will have clear links to their lives.

**(13) What kind of classes would the teachers and the students like to have? Why?**

Teachers want classes where things 'work' because they don't know why things don't 'work.' They want their students to be interested and excited by what is happening. And, as I noted before, the students just want to *do*.

**(14) Is there a difference in the way students and teachers view science? If so, why?**

Yes. The teachers see science as a subject to be taught: there is still very much a sense of 'covering the material' (as they would in other subjects) despite the inherent difficulties in doing so. This is to them, after all, what teachers are *supposed* to do; it is their duty

and responsibility. They naturally make the accommodations that let them feel the least stress. On the other hand, the students see science in the immediate: is what I am doing right now boring or interesting?

**(5) How comfortable do they feel about science?**

I've saved the answer to this question until the end, because I feel that it is in this answer that the themes emerging from the data are all intertwined. Both of the teachers in this study are obviously very uncomfortable, in terms of a personal understanding of its content and its pedagogy. Both see it as a challenge to be overcome.

The "surface" factors are the obvious blockers, of course, to the teachers' personal comfort level. How comfortable could teachers be expected to feel, having little personal background and knowledge with the subject, having scant understanding of the appropriate pedagogy, having an unclear perception of students' needs and interests, having little in the way of effective materials with which to work? Naturally, given these conditions, one would expect the subject to be poorly done. One might also expect that, in order to increase comfort level and therefore quality of teaching, all one would have to do is to apply the age-old remedies-- say,

a well-designed Saturday in-service workshop on a particular area of science, or a series of after-school sessions on science-as-process, or perhaps a well-supplied "lab-in-the-classroom" kit.

While any or all of the above might have some minor positive effects, they would not address the heart of the teachers' problem: the basic misunderstanding and downright fear of science. These two aspects might well be combined and termed science-as-mystery.

Gender is an important factor here. As mentioned previously, most elementary teachers are women, and women generally do not take science courses in school or at university for complex psycho-social reasons. What must be taken into account, then, is not just a 'deficit' in terms of an academic area, but a deeply-held cultural bias against science and things scientific by a significant proportion of the teachers who are expected to teach the subject.

There are in the literature a plethora of examples of undoubtedly well-intentioned but ultimately ineffective single-issue attempts at improving science. These are usually "cut-and-paste", short-term, and, one may say, short-sighted attempts as they usually ignore

the gut-feelings of dread and confusion experienced by the teachers. A few examples of this experimentation that I have come across recently deal with instructional practices (McPartland and Wu, 1988), how students are organized in groups (Johnson and Johnson, 1986), the use of science laboratory facilities (Robinson, 1985; Ivins, 1985), how science textbooks are organized (Covey and Carroll, 1985), and, of course, the myriad of studies already cited involving teacher and/or student attitude towards the subject, often with some aspect of science instruction as a variable.

It is here too that the deepest of the themes suggested by the student data comes into play-- we learn what we **do**, not what we are **told**. Not only do the foregoing in-service activities add to the teachers' already overloaded time-frame, but they would almost by necessity be didactic. But teachers don't *teach* science-as-process because they've never *learned* science-as-process; one can't be told how to do it, one has to actually do it.

Comfort, therefore, will be present or absent in the proportion that teachers have, or have not, experienced the processes of a science subject area first-hand-- not in a theory or methods course, not out of a book, but having done it themselves. I can easily attest to this: I have worked with electricity and elec-

tronics since I was a boy. It has always been my hobby and interest, I'm a licensed Radio Amateur, and I'm constantly tinkering with circuits. Obviously I feel very comfortable teaching that area of science, although I am open to, and even on the lookout for, better pedagogical techniques. Not so in other areas, as I've recounted in the teaching experience wherein I sidestepped teaching life-cycles. I can read about life-cycles and adaptations all I like, but until I actually do some activity like hatching mealworms or breeding guppies or whatever, the area will remain science-told, not science-done, and I will not be comfortable with it.

#### OTHER ANSWERS

It is interesting to note that both teachers involved in this study expressed gratitude for having been asked to be involved, and both thought that their teaching of science was improving-- perhaps it had improved during the year of observation. Carol said towards the end of the year,

I'm having more fun in science this year. It's better now that I'm out of the textbook. It's easy to say, "read the book and do the questions" but that's not the thing

to do. I'm lucky to have the resources that I need for the unit on wild animals. I use the topics that I can find information on.

I mentioned before that I tried very hard to avoid giving "in-service" during this time, and I believe I was reasonably successful, so, why would Carol and Alice both think there was a change during the year? I believe that a variation of the "Hawthorne Effect" comes into play here. In this seminal study by Roethlisberger and Dickson (1939), the illumination in a factory was varied to see the effects on production. It seemed that, even though illumination was decreased, production increased. It turned out that it was not the amount of illumination that was responsible for the increase in production, but the amount of attention given to the workers. Teachers are used to working in relative isolation, with only the occasional visit from an administrator for evaluative purposes. My being in their classes so often during a subject that gets less than the usual small amount of attention from the 'outside' has, I believe, prompted them to think about the subject in a deeper way. And, perhaps they were encouraged to experiment with some of the techniques and strategies that they had been thinking through for a while, in the hope that they would get some feedback on their attempts. It is

clear that they are looking for some mentorship.

There is a link here to the concept of *science-told* versus *science-done*, as discussed elsewhere in this paper: by consciously avoiding telling the teachers anything about the subject area or its pedagogy, I 'forced' them, in this limited context, to do it themselves to keep trying to get my reactions. I believe that their own attempts, even in these narrow confines, produced more meaning for them than if I had answered every question (*told* them) at length.

It is also interesting that when these teachers were asked what would help them the most in their teaching of the subject, they cited, at various times, all four of the "surface" aspects that this study has mentioned-- a better personal background in the subject, some teaching ideas, subject matter that better met their students' needs, and better materials.

Yet, were these needs to be met, however it was done, I seriously doubt that much change would accrue. As discussed before, the kind of in-service that teachers jokingly call the "vaccination" type (one shot and you're good for the rest of your career) would seem to be as much a waste of time for science as it usually is for other subjects. Rather, a programme that is based on an entirely different premise would be needed. The weight of

evidence in science research that I have read, combined with my own experience, reveals clearly that there are serious difficulties in how the subject is taught. I believe that this paper shows that the reasons for this state are (like so many human endeavours) complex-- there does not seem to be one, single, simple 'cure-all' that can be prescribed. Rather, *how* the problem is approached must be examined.

#### THE CENTRAL DISCREPANCY

If there is one, single theme that emerges from the data collected in this study, it is that there is a fundamental discrepancy for both teachers and students between what might be termed the *external* world of elementary science, and the *internal* world. The former describes all those factors *outside* the daily teacher-student interaction, the latter those factors *inside* it. The external world for the teacher consists of the Program of Studies and other such societal expectations and motivations for the teaching of science. It also involves the teachers' background both in science and science pedagogy, the amount and quality of material, supplies,

books, and other resources available, the nature and composition of the classroom, etcetera. Any and all of these external factors may be changed, and such change has been frequently tried in carefully controlled experimentation, as previously noted. The external world for the student consists of whatever classroom organization, learning objectives, experiences and materials the teacher provides throughout the year. These also have been subject to much experimentation.

But the fact that science is still in the sorry state it is, despite the many years of attempts at change, leads me to the conclusion that the *direction* of these attempts has been too narrow: rather than attempting to change only the *external* world of elementary school science, the *internal* world (as described below) has to change as well. This is the *real* world of elementary science for teachers in the field-- the world of fear and mystery, and for their students-- the world of the immediate.

#### GROUNDED THEORY

My data suggests to me that the real world of elementary science is a substantially different place for

teachers and for students, so I will make separate conclusions for them.

For teachers, I theorize that regardless of external factors, teachers will respond to an internal 'schema' when dealing with a subject matter. This 'schema' is the sum total of that teacher's experiences, good or ill, with the subject. It might include assets such as whatever background knowledge and pedagogy is available, suitable or not, but it is controlled by feeling. In the case of science this feeling is one of awe, fear, and mystery resulting from a lack of a personal connectedness to the subject. Gender is often a factor here, as mentioned previously. When only external factors are changed, little substantial change will occur in how the teacher handles the subject. Real change will occur only when this 'schema' is an integral part of any plan of action.

I believe that this helps to explain the confusing and contradictory results from experimentation that takes only attitude into account, as previously discussed. Attitude, as measured by many of the studies cited in my literature review, is a surface, external reaction: teachers generally don't like science. But this attitude is unlikely to change when only external factors are changed. The core, gut-feeling that creates and

drives this attitude must also be a factor for this experimentation to yield meaningful change.

For middle-elementary students, I theorize that science does not exist as a distinct entity for them to either like or dislike. They like or dislike what they are doing at any particular moment, and they most definitely like to be doing, active, involved, learning first-hand about the world. The science processes are for them ideal learning experiences.

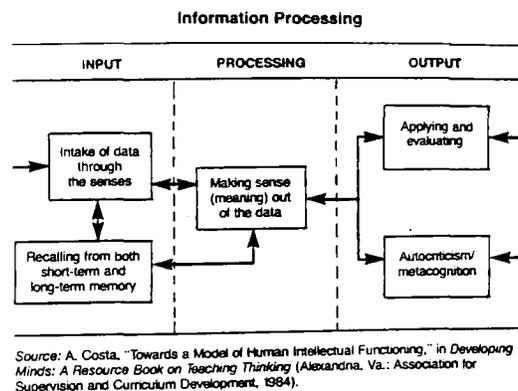
So, here too, measuring attitudes to science has not and will not lead to meaningful data if students don't really have attitudes to science, but attitudes to what they are doing, regardless of what we call it.

#### IMPLICATIONS FROM THEORY

As it is the teacher who effects much of the world of the classroom by commission or omission, I will concentrate on how the above theory-- that teachers respond to an internal 'schema' when dealing with science-- calls for action in regards to the teacher. For a teacher to go beyond what is presently done through habit, previous learning, or emotional response, that is, for a teacher to change the internal 'schema' which shapes his or her reaction to a subject, cognitive proc-

esses-- thinking-- must be involved. Costa, Garmston, and Lambert (1988:151-3) explain it in this way:

What is this process called thinking? How do we view the process of information processing that is the basis for teacher...decision making? Figure 6.3 summarizes many of the psychological and psychobiological concepts of human information processing. According to this model, the individual constantly interprets information in terms of what is already known. If a teacher can easily understand new information based on existing knowledge (assimilation), then there is no dissonance or challenge. If, however, the teacher cannot assimilate the new information, that information must be processed, more information collected, and the ultimate resolution tested for its fit with the teacher's reality (accommodation). Accommodation may be achieved by a modification of that reality either in one's self-view or world view. This process, not surprisingly, is called "learning" and entails knowing, doing, valuing and thinking.



My reading, and the experience of this study, lead me to conclude that attempts at reform or change in

science have generally not taken this need for accommodation into account. Teachers have to *make meaning* of science for themselves, before they can effectively teach it to others.

The meaning of any learning experience, or any attempt at change is, at least in part, internal, according to Fullan (1982). One particular experience of mine is now clearer to me when seen in the context of Fullan's concept of The Meaning of Educational Change. I attended, a few years ago, an intensive training session on the use of the Alberta Diagnostic Reading Program. During this packed three days, I became excited about this program, and very enthusiastic about "bringing it back" to our jurisdiction staff. I was therefore puzzled and disappointed when it was received in a lukewarm and skeptical way by many staff. What I didn't realize is that I had made meaning, for myself, of the program and its potential during the concentrated sessions I had attended, but unless I could help the staff find their own meaning in it, it would (and, as a matter of fact, did) remain external to them, not part of their classroom reality.

Fullan (1982:103) makes the point that "many of those concerned with educational reform have been preoccupied with developing and advocating the goals of

change, as if all that is needed are good intentions." But so many of these educational reforms fail because "the developers went through a process of acquiring *their* meaning of the new curriculum. And, once it was presented to teachers, there was no provision for allowing them to work out the meaning for themselves of the changes before them." He summarizes as follows (p. 295):

In brief, the key to school improvement is to recognize that *individual meaning is the central issue*, and to do things that will enhance this meaning. Several aspects of change become integrally related in this definition. We cannot have successful change if individuals responsible for making it happen do not come to experience the sense of excitement, the mastery of new skills, and clarity about what the change is and why it is working. When people do experience excitement, mastery, and clarity in attempting something new, we are witnessing professional development at its best.

#### FURTHER IMPLICATIONS

In order for science improvement to occur, then, it must take into account the central realities of the science classroom for both teacher and student. And, for teachers to make good science teaching part of this reality, they must make their own meanings of both the subject and of the pedagogy of the subject. It cannot be imposed from the outside. No plan for improvement can be

one-shot, nor can it deal with only one or just a few factors. Rather, a plan must involve the teachers in making their own personal meanings of

- (a) the nature of science and scientific thought,
- (b) the content areas covered in the elementary grades,
- (c) the process skills, and
- (d) the kinds of hands-on activities suitable for elementary students.

They must establish a personal connectedness to science that removes the sense of mystery, the sense that science is somehow outside their world.

This is a tall order indeed. But it is old wisdom that says the way to eat an elephant is one bite at a time, or that a journey of a thousand miles begins with a single step. There is little point in doing a patch-up job and thinking that is all that is required. It is far better to attempt a long-term program that will eventually take into account all the requirements mentioned above.

## CHAPTER SEVEN

## WHAT DO I DO NOW?

## IDEAL PLANS AND PRACTICAL PROBLEMS

Fullan (1982:103) comes to the conclusion that, for any program of innovation to be successful, it must "combine good ideas with good implementation support systems."

He goes on to say

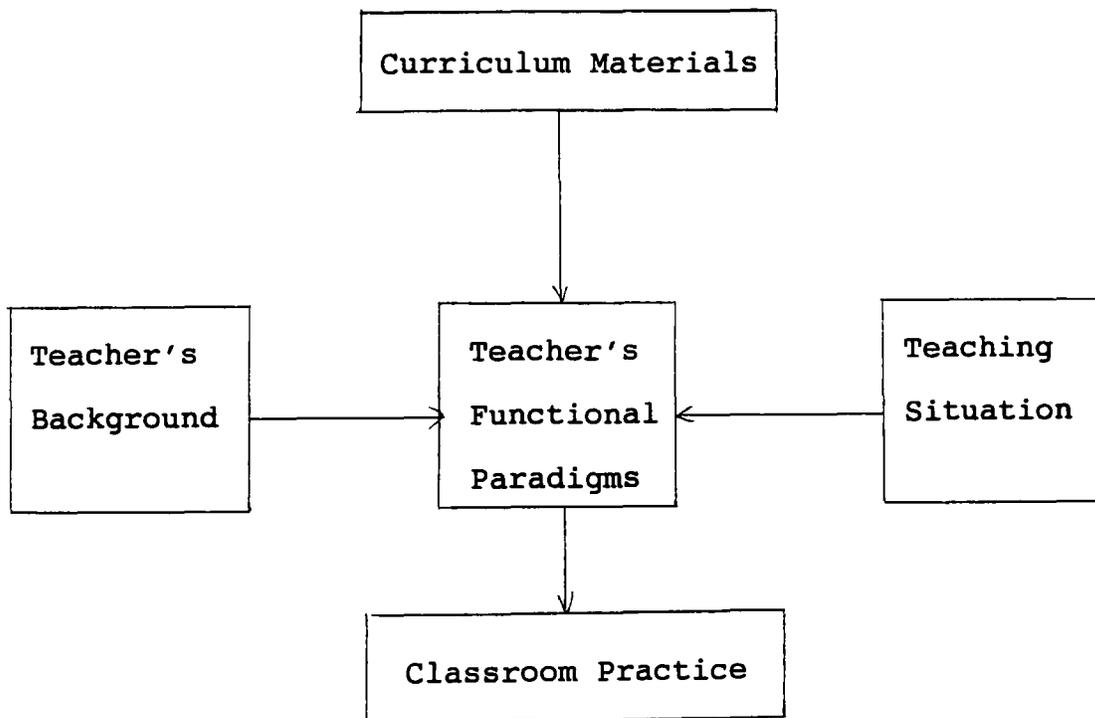
Our tendency is to return to familiar ways of doing things, or to practice new ways privately so as not to expose our inadequacies to peers and to supervisors. It is exactly the opposite that is needed-- exchanges among peers and others about the *natural* problems of learning new skills. It takes an enlightened, supportive, and ongoing approach to staff development... to counteract the tendency to avoid confronting problems of implementation. (p. 274)

What happens, however, when there is a direct conflict between aspects of the teachers' internal world, and the external world of the curriculum? One example of conflict has been cited in this study, that of 'appropriate pedagogy.' Crocker (1983) in his study of the functional paradigms of teachers, makes the point that

(in) elementary science...notions of discovery learning and first-hand experiences have long been held as basic to the teaching of science. These principles, however, clearly conflict with the established teaching principles. (p. 359)

It is possible to effect change, however, "...provided such changes can be accommodated within the existing paradigm or a sufficiently strong support system can bring about adoption of a new paradigm" (p. 359).

A schematic showing the central role the functional paradigms of teachers play is given by Lantz and Kass (1987:119)



It is interesting to note that the factors

termed in this study as *external* fit into the 'contributing' boxes in this schematic (Teacher's Background, Curriculum Materials, Teaching Situation), and the *internal* factors are at the core, as part of the functional paradigms.

What is needed is an organized program using peer support and cycles of peer supervision, supported by amateurs on both the district and school levels. Support in terms of materials, supplies, and time must also be there. The details of the structure and the direction of this program must be decided **by the teachers themselves**, if it is to become meaningful for them, in Fullan's sense of the word.

I want to emphasize that this cannot be what some might call "a pooling of ignorance"; simply getting teachers together and asking them how they want to improve their science teaching is not likely to get very far. Butt (1985:16) in discussing eras of relationship between teachers and curriculum reformers, observes that

Only when we practice *mutual adaptation* (Rand Studies, 1978) do we begin to see changes in the classroom facilitated by a change in the relationship between insider and outsider from a logistic to more dialectic or problematic modes. An important impetus embedded within this change in relationship is the realization that teachers teach what they do and how they do for very personal and practical reasons. It is

very difficult, therefore, for the curriculum prescribed from the outside to be right for one classroom, let alone *many* or *all*.

It will be in the dialectic between the outsiders (the amateurs, the helpers, the facilitators) and the insiders (the teachers) that change will occur; given the right conditions, change will be in the form of a science curriculum designed by the practicing teachers for their own classrooms.

That is the ideal. It can be facilitated by many of the developmental techniques that take into account the internal worlds of the teacher, such as teacher stories, biography, and collaborative autobiography (Aspinall, 1986; Butt, 1990; Butt and Raymond, 1989; Butt, Paul, and Smith, 1988; Butt, Raymond, and Yamagishi, 1988; Butt, Raymond, McCue, and Yamagishi, 1990; Grumet, 1980; Knowles, 1988; Krall, 1988; Pinar, 1980; Pinar, 1981; Pinar, 1986; Raymond and Surprenant, 1988; Raymond, Butt, and Townsend, 1990; Sikes and Aspinall, 1990; Townsend and Butt, 1990).

The practical may well be limited by other sorts of realities-- budget constraints, for example. Materials and supplies cost money, but even more so, time costs money, and time will be an essential ingredient. Time will be needed to get teachers together to plan (substi-

tute teacher and travel costs), time will be needed for cycles of peer supervision (more substitute teachers), and my time (or someone else's) will be needed to act as animateur. But even limited success will be far more than has been achieved in this area in many past attempts, and it is an area desperate for any successes at all. We must try.

#### THE QUESTION OF TEACHER PRE-SERVICE TRAINING

I have not, up to this point, considered the question of teacher pre-service training in science except to cite, in the case of the teacher-participants in this study, the lack (or ineffectiveness) of it as a factor in the problem under consideration. My main consideration has been the teacher already in the field. However, it is obvious to me that sweeping changes will have to be made in pre-service teacher preparation as part of any long-term attempt to improve the teaching of science. Surely it is better to 'fix' the problem *before* it occurs than to try to patch it up afterwards.

It is beyond the scope and intent of this study to propose changes to teacher-training programs, except in the most generic of ways. In the light of this study's

findings, however, any changes must address a number of 'givens'. They are that:

(1) most elementary teachers will be assigned to teach science, therefore

(2) as part of their preparation they need to be given the chance to find a personal connectedness to, and meaning in, the subject, and

(3) they need to experience science-as-process first-hand.

If these 'givens' are not addressed, teachers will continue to enter the profession ill-prepared to teach science at the elementary level because they fear the subject, and it is a complete mystery to them.

#### FURTHER RESEARCH

It was never the intention of this study to provide a full-fledged action plan to use with the participants, or any other group for that matter. Different kinds of case study are needed now-- action research case studies. These must recount attempts at reaching the internal worlds of teachers of science, and detail successes (and failures) at easing the fears teachers have

of science, at helping them find a connectedness to science, and at providing them with first-hand experience with science. These case studies will hopefully point the way to more effective teacher development in science.

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**APPENDIX A**

Note: This is the letter and informed consent sent to both teachers. The letter and informed consent sent to the parents of the students involved was essentially the same.

September 8, 1989

Dear -----,

Enclosed is a description of a research project entitled The Realities of Elementary School Science which I wish to undertake. The project aims to understand what it is like to be a teacher and a student in the elementary Science classroom. I will need the co-operation of teachers and students in this project, as co-researchers with me. Please read the enclosed description which outlines the purposes, objectives, methodology, and time-lines of the project.

Listed below are the details of your role and rights, should you agree to participate in this project, and how the data generated by it will be treated in order to ensure privacy and confidentiality, and minimize risks to you.

1. I wish to gather information through interviews and classroom observation relating to both your theory and practice of teaching Science, and to your feelings about the subject. Disclosure and level of disclosure of information of a personal or private nature in any aspect of this research project is under the sole control of you, the subject. You have the right to inform the researcher that you do not wish to pursue a particular line of questions or type of inquiry. Further, you have the right to delete any question or questions at any stage of the research.
2. Field notes, transcriptions of interviews, records of observations, or any other written records are open to review by you, the subject concerned, at any time. You have the right to remove or prevent the use of any portion of these materials or data sources.
3. You, the subject, will be asked to collaborate in the interpretations made of data, and you have the right to veto any particular interpretation(s).

4. You, the subject, will have strict control over access to the data, and use of the data. Data will not be made available in any form to any other person, except with your express permission. All data will be kept secured by the researcher.
5. Your anonymity will be strictly preserved in the published report resulting from this study. Neither your name, nor the name of your school or district will be used.
6. You, the subject, will have the right to approve and edit any and all published reports resulting from this study, prior to release.

I would be happy to answer any questions you may have regarding this project. You may also refer any questions about this project to the Supervisor, Dr. Richard Butt, University of Lethbridge, (329-2434), or to Dr. Nancy Grigg, Chair of the Human Subjects Research Committee (329-2459).

If you are satisfied with the above guarantees and procedures, please fill out and sign both the attached consent forms, and return one to the undersigned, retaining one copy for your records.

Thank you in advance for your participation in what I hope will be an interesting and useful learning experience for both of us.

Sincerely,

Wayne M. Youngward

INFORMED CONSENT

I, \_\_\_\_\_, agree \_\_\_\_\_  
do not agree \_\_\_\_\_

to participate in the above indicated research project under the conditions outlined in this letter, and agree to allow the researcher access to my classroom as outlined in the project description.

I understand that I may withdraw from this project, without prejudice, by contacting either the researcher, or the Supervisor, Dr. Richard Butt, University of Lethbridge.

signed \_\_\_\_\_ dated \_\_\_\_\_

**APPENDIX B-- INTERVIEWS**

Note: Where interviews were reproduced in the text of the study in their entirety, they were not repeated here.

## Interview with Alice

- Q: What is your educational background in Science?  
A: One course in Jr. E. in how to teach Science.  
Q: What did you do in the course?  
A: She had rats running up her arm. This is how you would handle a situation where you would have a hamster or a little white mouse. Let the kids look at it. I never did get to that stage because I don't like those little creatures.
- Q: What is your teaching background in Science?  
A: I've taught grade four, and I've taught one year in grade eight. That's basically what I have taught. I just glean my information from the Teacher Resource Book and from films, etc.
- Q: Did you take any courses in Science in your own academic background?  
A: No, High School Chemistry and Biology-- not Physics; we didn't have Physics then.
- Q: Do you ever find it a problem not to have this academic background, that there are concepts you don't recognize, or would you say that the curriculum is simple enough?  
A: The curriculum is fairly easy to follow. I want to switch to experiments; try to get just experiments. Maybe it takes time to get things set up. They don't have that many in the book that I am following, and I have to search more for certain areas-- more that I feel comfortable with. I want the ones that never fail. Because I find it very difficult to explain why some of these fail, so I like to be on safe ground with the children. Do you understand?
- Q: If I played a word-association game, and said Science, what word would come into your mind?  
A: Oh!  
Q: Oh? As a word?  
A: I don't feel as competent in Science as in other areas, because I have to search for things, I don't understand things as well. I'm becoming better-- like, I think I understand electricity and everything else a little bit better but I don't understand it as well as some of the other things. I guess I'm not scientific.

cally-minded.

Q: Do you think teachers should be scientifically-minded to teach Science? In other words do you think there should be a Science specialist teaching Science?

A: It probably would be... to get an onflow of terminology, etc., I think that would be great. But I don't believe in breaking up in Elementary for all these specialized things is good for the children. So I think we probably need a few courses, more hands-on courses, or just some p.d. days that we have special things aligned for Science. 'Cause that would help me more than...you know...

Q: In preparing for your year, in setting everything up, what kinds of things do you do for Science?

A: Well, I make sure I look over the film list. I try to get a lot of films if I can that will enlighten the children. And then I search for some simple experiments.

Q: Where do you search?

A: I have Zed's Experiments. I have special books around that... some of those in the Illustrated Science Book... there's some very simple experiments. And I try to keep it simple. I try to search more for areas when we're doing the Science Fair. I try to get a great number of activities so the children would be able to search through different areas. But I sort of stick very close to the books, the Science text books... I guess you might say I'm a Science text book teacher, and just going over to pick up some things...

Q: You don't feel confident enough to wean yourself away from it, perhaps?

A: Oh, some chapters I almost know by heart, but I still go back to basics so the children have one special thing... I'm trying to get what [an Alberta Education Science Consultant] wants us to do...that they have four or five different corners and they work on a problem and then they solve it. But I just feel comfortable in some areas. Like electricity- that's very comfortable because you can give them their problem and have them solve it...and really that's just an elective with grade four. I make sure they have that because it gives them something extra for the Science Fair. That's an easier one, but Living Things... first of all, we have a few living things, but we have to get mealworms, and all of these things-- it just seems like...probably our lab is not well supplied. You have to supply a lot of things.

Q: Do you find that it takes a lot of time to get these things?

A: Yes, and they're not conveniently located.

- Q: You're as far away from the Science Lab as anyone could possibly be, aren't you? When you do go down to the Science Lab, do you find that the things that are there are useful for you?
- A: It just depends on what I want to do. They have a lot of things there. I don't take the children down there.
- Q: You don't use the lab, you bring the stuff back here?
- A: Yes. There are just too many things there that I don't want them involved in... acid or stuff.. I'll let them go down there as they get older...with another teacher...probably in Junior High. I know some of the teachers have gone down there but I did a couple of times and I think I was...I fretted more about what there...well, maybe because they were so curious...
- Q: What they could get into?
- A: That's right. I thought that maybe the lessons weren't as well-conducted as they could have been...working in the classroom, as they had been doing.
- Q: Do you have a little cache of materials here?
- A: Oh, yes, we have that old Science Concepts, and we have quite a few things there.
- Q: The Classroom Lab?
- A: And I just fill it up every once in a while.
- Q: Do you find it useful?
- A: Some things are used, and some things are never used. There are seeds, and they're gone a long time ago, but you supply new ones, to make sure that they will sprout.
- Q: What textbook series do you use?
- A: S.T.E.M., and then we have the other ones in the room too...Exploring Science...we have a few around-there's one of each one, for reference. Science for Tomorrow's World, Concepts in Science, although that's a little old, it still has some concepts that you can go through. So I just have them sitting around there.
- Q: Do you find the Library useful for you?
- A: Yes, we have some new books, some good books. I still didn't pick up that one from Nova Scotia, from St. Francis Xavier...they have an excellent...it's about \$25...I think Kim [former Sr. High Science teacher] had it. Kim was very good. You asked him anything...he loved Science...he would just tote everything to you...he wanted Science to be really taught well...he liked it...he helped us out lots.
- Q: How would you characterize the range of books in the Library? If you were trying to make up a plan for some particular unit, would you feel confident, if you went to the Library, there'd be lots of materials there?
- A: It depends on the subject...we have a fair number. They can at least find something at their own level.

- It's getting quite good. We just don't use it that much. I guess there are lots of ways of tackling Science. In these, my last few years, this is what I really want to shine up, so that I feel I accomplished that, and that I don't fear Science anymore.
- Q: Who gets to choose the books in the Library: do you get together with the other teachers, or is it just the Librarian?
- A: If you wish to have a book, we ask Debbie [the Library Aide], and she's pretty good at getting it.
- Q: You don't meet at anytime during the year and ask, What books do we need?
- A: They send out...if she gets a new pamphlet, or book list, she'll send it around, and ask if we're interested...I think she has balanced it within her budget, so much for Science, and for Social Studies, etc.
- Q: And the grade areas too?
- A: Probably. You just can't spend all your money on one area.
- Q: Speaking of spending money, do you find that it's expensive to buy whatever you need-- seeds, etc? Do you have a budget for that?
- A: We can present a bill, but, half the time, well, I don't bother, it's just a lot of bookwork. I just feel that I'll just go out and buy it. And batteries do get expensive, like, with a big class...they will last for two years, and the bulbs, but working in groups of four, maybe five...it does get expensive, but if they last for two years...the kids have a great time with them. It doesn't bother me to spend my own money to help the kids-- you may do too much of it-- but I think you don't need every penny given to you...if you want to do something...
- Q: In terms of your timetable, do you calculate how many minutes you spend a week on Science compared to other subjects?
- A: It's 150...right after recess you have 35 minute periods. Language Arts has 560...Social Studies has 160, Music and Health has 80...
- Q: So it's balanced?
- A: Yes.
- Q: The way it's organized into 35 or 40 minutes-- do you find that's enough, too much, too little...do you ever find you want more or less time?
- A: For some things, I'm flexible, if I'm covering a subject I just go through to the next period, and pick up that period I missed the next time...so there's no big problem there...I borrow from another one...it balances out.
- Q: So if you set up an experiment that took an hour

instead of the 35 minutes it'd be possible to do it?

A: Sure, as long as you're within your classroom, you're the manager; you can switch a little bit. The principals don't say anything. Sometimes it's best to finish a concept, than to drop it...then go back to the place where you were the day before.

Q: Have you ever thought of integration of your Science with other subjects?

A: With the Harvest Unit this time, we were talking about the bees harvesting, so we're talking about Living Things. I try to...I'm working at it, to get the Science into the Social Studies and the Language Arts...I'm trying to get into the Whole Language. But to me, I think it's more difficult, because some area, you're not really covering in the Whole Language...you don't have that theme, and so, I guess you have to reword your theme, because I've been looking at these themes that other teachers have used...and that's what they did so that they could cover all aspects. But, like, Social Studies and Science-- when you're studying dinosaurs, you can study a little bit from Science, and Social Studies...I think I work in Science and Social Studies more than anything.

Followup interview with Alice. I asked her to look over a transcription of our previous interview and comment. This is a transcription of my notes.

She indicated that she was really comfortable this year--- the students were "keen but orderly." She indicated that she was "coming to the end of her career and getting braver," so she wants to get into new things. And it's helped by the fact that "there's no school evaluation this year (as there was the previous year) so she is "not so uptight."

She commented that she is still concerned with poor quality media. The films and filmstrips are obsolete or at a level too high for elementary.

This year the students are starting to do research, and "you don't have to spoonfeed them." But there is a problem with the quantity of material in the library on which to do this research. "I have to have lots of subject areas because there aren't many (books or resources) on any one subject area."

## Interview with Alice

- Q- Just to set the context, can you tell me something about the unit you're working on now in Science?
- A- We are doing a weather unit because it's spring, so we're just looking at the temperatures, and doing graphs because this works with our Math. And then we just basically talk about the air, how cold air settles, and hot air rises, and it's not going to be that detailed.
- Q- Think back and tell me what lesson you did in science, whether in this unit or any other, that you were the happiest with, you thought was really the best lesson you've done so far this year.
- A- When we did that electricity deal, I had to prepare all the questions, and then I worked with some of the students, etcetera, and it was really exciting seeing students working with a peer.
- [some grade 11 and 12 Physics 30 students came down to help the teacher with this unit]
- And everybody, they all fared quite well in the test, because they had it all hands-on because it was four (in each group) and I didn't have to go from...usually we do it and we have the groups but I float and they get too frustrated by the time I get there, some of them, because somebody can't do it, but when they had that one (extra) body, and the kids really enjoyed it. They were so excited. They really worked well with them, and they were so appreciative of that. That was one that I found really rewarding. It's okay if you have 20 kids cause you can get around to five groups but when you have 8 groups it's a little bit different. So it was really rewarding. Now, my favourite science one, which lesson... It might be once when we were making mud-pie mountains (for a unit on erosion) because everything worked well. Everything just seemed to fall into order. The experiments worked as they should.
- Q- The experiments worked as they should. That's important?
- A- That's very important! Because then you don't have to start to explain the reasons why this may not have worked.
- Q- Along those lines, can you think of maybe one that you think was unsuccessful, that you were really not happy with, that you wish you had done something different.
- A- Thinking back to the beginning of the year when they had all those animals, that really worked well, then we had the fresh-water environments and salt waters

environments....I wish I might have had something more for the salt water, like I have to find more realistic things. We can work with the fresh water, but the salt water, it was little bit foreign to the kids, and I didn't have a backup film that really explained things. There was something missing. They were sort of dead that day. But maybe it was because they had all the animals from the fresh water and then we went to this thing, it was pure.....

Q- So they got excited by the hands-on approach, and when you tried to use something that was less...

A- Less hands-on, they're not as excited. That probably is it.

Q- Have you thought of any way that you could address that question? In that particular unit?

A- Well, I'm going to try to get something, even if I can get some plankton form on of the science....they probably have slides of plankton anyway, we can just look at the slides of plankton. Like, we can get (hands-on items) from fresh water, but the salt water, it's a different life completely. You know, like the fish, etc, and we just didn't have enough.... And maybe I just need to...I have to search for something in that particular area, because it's a little bit weak.

Q- How important is it to do that unit? Could you envision doing the fresh water unit where you seem to be happy with the success you were having, then completely leave the other one out, would that work?

A- Probably we could do that, because I have another fresh water unit that I didn't dare bring into the class because you're supposed to bring in some pond water and have this swimming pool but it would be really ideal to have this, so kids could really see it. But we could do that. It's just that they like the big animals. I guess you still study the big animals because they love the sharks and whales. That's one thing they are really keen on. So I might even just do a research paper. I might, with this particular group, anyway. I should have done a research paper where they could choose one animal of the deep, and just look at it a little bit closer. It depends on your class. At the beginning of the year you don't know the depth of your students' interests either....at the end of the year I might just go over something like that. A quick project. If I have enough time and I feel I want to review something, and just have a writing assignment too. I may just polish that up...that's what I do sometimes, if I'm not satisfied, I just polish something up another time.

- Q- Either in planning, or in teaching, how do you know when it's going well? What feedback, what clues do you have? What tells you that?
- A- The students, because if they're restless... and if they have lots of questions and their eyes are sparkling, you know it's okay, but if you're forever having to get them down from something else, you have to do something different.
- Q- What kinds of things have you found they've responded to the best?
- A- When they get to do experiments. Sometimes I don't choose them all to do experiments just because of mess and size...it depends on the size of your class, so this class is really good but I still choose what experiments they do because you don't have the space, and it can be a big mess.
- Q- Was that what you meant before when you were talking about the swimming pool?
- A- That right. You have to be very careful. It would be Al to have something like that, in fact I think that particular little blurb came out in one of the science articles afterwards. We had done this particular activity. I may do it next year. Just bring something in and let them see...get some tadpoles in there and let them swim around...The janitor doesn't appreciate some of these finer qualities of life! He's a good janitor....
- Q- What about in planning, what do you use as a guide in your planning when you're trying to figure out the kind of thing that would be successful in the classroom?
- A- Well, I look at how the experiments are and try to cover the specific objectives, and I also go through the film (catalogue), and we don't have too many science films for grade four. They're either too elementary or we have to go to the grade seven, eight or something, and they're too difficult. I have to try...I get many magazines...I get the National Geographic, so I try to get something from those too, and we listen to the news, try to bring in what's current, and prevalent in the world right now...we try to get something from the newspapers. So, everything's general...not exactly specific, once in a while I can find something to throw in there, so I leave spaces so that I can pull that in, I don't want to have it airtight. I want it so I can keep it up-to-date.
- Q- What, from your perspective of having taught grade four for a number of years, does science mean to the students? What is meaningful science to them?
- A- Not book-learned. That's not meaningful to them. I

guess because it's such a hands-on world. They like that. They gain some knowledge and they can understand it. That's what I've learned-- the trend in teaching that is coming. It's not important to know specific science facts it's to know how you come up with that generalization, and you sort of have to come around to that point. So if you can get them involved in something, they will probably remember something of it. They may have to go to a book and find a little bit more...I remember years ago, we learned everything in that book...that was the program. That's what we did...probably it's because that's what I did too, and you have to change, to fit the times.

Q- What are the topics or areas you've found most successful with these kids?

A- The living things was excellent. That animals and plants, because we grew things and we caught things. Then the electricity unit, it was just an introduction to cells and circuits, that's all it was, but that was worthwhile, and we made testers (for conductors and insulators), they're just finished now, and we're going to have those on display for Education Week. Those are exciting things because they had to research and do something, and they made them, and they're excited. They want to share them, and they're going to. Erosion wasn't as exciting.

Q- Why not?

A- Maybe I'm not as interested in it.

Q- I heard you saying they were excited about making things, they were excited about sharing things. Would you agree that that happens just as much in other subjects as it does in science?

A- Yes.

Q- What makes science different, then, for these kids?

A- I guess we're looking for specific answers in say, math, but you can get involved in hands-on things. I know they like Social Studies because they can learn about different types of people. But kids in general like the other subjects better than science, and I'm not really sure why.

Q- Do you think it has anything to do with their ability to see the world, their understanding of it?

A- They may not be mature enough to really understand, and some things are very simple.

Q- If I asked you to make a priority list of subjects, of what is the most valuable for the kids, what would that be?

A- I would put Language Arts, then Math, then I would have to put Science before Social Studies, because Science tells you the modern world and they have to

deal with scientific things. History is not that important. That's probably the order I'd put it in.

Q- What I hear you saying is that there's a dichotomy between the way you see what the students think is important...or what they like and at that age I assume it's the same thing....

A- Well, what the students like is Phys. Ed. and art. Then, if there's keen in math they'll like math, and if they like to read and write they'll like Language Arts.

Q- But I heard you say they don't like science as well as, for example, they like Social Studies.

A- Well, I don't think they do. It seems like you don't get the same response, and it could be me too. Maybe I'm just not as scientific. Because I really like Social Studies. Maybe it could be a feedback too.... You can pass on vibes without even knowing it.

Q- Would you say that science and these other subjects like Language Arts and Social Studies and Math, are the same in some ways?

A- Yes, because they can be problem-solving. Basically in all those areas now we're looking at problem-solving approaches now. I think they might become more interested... I think if we had a lab that we could just go into that was set up for us...that was just down here...I think science would become more exciting. But when we have to traipse way down to the other end [the science lab is literally at the extreme other end of the school from the grade four room] or bring everything in, that's probably where we tire out (laughs). Because the kids just loved it when I had all their bags for electricity and they had these other kids come in, they just loved it. I think that's what happens, we don't make it as exciting as we can. Simply because you have to move things into your area, and you have to go all the way up to the science lab, you just don't do it as much as maybe you should.

Q- How do you find teaching science different from teaching say, Language Arts or Math?

A- Math is specific.

Q- You mean the content?

A- Yes. The content is specific and you cover the basic facts before you go on and do something else. Social Studies, you more or less make a story out of it. You create it in a story fashion if you wish to. And science, I just haven't...I think probably I just haven't done enough problem-solving, from that approach. It's more or less just been a factual approach...going in factually and trying to come out with experiments, instead of going in with experiments

and coming out with factual... I know I'm changing in science [speaks here of her ongoing discussions with another teacher about the pedagogy of science]...and that's one of the areas I've felt least comfortable with. In these last few years [before she retires] I want to get it down to where I feel good about it. Things are changing....we're experimenting...

Q- Picture the typical kinds of classes you have in science, would you say that teacher control is different in a science class compared to other subjects? The amount of control or the amount of direction you're giving them?

A- It depends. Most of the subjects are quiet. Science is...let's see...if you have the experiments they can get noisy and forget what they're doing... You really have to train them what you want them to do, then it works well as long as you choose who's in the groups, but you try to get all the kids working with each other at some time, and your grouping may cause problems. So I guess there's probably less teacher control in science than maybe in the other areas.

Q- Where do you go from here this year in science? What are you planning?

A- I'm going to put them all into themes and strictly do experiments, finding experiments to fit the topics...

Q- You're going to try to integrate?

A- Integrate everything that we have. We're doing "Back to School" in the fall and I'm going to look at Fall things, like how carrots store their food and how leaves change colour and I'm going to try to get into Living Things. That's what I'm going to try anyway. I don't know about testing so much either. You have to test something because you have to come up with a science mark but if you have them write up experiments and mark that, I think that may give you an idea of just where that child is in his knowledge of that particular problem. Instead of specific facts...I know you have to deal with specific facts some times, but some things change...but I'm going to be more aware of what kinds of questions I need to test and the others, I'll just work from their knowledge, what they have gained from experiments.

Q- If you could have any one thing that you wanted, what would be the thing that would help you most in science?

A- Have running water in this room so that you could have it immediately, so you wouldn't have to go in the hallway, or a cupboard so you could have a place to work on a particular experiment...

Q- So, facilities?

A- Yes, facilities right now, and I'd like to have all of David Suzuki and National Geographic (tapes and films), those things right here, and then there's Wonder World (T.V. programs available on videotape) because they always come up with a question...I find that program so exciting. I'd like to be able to teach like that particular person.

Q- Why is that person able to teach in that way?

A- He must love science. He feels comfortable with it.

## Interview with Carol

- Q: What is your educational background in Science?
- A: Just in high school. I have no university Science except one course in introductory Biology.
- Q: What did you do in that course?
- A: It was just an extension of my high school Biology. I don't remember much.
- Q: What is your background in teaching Science?
- A: I taught grade 7 for 3 years, and this is my sixth year of teaching grade 4.
- Q: What about courses on teaching Science?
- A: I had no Science methods courses at all.
- Q: Do you ever find that this lack of background is a problem?
- A: I would teach Science like I taught Social Studies. Using the texts and the kids taking notes. In the last couple of years I've been trying to change. The books aren't much help. Now I write down the process skills when I'm planning.
- Q: If I played a word-association game, and said Science, what word would come into your mind?
- A: I thought of inquiry....but I'd say investigation.
- Q: Do you think teachers should be scientifically-minded to teach Science? Should there be a Science specialist teaching Science?
- A: The kids would be better off because they'd get a better Science program. A Science person would know how to approach it. The textbooks....you can't even use them. If I get one idea I can go with it but it's hard to come up with the original idea. I have to teach myself. The program is better (than it used to be) but I'm not bragging about it. The kids in previous years hated Science but this year they seem to like it. They like the hands-on.
- Q: In preparing your year what kinds of things do you do for Science?
- A: I try to look for topics that are process-oriented--- to investigate things. The curriculum is pretty broad. We three teachers (the grades 4, 5, 6) try to get together to make sure we cover everything. I do my planning in six-week blocks.
- Q: What do you think of the textbooks? Are there any problems?
- A: I'm looking for books for myself, for experiments and examples of investigations. The (text) book is poor... I have to demonstrate (the experiments). The materials are hard to get or impractical. The reading level (of the text) is inappropriate. Texts are a waste of money. I've

never liked them. They're average but I've not seen others to compare them.

Q: Do you ever use the Science lab?

A: No! It's physically not set up for nine-year-olds. I don't feel confident with the chemicals, etcetera. There have been some demonstrations set up there but most are done in the classroom. A lot of it is my fault because I don't know what to do with it.

Q: Do you think a properly set-up lab could be useful to you?

A: If the materials are related to the curriculum, and we knew how to use them.

Q: What about materials and supplies--- are they a problem?

A: We can get \$20 things easy enough...for electricity a few bulbs, etcetera. I haven't tried to get other materials. I try to use what I can bring from home--- I try to do simple things. I feel frustrated by not having things like scales and weights. When I did Science I had to chase all over to find sandpaper. I have to spend a lot of time (strong emphasis) on three periods a week. I resent it (but) I've decided it was Science's turn this year.

Q: What text do you use?

A: S.T.E.M.

Q: Any others?

A: There's a set in the bookroom, and I have a few others around. I use Larry (the Senior High Science teacher) for ideas at times. I don't have any other sets (of texts).

Q: What about the library? Is it any use to you in Science?

A: There are some references. Linda (the library aide) will get anything we need. There are more for the older kids, like Junior High.

Q: What about your timetable? Are three forty-minute periods adequate?

A: Yes. I used to have four but I didn't feel I needed it. I needed more for math or Language Arts. You don't need four.

Q: What about the length of the periods? Is forty minutes OK?

A: Yes. If I'm doing an investigation I'll just continue into another period.

Q: Do you any integration with other subjects?

A: I've had a Stars and Space theme with Language Arts. It's almost impossible to integrate with Social Studies.

Q: What would be the most help to you in teaching Science?

A: To see someone who knew what they were doing teach a unit--- see someone's unit or lesson plans. A model.

## Interview with both students at Carol's school

- Interviewer: What can you remember about the kinds of things you've been doing in science this year?
- Girl: We've been doing... we've talked about whales and stuff.
- Boy: We've done a lot of campaigns about saving endangered animals.
- Girl: We've done whales and elephants. Most of it (hunting) has been done legally and some of it we have no power to stop.
- Interviewer: Can you remember any other subject areas you've been doing in science?
- Girl: We talked a little bit about the mountains.
- Boy: At the very beginning we kind of circled around people, we did friends, and we did ourselves, and we did parts of our body and how to keep healthy, like toothbrushing. When we were in groups we played some games so we could remember all that stuff. Then we went on talking about animals and people who are different from us. We did animals that were endangered or they were extinct.
- Girl: We wrote letters to them.
- Interviewer: Who did you write to?
- Boy: I wrote to Iceland.
- Girl: I wrote to Iceland too.
- Interviewer: Oh, you wrote to countries?
- Boy: The embassies.
- Girl: Then I got a letter back, and it just said all these excuses, and it said, in different words, mind your own business...
- Interviewer: Let's talk about your actual science classes. What kinds of things do you really like doing in science?
- Girl: When we do saving the whales, we do posters and stuff and we draw these t-shirts, and we put the whales on them, pins and buttons
- Boy: I like it when we do the activities.
- Interviewer: Can you give me an idea about what kind of activities you've been doing?
- Boy: We have campaigns about saving things, whales, elephants and other endangered animals. We usually do a lot of things like raising funds....
- Interviewer: What other kinds of things have you been doing in science?
- Girl: We've been talking about landscapes and stuff.

Boy: We had a book that was called Landscapes of Alberta and we looked at the different things that were happening, like we looked at sugarbeets, where sugar came from, and all the things that sugar went through to be made. And we learned about how much Alberta is such a good country for things...we have a lot of raw materials. And we've been talking about National Parks.

Interviewer: If you had a choice, what topics would you like to study that you don't now study?

Boy: I would like to study the government, the Liberal leaders.

Interviewer: Would that be science?

Boy: No, that would be social studies, I guess.

Interviewer: What would you really like to now in science that you don't now know?

Girl: I'd like to learn about beans and stuff.

Interviewer: Plants and growing things?

Girl: We went to the bean plant (a local processing plant for pulse beans) and I'd like to learn about how they grow and stuff.

Interviewer: The life-cycle?

Girl: Yes.

Boy: I would like to know about certain people.

Interviewer: Do you mean scientists?

Boy: Yes. What I really liked was space. We learned about Challenger going up, and that teacher...

Interviewer: Do you do many experiments in class?

Boy: No.

Girl: We did this one where you had all these little bottles, and you had to blow into them to make these different sounds.

Interviewer: How did you change the sound?

Boy: More water and less water.

Girl: The experiments are fun.

Interviewer: You like doing those?

Boy: Yes.

Interviewer: If you looked at your science program over the year, how much time do you think you should spend on experiments?

Girl: All of it!

Interviewer: Do you like to do something every time you do science?

Boy: We should learn as much as we can and then have an experiment for every topic. And at the end of the topic we have a test, and with each test there should be an experi-

ment and that should be part of the test mark, because it shouldn't be just how much we know but how much we can show...if it's just stuck up in our head somewhere it won't do a lot.

## Interview with Carol

- Q - What unit are you working on now?
- A - Oceans and Whales Theme - working on ocean environments and the study of whales because they are endangered and we are saving them.
- Q - Social and ecological awareness.
- A - Yes.
- Q - Either in this unit or if it is better to think of a better unit to this question, which lesson comes to your mind as the best lesson that you taught in science? What was the one you were the happiest with? The one you were proudest of yourself for.
- A - I have had a couple of those this year. The hands on material was pretty good. In the electricity I had them do a lot of things - bulbs, wire, etc. and had them make a circuit and they had to figure which end of the bulb went to which end of the battery, had students investigate this themselves. Worked quite well.
- Q - What I am hearing you say is what you liked about it was the fact that the students could do their own investigation and there'd be less input from you.
- A - Like when we did insulators and conductors they just had to try it, complete the circuit and put stuff in between and then they had to arrive at the conclusion that stuff that is metal is a conductor and other stuff isn't and able to generalize and make definitions of what a insulator and conductor were. Things that they had to investigate. That is the kind of stuff I like to do. And now saving the whales is a whole different ball game of course; background in what a whale is, why there was hunting and they investigated the history of whales and how their slaughter is affecting the ocean environment ecosystem and if we can't save the whale we can't even save ourselves and so let's get at it. Ecological awareness and all that you know. I am trying to have them do more this year. We are trying to stay out of the textbook for starters. Try not to read in textbooks, a lot more discussion and digging around and trying things out. Not as much as I would like to do but it is coming, a lot better than last year.
- Q - Along those same lines now, can you think of something you have done this year that you wished you hadn't in science. Given the chance to go back and

- do something completely different or somehow different you would, that it just didn't work or didn't work as well as you wanted it to.
- A - Well I know when I did my stars and space it was more of a fact kind of thing. We really didn't do a lot of what I think is science process skills. I found it difficult and maybe I just didn't try hard enough to make it more of a process orientated thing. It was a new theme for us. Of course you know me I worry about the Language Arts first. I would have liked to have got them outside more and set up a better at home study program for them. At night they could look at the stars better and try being astronomers. It would have be nice to get them to the planetarium in Medicine Hat maybe. This could have lent itself to more outside of school things. And I should have probably tried to do that more with them.
- Q - If you decide to do that unit again in future years what would you do differently? How would you organize it different?
- A - I would try and do that more. I got Linda to order a book that helps you get out and find stuff and would have had lessons at home to identify stars and constellations and look at the colors of stars, notice how they move, why do they move, you can even do that startrail stuff with the camera. You can get a camera and open the exposure and watch the stars go around and photograph that. Maybe making our own star chamber in a way, you could make a small one, some kind of a umbrellas and stuff more of that kind of thing.
- Q - I am just guessing here, you can react to this, maybe one of the problems is the subject matter itself?
- A - It could be because it is quite complex really looking into stars. If you get into the study of light and for these kids light is just light. I really didn't get into that either and I don't think I needed to with this age group. But again, materials, I would have had to make everything and now that I have this book that Linda is ordering it would have helped too. It is hard to dream up everything yourself. At least I think it is.
- Q - No, so does everyone else.
- A - Well, exactly, it is not just me. But I think too that I let the Language Arts take priority, and science is just... It was alright but I don't think the process point like it should be.
- Q - How do you know when either you are planning or when you are actually teaching the lesson if it's doing and going and heading the way you want it? What kind

of clues do you have?

A - Well I just sit down and plan it and I just have to watch the kids and see what happens and sit back and think is this what I wanted to happen sometimes it doesn't work out when you want it too.

Q - What do you want to happen?

A - Ideal science.

Q - I don't know about ideal, but the real world, how do you know, you have your kids sitting here and doing something in science, what tells you "yes, this is working and is good stuff"? What tells you that?

A - I think when I see them guessing and trying it. Giving it a whirl and seeing what happens and going "Oh, alright". Actually that one thing I did with stars worked pretty good. You were here that day when they were making those orbits and stuff. That actually worked pretty good. That is something I will do again. I guess, Wayne, in science they are supposed to be curious, investigate, make a guess, see what happens, and draw a conclusion. I don't know if I am off track with that but that is what I like to see them do. Like when we did electricity, instead of me saying this is the circuit this is how you put it together, here's you stuff make the light bulb light and they have to figure it out and draw their pictures to show me.

Q - What things interfere with that? You have described a situation that you want to see where they are being investigative, willing to take risks. What stops that from happening?

A - For something like when we did sound, it would be nice to have sound bells and tuning forks so lack of materials or the fact that I didn't know what to order or get a catalogue out and figure out what we should order so we can have it. It's my fault too cause I didn't order this stuff when I should probably.

Q - Or perhaps are you saying maybe you wouldn't know what to order

A - Yes, wouldn't know what to order. Exactly. Or sometimes having a topic and looking at it and trying to get into the science mode in my head instead of my Language Arts/Social Studies. Let's make this more of a science orientated approach like for myself switching into that gear is not easy.

Q - Following up with what you said, switching into that gear is not easy, I think I understand what you mean but maybe you can give me some details. Why or what for the teacher is different in science than in Language Arts/Social Studies? What makes it differ-

- ent for you? When you talk about switching gears, well why are the gears different.
- A - I think it is the, for instance the Language Arts, its the brainstorming, being creative, writing a fiction kind of a thing, but in science you have your facts, you have some information in front of you and you have to figure out how to investigate it and make guesses and prove them true or false. I don't know how I can say that better. For instance, when you do say for example electricity. I could have just stood up there and had the kids or told them (lectured)I wouldn't have done it that way but mind you some teachers do lecture, this is electricity this is how it works. Here are your notes or here is the textbook the chapter, read it and answer the questions. But that's not how you do it. You want them to investigate and figure it out themselves. To guess and check it out. Maybe I am not as awful as I think sometimes. Maybe it's just I don't always know for sure what a science approach would be. Maybe I do it more than I think I do. I don't know that. I am not really a science person so maybe I'm not off track as I think. Maybe we do more science process than I believe we do. I used to use the textbook quite a bit and used to lecture in a way or have them do reports and I don't think that reports is really science when you have a topic and go research it. That is more Social Studies again when you research stuff. Rather than having them guess and investigate a little more. To me that is more science, investigation, proving it, like manipulating it. Did I answer anything?
- Q - No that's exactly what I want. I want to know you know what your life is in terms of science and that's I am asking for and that's what you're giving me.
- A - Yes I think last time you were here I told you too that my science is 120 minutes a week. And for me to try and do a better science program, like a lot of prep time I resent having to put some much prep into my 120 minutes. I'd rather spend it making Language Arts or planning Social whatever. So for me it's don't be stupid and do this right and put some time into it. But sometimes I resent that.
- Q - How is science, whether you want to call it ideal science or the way you want to do science, how is the way you want to do science the same as Language Arts/Social Studies?
- A - Well this Social action stuff we are doing with the whales is definitely interrelated to Social Studies and then like writing our letters to these countries

Language Arts tied in there but specific examples you want brought up.

Q - No, any way you think of it.

A - When they had to make their own solar system I think some of that was definitely like when they had to describe their planets that's Language Arts they had to create mind you they had to base it on some actual facts so it wasn't really far out. They had to make it look like ok the planet could be this big and could be this cold because that is far away but they still had to be quite creative in their presentation of it. They just couldn't put down just anything. In science too we did this whale thing. They had to research like to begin with I just thought they should just know something about whales, so they had a whale to do and research it and made a little whale book and put it together. And that's more I wouldn't say that's not science necessarily. They're gathering background information and I think you need that but I don't know if I can really call that science. I don't know, what do you think? Or you don't want to tell me what you think.

Q - Not right at the moment, cause I want to know what you think.

A - That kind of stuff I would say isn't exactly science. What I think kids should do in science, they should come in and have all this stuff in front of them and I should pose a couple of questions to get them thinking and they should get at it and find the answers. And that's not always the way its goes.

Q - And the reasons I know we have already talked about, reasons why it doesn't always go that way?

A - With lack of materials or lack of my ability to channel them in the right direction.

Q - If you were asked to prioritize all the subjects that you teach your class into the most important things for them to, not only to do now but also in their future. What kind of list would that look like? Do I take it you would have the Language Arts/Social Studies at the top?

A - No I think, Language Arts definitely. You can't do anything if you can't read or write. You see some of Social, Social action part that concerns the environment, being an effective citizen, Social and science could overlap there a lot. Into today's society probably science got to be top or is not top but has to be high up there. In today's society I think you have to have some science I think. But again, you have to be an effective citizen to be a conscientious scientist. So that's some Social Studies too. But

as far as some of the materials or subject matter in Social Studies I would say it is important as the sciences are going to be as they get older.

Q - That is an interesting point as they get older. Do you think for example for have Grade 4, do you think that science is more important for the kids at the Jr. High or Sr. High level than it is at the elementary?

A - Yes it is. Cause I wonder, do these kids really care what a series or parallel circuit is? Not really, you know. I kind of wonder, what's the point? Or, when we do friction. You know, what's the point? They're nine years old. They could care less. Does it really apply to them? The stuff that I think they like the best in science is stuff they can apply to themselves more, they actually see some value. Like when we were doing electricity and I brought up the Christmas light thing - what do you do when you burn out a bulb. And they go, Oh wow, and then they kind of got excited about the series and parallel. I find you've got to find comparisons like that or they just could care less. But you do that with everything I guess, you've always got to relate it to them. To their background material or it's not relevant, but as they get older, science is more easily shown to be important to life in general, and they can see that it's got an effect. Like when you're only nine... Like somebody asked me, why are you studying whales? Like, why aren't you fighting acid rain? and I thought, right!, you're nine years old, and you're going to worry about acid rain? Like, whales are something they can get excited about, granted that we're in landlocked Alberta. Still, there's just that feeling, that attitude that we've got to save these creatures, then I can apply that, like we're doing endangered species next right, in general, and you can apply this to other animals, there's just a whole general feeling... you know, responsibility...like, we're killing these animals, and we have to save them. But you have to start with something they can get excited about. ...Whereas when they are in grade nine, ten, acid rain is something they can be concerned about, cause they can see what's going to happen. Whereas these kids, they wouldn't really have clue one.

Q - They have a more limited world vision?

A - Yes. Like acid rain, I mean, it's up in the air there somewhere...they don't care.

Q - You're teaching a science class...do you feel that the way you conduct your class is different from the way you conduct that same group of kids in Language

Arts?

- A - Well, it's a little more freewheeling...in the sense that I encourage them to mingle with their peers. I think in science if you're investigating, I think it's valuable to hear the insights of other students...they go, Oh, let me try that. Cause you can't think of them all yourself, when they get to do that I think that they learn more. Whereas maybe in other subjects I think it's important for them to come to their own conclusions, like figure it out themselves. Sometimes in science I think it's valuable cause there's more than one way of finding out things.
- Q - What about classroom control...your sense of control over what's happening in the classroom. Do you think it's any different in science than in, say, Language Arts?
- A - (long pause) I would say so. I would think it's more controlled in Language Arts. science, because of its investigative nature, there's so much more opportunity for the students to approach it from different directions...I can't control that, nor do I want to. Like, I want them to take risks, I want them to feel free to guess...lots of time in Language they know that there's really one way...like even when we're doing some story writing, I'll tell them, okay, I'm looking for dialogue, or proper punctuation, whereas in science...make the light bulb light, and there's lots of different ways to go about that. I'd like to think about that one... I'm not sure...
- Q - When they're older, they're going to have science teachers
- A - Well they do, they have specialists. And I think they're more ready for science too. People say Nonsense! to that, like baloney, and that's true, because I know that they do like it, they like it when I do it in an investigative way.
- Q - Is what you're saying, they'd be ready for a different kind of science?
- A - Perhaps, yes. Well, for sure, they get to use a lot more materials, you know, that's for sure, like the chemical side of it. But again, maybe I'm doing a better job than I think. Cause I've been trying this year, it's been my focus...this is science this year, its turn to get a little boost, so perhaps it's coming.