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THE UNIVERSITY OF ALBERTA

A METHODOLOGY FOR ASSESSING AND ENHANCING THE CANADIAN CONTEXT IN SCIENCE INSTRUCTION

by

RICHARD MONTEGUE MRAZEK

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

AND RESEARCH IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF SECONDARY EDUCATION

EDMONTON, ALBERTA

SPRING 1989

ISBN 0-315-52948-2

THE UNIVERSITY OF ALBERTA

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DEGREE: Doctor of Philosophy

YEAR THIS DEGREE WAS GRANTED: 1989

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled A Methodology for Assessing and Enhancing the Canadian Context in Science Instruction submitted by Richard Montegue Mrazek in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Supervisor

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Date: December 19, 1988

ABSTRACT

The study develops a methodology for assessing and enhancing the Canadian context in science instruction. The design of the study incorporated five stages. In Stage I the theoretical perspective for a Canadian context for science education developed by Mrazek (1982) and the clue structure derived from it, was expanded and refined. The revised clue structure was validated by a national sample of 142 science educators, scientists and science teachers. On the basis of the reaction from the validators the final revision of the clue structure was drafted.

Instruction in geology was used as the curriculum vehicle for developing the methodology in Stage II. An assessment procedure in which the geology component of the Alberta Grade 8 science program was specifically related to the elements of the final version of the clue structure was developed and applied to the prescribed resources and suggested supplementary resources.

In Stage III procedures were developed and sources were identified for collecting information for enhancing the Canadian context in science instruction. An Alberta-wide survey of 120 Grade 8 science teachers was used to obtain information regarding what they were doing to supplement and modify the prescribed geology curriculum with respect to Canadian context. Six teachers, who indicated in a survey that they were actively supplementing their courses for Canadian context, were interviewed to obtain further details on what the teachers were doing to modify and supplement the materials to upgrade Canadian context. Three practicing geologists were interviewed to solicit information regarding availability of resources within the geology component identified. Five Alberta science educators were interviewed to solicit working knowledge of the science area and geology component under study. Finally, further scrutiny of the related print and non-print material was done to identify suitable instructional materials for upgrading Canadian context.

The focus in Stage IV was on ways the information from Stages II and III could be used to develop instructional materials for science education to include an enhanced Canadian context. Validation of this process was sought by providing six practicing teachers with suggestions for expanding the Canadian context within a geology

component and interviewing each regarding the feasibility, desirability and implementation of these suggestions.

In Stage V, based on the experience with the geology materials in Stages II, III, and IV, the strategy for analyzing, enhancing and developing instructional materials reflecting Canadian context in any area of science was reformulated.

ACKNOWLEDGEMENTS

The author expresses sincere gratitude to Dr. Marshall Nay, advisor and Committee Chairman, for his considerable contribution to the conceptualization and development of the methodology described in this study for assessing and enhancing the Canadian context in science education. In addition, his generous contribution of time, guidance and encouragement are greatly appreciated.

Sincere and warmest thanks are expressed to Dr. Wytze Brouwer, Dr. Heidi Kass, Dr. Don Massey, Dr. Ken Jacknicke, and Dr. Alan Ryan (external examiner) for their guidance and critical reaction as members of the Committee.

Sincere thanks are expressed to all science teachers, science education graduate students, science educators and scientists who participated in this study.

A very special thanks is extended to my wife, Sheryl, who once again provided unfaltering support, and patience during this study, and to my mother, Mary Rose, for constantly reinforcing the necessary confidence and ambition.

This work is dedicated to the shining light in our life, Kristen Richelle, for whom I hope this work will assist in some small way in creating a more relevant and exciting learning environment for her science education.

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CHAPTER I

INTRODUCTION

1. Background and Justification for the Study

In recent years there has been discussion in Canada regarding emphasis of Canadian context in science education because of concern about a perceived inadequacy in this context. The concern has been about an inability of students to relate science knowledge to their own history, culture, and social and physical environment. Dubas and Martel (1973, 1975), Symons (1975), Suzuki (1977, 1980), Page (1979), and others who expressed the opinion that the manner in which science is taught or learned in Canada does not adequately reflect a Canadian context have recently been joined by the Science Council of Canada in its 1984 report on the status of science education in Canada.

Hodgetts (1968) was one of the first to raise concern about the lack of students' knowledge and appreciation of their country. He suggested that students also needed the intellectual skills, the knowledge and the opportunities to play more effective and satisfying roles as citizens in the wider Canadian society. Hodgetts argued that ensuring a Canadian context in our schools would enable elementary and secondary schools in Canada to play a more inspiring role in Canadian affairs than they had in previous decades. Two decades later, consideration is still being given to this concern.

In 1972, the Commission on Canadian Studies was established by the Association of Universities and Colleges of Canada. Symons, as chairman, was asked to consider the state of teaching and research about Canada in Canadian universities. Included was the question of whether or not teaching and research in the sciences was related appropriately to Canadian circumstances. Symons received representations from more than fifty scientific associations. In addition, some five hundred scientists personally made their views known. The first two volumes of the Report of the Commission on Canadian Studies, To Know Ourselves, were published in 1975.

The Symons Commission Report (Symons, 1975) considered it misleading to suggest science is only international; it does also have a national or cultural dimension. In the report, science is viewed as not just a set of laws, but rather as an activity which involves people, attitudes, aims and processes and is as much a part of the cultural fabric of a nation as it is a pillar of technology. The Symons Commission report provided a well-documented catalogue of neglect of Canada in university scientific research and teaching. In the 'Science and Technology' chapter it is concluded that Canadian school children learn virtually nothing about "the accomplishments and impact of science in their own country, and the reason is they are not being taught such matters" (Symons, 1975, p.162). The Symons' Commission added that in the area of science education, there was an almost unparalleled story of neglect and missed opportunities. It reported that science students "showed a general lack of awareness - often bordering on ignorance ... of contemporary and historical Canadian society" (Symons, 1975, p.151).

On the basis of its findings the Commission on Canadian Studies made recommendations which reflected the need for a Canadian context in science teaching. They noted that the responsibility for teaching about Canadian science is shared by all levels of education. These recommendations held that improving the amount and quality of Canadian context in our science curricula would have a significantly favorable impact on present and future students.

Symons was invited in 1978 to address the members of the Science Council of Canada on the issues raised in the science and technology chapter of his report. As a result of that session, the Council commissioned Page to write a position paper on the implications of Symons' observations. To assist in this work, the Science Council sponsored a colloquium on October 24, 1978 entitled "A Conversation About Canadian Content in Science Education" (Page, 1981).

In <u>A Canadian Context for Science Education</u>, Page (1979) explored the issues and concerns for science educators that were raised by the participants at the 1978 Science Council of Canada colloquium. He identified the major areas of concern in university teaching as:

i. lack of attention to Canadian dimensions and problems in science teaching and research.

ii. failure of Canadians to recognize that science and technology are integral parts of our society's culture.

Since our teachers are trained in our universities, there is no reason to suspect that the above two areas of concern expressed by Page fare any better in our elementary and secondary schools. Indeed, owing to the declining attention given to science in elementary programs which accompanied the revival of the 3 R's in our schools, the situation was probably worse than that in the universities. In Alberta, this was confirmed in the province's 1984 secondary education program review which provided direction for the present science curriculum changes. Alberta Education maintained "the role of science in society needs to be emphasized, with consideration given to the application of science, the social and environmental impact of scientific discoveries, and the moral and ethical issues which accompany the use of scientific knowledge." (Alberta Education, 1985, p.13)

Page (1979) claimed that the most significant result of the Science Council's colloquium was a firm statement of those present that "adequate" recognition of a Canadian context for science education ought to be a basic educational objective. According to Page, if Canadians understand the relationship between science and society and if they are able to comprehend Canadian science issues, then they will be able to deal more effectively with Canada's future. Page also suggested that the Council do a major study of the questions raised in the Symons Report.

Such a study was launched in 1980 by the Science Council of Canada under the title of Science and Education Study, with Graham Orpwood and Jean-Pascal Souque as project officers. This study went through three phases: issues identification (which entailed critical reviews of contemporary science education); research (consisting of four major projects, namely an analysis of science curriculum policies from all provinces and territories, an analysis of 33 commonly used science textbooks, a survey of more than 4000 science teachers and eight case studies of science teaching in schools); and eleven conferences across Canada to debate future directions for science education.

A preliminary report, Science Education in Canada: Does School Science Reflect Real Science? was published in 1983 in which the following telling comment was made:

> According to the Science Council's Science and Education Study, presently nearing completion, the difference between school science and real science is that the "science" in Canadian elementary and high schools is totally devoid of context ... Canadian students are not learning such things as the relationship of science to technology, how science is applied in an industrial setting, or those aspects of science which are important to Canadians. The unavoidable conclusion is that science in schools is seen as boring and irrelevant to many students (Science Council of Canada, 1983b).

The final report, Background Study 52, Science Education in Canadian Schools, of the Science and Education Study was released in 1984. In this report the findings of the study were distilled into eight major initiatives for renewal of science education in Canada and forty-seven recommendations for implementing these initiatives. Four of the initiatives suggest redirecting science education to focus more on science, technology and social relationships, including one which recommends taking into account the Canadian reality. Several of the recommendations are directed towards the achievement of these four initiatives, which are reflected in the components of the clue structure developed in this study.

Details of the interim and final reports of the Science Council of Canada study will be presented in the next chapter. At this point, only the major findings as they pertain to the neglect of Canadian context will be discussed. It was noted that, according to their 1981 survey, 174 science textbooks were officially approved across Canada, while surveys showed that 250 different books were reported as actually used in science classrooms with most unapproved textbooks being used as supplementary aids at senior grade levels. Of these, two-fifths were published before 1975, and one-fifth more than 16 years ago. These statistics are significant for this study because it is the newer books which tend to avoid stereotypes and introduce greater Canadian content and social perspective while most books and supplementary resources prescribed in the 1977 Alberta Junior High School science curriculum were published in 1976 or earlier. Low marks were given to textbooks by the Science Council for the use of Canadian examples and for accounts of the applications of science.

The matter of a Canadian context for science education reinforces these low marks. Orpwood and Souque (1984b) claim that in terms of offering a Canadian perspective, science textbooks used in Canadian schools teach almost nothing about science and technology in Canada, or about its history and impact on society. For example, many secondary books are American and therefore note population statistics for the United States, but not for Canada; list the racial types in the U.S., but not those in Canada; mention American universities as career goals, but ignore Canadian universities. Where Canadian references do occur, they usually concern problems of pollution and energy and are very superficially edited for the Canadian market. The northern character of Canada, its lifestyle and form of government as these relate to science and technology are virtually ignored. The history of science and technology in Canada is also treated inadequately. Almost no information is given about career possibilities in science and technology in Canada. The books with the least information on Canada are those used in the early and senior years. Significantly, French translations of American works contain more Canadian context.

The Science Council reports (Orpwood and Souque, 1984a) point out that the lack of a Canadian context extends to the teachers themselves. "Science and Society" objectives were rated high by the teachers responding to the survey component of the study, but these same teachers assign little importance to increasing students' awareness of science as it is practised in Canada. On this point at least, teachers, curriculum guidelines, and textbooks seem to be consistent in their lack of emphasis. Science is not taught in Canadian schools as part of the cultural fabric of Canadian society. In general, the teachers surveyed believe they are most successful in achieving those objectives they consider most important. At the same time, teachers rely heavily on textbooks (which they generally find to be of acceptable quality) for planning their courses. They make surprisingly little use of ministry guidelines and other materials not produced specifically for teachers.

The Science Council of Canada believes that the time has come to reinstate the sciences of geology, agriculture, botany, health science, and engineering as basic to education in elementary and junior secondary school. The more abstract sciences of chemistry, physics, and advanced mathematics, it is claimed, can then be built on this firm base. It is argued that such a sequence from concrete to abstract would also be consistent with what is known of children's intellectual development and might therefore counteract the present difficulties encountered by younger adolescent students in courses they find too theoretical. Thus the term 'basic' would be seen as basic relative to the physical and intellectual development of the student, not basic to the logical structure of the subject matter. To some degree, this is being done in parts of Canada: agriculture is taught as part of the Prince Edward Island science program; the geology of Newfoundland is a component of elementary science in that province. But much more can be done. The Science Council would like to see teaching materials developed that transform examples of 'Canadian' science into opportunities for all Canadian students to learn about science and about their country at the same time.

The creation of instructional materials to reflect a Canadian context is not an easy task. One of the obstacles that must be overcome is the tradition of making curriculum changes in Canada on the basis of research and curriculum projects conducted in the United States and, to a lesser extent, in Britain. American projects in biology, physics, and chemistry, including the textbooks and programmes which were produced in connection with them, have been used in Canada. Such modifications as have been made have been limited to relatively minor accommodations of local phenomena (Crean, 1976; Orpwood and Sorque, 1984a).

A second factor of concern is that of attitudes and values. Factor and Kooser (1981), in their study of American college level chemistry textbooks, point out that it is intrinsic to the nature of education to produce changes in attitude which include values and that it is acceptable for teachers and authors to use materials or textbooks to present opinions, issues, facts, and policies whose ultimate effect is to change student attitude about science in a free society. The question posed is how such values should be argued, defended, or criticized. Factor and Kooser (1981) suggest that:

> If there is a central cluster of values in science pedagogy, and if these are shaped and preserved by the standardization process as well as the author's preference and expertise, then those values ought to be stated in a context or form which is different from, but not incompatible with, the ways in which basic facts and fundamental skills are stated (p. 45).

Values, as Factor and Kooser (1981) use the term would include any principle, proposition, policy, fact, or idea which is the object of human interest including assertions about the nature of scientific method, assertions about the costs and benefits of a particular technology, specific historical episodes, as well as specific ethical principles or moral prescriptions. How does this question of attitudes and values pertain to Canadian context in science education? It manifests itself primarily in the position that there is a need and obligation to give appropriate recognition to Canadian context in science education. However, in order to provide students with as complete a view of science education as possible, we must not teach in one context to the exclusion of others. If a Canadian context for science education can be determined, then it should be given consideration in our schools, complementing other contexts already in use.

Given the situation that instructional materials can reflect many specific contexts (including combinations thereof) how is it possible for teachers to choose the ones which best suit their needs? The task of choosing from among several alternatives, or deciding to adopt a given set of materials, involves weighing simultaneously many different factors, both theoretical and practical. Jenkins (1987) provides an example of such an interpretation in his conceptual analysis of science textbook discourse. This analysis used a basis of theoretical perspectives which included epistemology of science, normative perspectives, curriculum emphases, practical inquiry, and science-technology-society education. Werner (1978) also suggests that it is necessary to evaluate the program, including the instructional materials, from a critical interpretation:

> Program perspectives are shaped within larger political, geographical, and social contexts of educators. Their outlooks are not only associated with, but also serve, the interests of various groups (i.e., class, occupational, political, and religious). Because educators are members of these groups, there is little neutrality in teaching, developing, or evaluating programs. Bias is inevitable because group members specify goals, select material, and define activities. These tasks cannot be accomplished with a blank mind, without prior suppositions and beliefs, with an interest free stance, or with empty anticipations. Inevitably, these perspectives are shaped by former experiences within social and geographical locations, and political affiliations. Because everyone brings a viewpoint to the tasks at hand, and because this perspective serves as a basis for thinking and acting, the evaluator needs to examine the foundations of a program (Werner, 1978, p.18).

How does the matter of diverse values embedded in instructional alternatives relate to the need for more emphasis of Canadian context in science education? Obviously, such emphasis will come about if science teachers, science education policy makers, science curriculum developers and others put a greater value on Canadian context in the education of Canadian youngsters, and provide appropriate instructional science materials which reflect this context. Nay (1980) points out that before one embarks on preparation of curriculum materials for teaching science in a Canadian context, there is a need for a penetrating analysis of current science education policies, practices and needs in Canada, and in what way they are uniquely Canadian. A methodology for handling this problem would have three kinds of products. The first of these would be to help in assessing what Canadian context is present in instructional materials at present. The second would be to assist teachers in modifying those materials currently used to include more Canadian context. The third would be to build new or supplementary curriculum materials incorporating Canadian context. As well, the methodology must allow for achieving these tasks in a more rational and comprehensive manner than is being done at the present time.

Mrazek (1982) took steps toward developing a methodology for dealing with Canadian context in instructional materials. His study was designed to develop a theoretical perspective and subsequent clue structure (identified components which provide systematic information about science instructional materials) to describe a Canadian context for science education which could subsequently be used to determine the extent to which instructional materials used in science teaching in Canada reflect a Canadian context. Development of the theoretical perspective and clue structure with appropriate validation of each phase was accomplished in five stages. In Stage I an initial draft of a theoretical perspective for a Canadian context in science education was developed. In Stage II reaction to this initial theoretical perspective by a limited sample of science educators was obtained. In Stage III, on the basis of the Stage II reaction and further literature research and informal analysis, a revised edition of the theoretical perspective was prepared and in Stage IV was validated by a national sample of validators. Several major ideas were emphasized by the validators.

In Stage V the elements of a clue structure were identified in the revised theoretical perspective. A total of 15 elements were identified (see Appendix I), ten of which were content and five were methodological in nature, as perceived in terms of a science curriculum, which would, in the opinion of the respondents, "adequately" reflect a Canadian context for science education. The content elements focused on interdisciplinary studies, science-Canadian society interaction, science-technology relationship, history of Canadian science and technology, contribution of Canadian scientists, Canadian scientific tradition, methods of inquiry inherent in Canadian science, and Canadian science policy. The methodological components included the use of the local environment in science courses, relevant and topical issues in science, use of Canadian produced instructional materials, guidelines for adapting foreign instructional materials, and integration of local, regional, and national concerns in science education.

In general, the study (Mrazek, 1982) showed that a theoretical perspective and clue structure for a Canadian context in science education can be formulated. This could be used as a basis to analyze science instruction and instructional materials for Canadian context and guide the enhancing of Canadian context in curriculum materials currently used in schools and the development of new curricula.

The next steps in the development of a methodology for assessing and incorporating a Canadian context in science instruction pointed to further validation of the clue structure, applying it in the analysis of specific curriculum materials and then using the results of this analysis to guide the modification of these curriculum materials so as to enhance the Canadian context in them.

2. Statement of the Purpose

The purpose of this study is to devise and validate a general methodology for assessment and improvement of Canadian context in science education instructional materials. Both the assessment and development aspects are guided by Mrazek's "Theoretical Perspective for a Canadian Context for Science Education" (1982), and in particular the clue structure that arises from this perspective.

Instruction in geology is the curriculum vehicle for developing and testing the methodology. Specifically, assessment focuses on the extent of Canadian context in geology components in the Alberta Grade 8 Earth Science program (Alberta Education, 1978a), including the curriculum-as-planned (the prescribed instructional materials) and the curriculum-in-use (classroom practice). Selection of the geology component stems partly from a number of perceptions including: Canadian geology may be more clearly "Canadian" in terms of specific subject material than an area such as chemistry; geology is important in terms of Canadian science-technology-society economic relationships; the researcher's own science background; and partly because it is in keeping with the recommendation of the Science Council of Canada on the need to emphasize unique Canadian contributions in sciences such as geology. Another reason for choosing the geology components of the Alberta Grade 8 Earth Science program is that a review of the prescribed instructional materials by the researcher revealed a deplorable situation where Canadian context is concerned. Mention of Canada and Canadian examples were totally absent, while U.S. locations, examples and emphasis were abundant. One is drawn immediately to the conclusion that this is not a medium which, in its present form, promotes a Canadian context.

3. Summary of the Design

The design of this study incorporates five stages, the first four of which focus on the development of a methodology for dealing with Canadian context in science instructional materials. The stages are detailed in Figure 1. In Stage I the theoretical perspective for a Canadian context for science education developed by Mrazek (1982) and the clue structure derived from it, was expanded and refined in an attempt to identify the most important aspects of Canadian context. Following in-depth clarification the revised clue structure was validated by a national sample of 142 science educators, scientists and science teachers. Attempts were made to have a representative sample with regard to geographical distribution and distribution among individuals integrally involved or affiliated with science education in Canada. On the basis of the reaction from the validators the final revision of the clue structure was drafted.

Instruction in geology was used as a curriculum vehicle for developing the methodology in Stage II. An assessment procedure in which the geology component of the Alberta Grade 8 science program was specifically related to the elements of the final version of the clue structure was developed. The assessment of the geology component of the Grade 8 program for Canadian context was done for the prescribed resources and suggested supplementary resources.

In Stage III procedures were developed and sources were identified for collecting information for enhancing the Canadian context in science instruction, which included science teachers, scientists, science educators, as well as available print and non-print reference materials. An Alberta-wide survey of 120 Grade 8 science teachers was used to obtain information regarding what they were doing to supplement and modify the prescribed geology curriculum with respect to Canadian context. Six teachers, who in a survey indicated that they were actively supplementing their courses for Canadian context, were interviewed to obtain further details on what they were doing to modify and supplement the materials to upgrade Canadian context. Three practicing geologists were interviewed to solicit information regarding availability of resources within the geology component identified. Five Alberta science educators were interviewed to solicit working knowledge of the science area and geology component under study. Finally, further scrutiny of the related print and non-print material was done to identify suitable

STAGE I

Refinement and Further Validation of the Clue Structure

1. Expansion, refinement, and detailing
2. Further validation
3. Preparation of the final version of the clue structure

STAGE II

Procedure for Application of the Clue Structure to Assessment of Instructional Material

1. Development of the assessment procedure
2. Analysis of instructional materials for Canadian context
   (a) Prescribed
   (b) Suggested supplementary

STAGE III

Sources of Information for Enhancing the Canadian Context in Science Instruction

1. Science teachers as a source of information
2. Scientists as a source of information
3. Science educators as a source of information
4. Print and non-print reference materials as a source of information

STAGE IV

Procedures for Enhancing the Canadian Context in Science Instruction

1. Use of findings from Stages II and III
2. Procedure for enhancing the Canadian context in science instruction through instructional resources

STAGE V

Formulation of a General Strategy

Formulation of a general strategy for analyzing and enhancing the Canadian context in science instruction, using information from Stages I, II, III, and IV.

Sequenced Steps for the Development of a Methodology for Assessment and Enhancement of Canadian Context in Science Instructional Materials

FIGURE 1

instructional materials for upgrading Canadian context in the geology component of the Alberta Grade 8 Earth Science program.

Stage IV focused on ways the information from Stages II and III could be used to develop instructional materials for science education to include an enhanced Canadian context. Validation of this process was sought by providing six practicing teachers with suggestions for expanding the Canadian context within a geology component and interviewing each regarding the feasibility, desirability and implementation of these suggestions.

In Stage V, based on the experience with the geology materials in Stages II, III, and IV, a generalized strategy for analyzing, enhancing and developing instructional materials reflecting Canadian context in any area of science was developed.

4. Definition of Terms

Methodology: A study of systematic and clearly defined procedures fundamental to assessing and enhancing the Canadian context in science education.

Context: Many dictionaries give only one definition — as it applies to written work. Some give a definition for *contexture* which is congruent with the meaning of context as used in this study: "the manner of interweaving several parts into one body; the disposition and union of the constituent parts of a thing with respect to each other." (Woolf, 1976).

Canadian context for science education: Orpwood and Souque (1984a, p.202) defined this phrase for purposes of their study as "the body of information contained in the textbook that is equivocally related to Canadian circumstances in all forms, and to whatever is unique therein." They included the following dimensions: physical (the Canadian geographic environment), historical (both scientific and technological activity), and sociocultural (impact of scientific and technological). Mrazek (1982) elaborated each of these dimensions in his theoretical perspective. In addition, during the development of this perspective it became obvious that Canadian context subsumes other components, each rooted in the total social institution called education. Of most immediate concern was the methodological aspect of Canadian context; that is, the ways of teaching science in which Canadian content receives greater emphasis. Curriculum development also came to the fore as an important entity. The matter of implementation of science curricula with greater emphasis of Canadian content first became apparent in the theoretical perspective, but became increasingly important as part of Canadian context as this study progressed. Therefore, for purposes of this study, Canadian context in science education consists of a composite of pedagogical processes and products all designed to promote in Canadian students a greater knowledge and appreciation of the scientific part of the society in which they live.

Content: Webster's (Woolf, 1976) interpretation is that content is the matter dealt with in a field of study. This matter is "the information, facts or theories put forward in support of an idea" (MacLean, 1981, p.29).

Canadian science content: Subject matter that actually includes reference to Canada (i.e., geographical location, Canadian discovery or invention, Canadian science industry, etc.). In this study, Canadian science "content" is perceived to be included in Canadian science context.

Theoretical perspectives: Conceptualizations which provide ways of viewing the complexity of educational phenomena in orderly and meaningful patterns and which were developed by Mrazek (1982) specifically for Canadian context in science education. The notion of "theoretical perspective" was proposed as a research paradigm by Roberts and Russell (1975). The model basically takes the important issues associated with everyday science education practice (i.e., authority, knowledge, teaching, scientific theory, status of models) and uses philosophical treatments (especially informal analysis) to get to systematic theoretical perspectives for understanding issues of education and science.

Clue structure: To make the theoretical perspective useful in guiding educational practice, it is translated into a clue structure. These are analytical questions (statements) which in this study are called *components* of the clue structure. Each component is further broken down into a sub-question (sub-statement) which are called *elements* of the clue structure. All of the questions in the clue structure should meet the following criteria:

1. They need to be broad enough to capture the important, generally accepted aspects of science education in a Canadian context.

2. In both terminology and content, they need to have meaning for many audiences, including those unsophisticated in science and in education.
3. They have to be limited in number.
4. Each question needs to have some important unifying feature and to distinguish it from other questions in a meaningful way.
5. They have to lend themselves to operational definitions in terms of practice in science education and associated student outcomes.

Validation: This term is used in two different senses in this study. In the first sense, it refers to the perceived relevance of elements in the clue structure in terms of a Canadian context for science education. In the second sense, validation refers to the extent to which science teachers agree that the elements for Canadian context are reflected in a science curriculum.

Geology components: The concepts within the Alberta Grade 8 Earth Science program outlined in the Junior High School Science Curriculum Guide (1978). This includes the crust of the Earth, its formation and constant changes including related aspects of mineral and rock formation, erosion and deposition, landform movements, weathering, continental drift, and plate tectonics. These components are further elaborated for instruction in the prescribed resources Challenges to Science: Earth Science (Heller, 1976), Spaceship Earth: Earth Science (Jackson and Evans, 1976) and Learning Resources - Junior High School Science (Alberta Education, 1978b).

Science instructional materials: All student and/or teacher resources explicitly designed to be used for teaching and learning in the science classroom. This study dealt specifically with only those relevant for the geology component of the Grade 8 science program.

Assessment: A determination of the amount of a particular characteristic present. In this study, this characteristic is Canadian context in science education.

Enhancement: Increasing the amount of a particular characteristic; for example, Canadian context in science education. It can also include value or desirability as in the notion of "improvement".

5. Assumptions

In this study, the author makes the following assumptions:

1. A developer of instructional materials makes certain explicit or implicit assumptions about what is worth learning, about the nature of teaching and learning, and about the importance of education for the learner in society when preparing instructional materials.
2. Teachers have a perception of a Canadian context for science education which they can use as a basis for making evaluative responses, although they may not be able to clearly express it.
3. The Canadian context characteristics as explicated by the clue structure are applicable to all sciences in the school program.
4. The clue structure will be interpreted and applied by science teachers, educators, etc., as the developer intended.
5. There is a major revision of Alberta junior high school science curriculum which includes the current grade 8 program of which the geology components reviewed are a part. Each of the components will still be in the science curriculum but will be shifted throughout the grades. For example, evidence of erosion will be taught in grade 7, changes in the earth's crust in grade 8, environmental quality as related to earth science in grade 9. In addition, Science 14 (grade 10) will include a unit on investigating the environment, Science 24 (grade 11) a unit on geology, and Science 10 - a unit on formation of scientific models focusing on models of the earth. Therefore the findings of this study will not be applicable only to the current grade 8 program but will also apply to the other grade levels indicated. Therefore the findings of this study will not be applicable only to the current grade 8 program but will also apply to the revised science curricula.

6. Delimitations

1. The methodology is being developed on the basis of application to one area of science at one grade level which is assumed to be representative of science curricular components in general.
2. The methodology proposed in this study for dealing with Canadian context in science education is procedural. The study does not deal with the dynamics of the curriculum change process - of how science curricula with adequate emphasis on Canadian context can best be developed, implemented and evaluated.
3. The reasons why Canadian context is not given greater emphasis in science instruction are not considered in detail. However, these reasons do surface at various points in the study.
4. The study does not deal with the question of whether more Canadian context in science education results in improved scientific literacy of students.

7. Limitations

1. This study represents only one method of evaluating and developing science instructional materials for Canadian context. The methodology developed in this study for dealing with Canadian context in science education may be limited by being based on a specific theoretical perspective and its clue structure, one geology program, and the researcher's selection of sources of information.
2. The study will not suggest what budget commitment would be needed for an assessment and enhancement process of the type described here.
3. Validation is limited to the mailed questionnaire "expert" judgement of small groups of teachers, educators and scientists. Their view may not be an adequate representation of the breadth of prevailing opinion.

4. The criteria for validity, i.e., expert opinion, may be incomplete without consideration of other means of collecting empirical evidence such as classroom practice and student learning outcomes.

8. Organization of the Dissertation

It was decided not to report this study in the conventional manner in which a chapter was devoted to each research step, namely design, results and discussion. The main reason for this decision was that it was deemed difficult and would engender incoherence to report a methodology for dealing with Canadian context in instructional materials in which the major research steps are dichotomized into chapters. Consequently, a separate chapter is devoted to each stage of the study outlined in Figure 1, in which a complete account of the stage is provided. The dissertation, therefore, contains eight chapters: the introductory one, one on the review of relevant literature, one chapter on each stage, and a concluding chapter.

CHAPTER II

REVIEW OF THE LITERATURE

The aspects of the literature that are deemed relevant to review for this study are as follows:

1. The current state of science education in Canada. The focus here will be on ideas, practices and issues that are relevant to the question of Canadian context.
2. Canadian context in science education. Mrazek's previous study (1982) will be central in this discussion.
3. Sources of information for dealing with Canadian context in science education.
4. Research on main techniques used in the study.

1. The Current State of Science Education in Canada

Until fairly recently, it appears that much of the discussion at a national level pertaining to science education in Canada has been devoted to science teaching in universities. Fortunately, in the last few years much attention has been given to science at the elementary and secondary school levels (Orpwood and Sorque, 1984; Connelly, Crocker, and Kass, 1985; Ryan and Nay, 1985; Jenkins, 1987 and Aikenhead, 1988). The major findings of science education studies are addressed in this chapter in a manner which attempts to clarify the place of science in Canadian education, the state of science education in Canada today and the perceived relevance of Canadian context within it.

1.1 Social, Political and Economic Underpinnings of Education in Canada

To appreciate the structure of the educational system and curriculum in Canada, certain observations must be made. First, unlike the United States, Canadians have never been conscious of a manifest destiny or of a providential plan. This has led to what some have called political maturity, marked by moderation and impartiality which is in keeping with our national character; free from haste or exuberance, slow and cautious. Second, Vincent Massey noted that rather than being a melting pot, Canada has been identified as an association of peoples who have, and cherish, great differences but who work together because they can respect themselves and each other (Government of Canada, 1951).

This recognition and harmonization of differences has been recognized as a strength of Canada, and has had a definite impact on the education system. Stevenson and Wilson (1977) identify Canadians, with their muted sense of identity, as well placed to pioneer models for political formation based on human understanding rather than bureaucratic imperatives of a passing age subservient to technological rationalization. The period of national development was one of mobility, primarily social but also geographical and cultural. In this context the function of schooling was to "proceed by abstraction, to divorce knowledge from application in order to increase its range and potential, and to retail such knowledge to individuals who were similarly abstracted as far as possible from their social and economic content" (Stevenson and Wilson, 1977, p.120). The appearance that Canadian educational policy is one of the least politicized in the world led the Organization for Economic Co-operation and Development (OECD) to state that Canadian education programs (curricula) are "derived from no explicitly stated, overall national conception of the country's interest" (OECD, 1976, p.21). The OECD promoted four principles for increasing federal involvement in education which include the following:

(a) Education is a right of each citizen, irrespective of his place of residence.

(b) The standards maintained by schools, community colleges and universities are of national interest, because a large part of scientific-technical achievement and hence economic and social well-being may depend on them.

(c) Unity of the education system is a national interest, in order to maintain and guard the freedom of choice (via mobility) of citizens.

(d) The educational philosophy of an educational system and principles underlying its operation are matters of national interest, because cultural and national consciousness depend on it.

To reinforce this, the OECD noted in summary of their analysis of Canadian educational policy that the central educational issues specifically involve improving the mechanism for relationships among the provinces, between the provinces and the federal government and among agencies within the federal government. Such improved relationships would have a profound impact on incorporation of a Canadian context in education. However, as Stevenson and Wilson (1977) and others have noted, the many legitimate national considerations which are intimately associated with education are not being realized because education is a matter of provincial control under constitutional provisions. This provincial focus dominates and often obscures issues of national importance. Speaking to this, Smiley (1967) emphasizes the fact that when schooling was delegated as a provincial responsibility at the time of confederation, it was not compulsory. Professions afforded few opportunities and to prepare for these, parents were expected to pay at private schools. The technical complexity of our society in more recent time, which has revolutionized educational methods and costs, lay far ahead and unforeseen. Hence, almost by default, the British North America Act gave control of education to the provinces. Therefore no guidelines exist for encouraging provinces to include a Canadian context in educational programs. Instead, in the absence of a federal department of education, the Council of Ministers of Education for Canada, established in 1967, has developed mechanisms for inter-provincial activities and communication with federal departments in areas of their involvement in education. Educational questions of national concern must be addressed by the Council.

The Organization for Economic Co-operation and Development (1976) identified the following educational functions to which the Canadian education system must attend: development of the intellectual, physical, emotional, and moral capacities of the individual; socialization of the individual; emancipation of the individual; innovation and improvement of the quality of life; production;

absorption and regulation of fluctuations in manpower supply; and transmission (preservation or reproduction) of the values, behaviour and standards of cultural taste peculiar to each Canadian. According to the OECD (1976) education can no longer merely give everyone a minimum of basic knowledge, provide occupational training and select an elite. Rather, it must be directed towards developing the capacities of individuals and preparing them to participate in a range of social and professional activities in a highly mobile society. The implication of these O.E.C.D. suggestions is that science education must be taught with consideration of a context that reflects that which is Canadian.

Stevenson and Wilson (1977) similarly identify the main educational question facing Canadians today as whether education is to be seen primarily in terms of its cultural or its economic benefits. They assert that the primary task of Canadian education is clear and it is only different in degree from the main task of education from time immemorial which is to provide its subjects with an adequate and effective comprehension of the material basis of their existence, of the bounds and bonds of their ecumene. However, the task is not simple, for these authors quickly add that for Canadian educators and Canadian society there exists also the problem of defining how to achieve the main task of education while taking into account the values that underlie interdependent existence and cultural variety within Canadian borders. The methodology developed in this study may assist in solving the challenge posed by Stevenson and Wilson.

1.2 The Place of Science in Canadian Education

The Canadian educational structure consists of a group of systems developed independently in and by each of the ten provinces. The federal government has virtually no jurisdictional functions in education (except in the territories) but it has for many years participated substantially, though indirectly in support of certain sectors of education under various financial agreements with the provinces. The development of the science curricula and selection of educational materials to teach them is dealt with independently by each of the provinces.

On the whole, government documents show that the study of science is a separate part of the curriculum from Grade 1 to the end of Grade 9 or 10 in most provinces. Usually, some aspect of science is required at the upper secondary level as well. Connelly, Crocker and Kass (1985) note that about ten percent of instructional time is devoted to science. Their study ranks science behind language studies, mathematics and Canadian studies (e.g., in history and geography) in importance; stands on a par with social studies, physical and health education, and second language studies; and is ahead of music, art, and business and technical studies.

Science in the first eight or nine grades tends to be general. In the early years there may be some integration with other subjects. At the upper secondary school level science is taught mainly as the specialized disciplines biology, chemistry and physics. The recommended focus is on basic scientific concepts, cognitive skills and science processes, with the emphasis on concepts gradually increasing over the grades.

1.3 The State of Science Education in Canada Today

A comprehensive look at the condition of science education in Canada came as a result of the Science and Education Study by the Science Council of Canada (Science Council of Canada, 1984a). This was followed shortly by another study by Connelly, Crocker and Kass (1985) called Science Education in Canada. Volume I: Policies, practices and perceptions. The findings in these two studies are used to describe science education in Canada today.

1.3.1 The Science and Education Study

The scope of the Science and Education Study was mentioned in Chapter I. The final reports were published in 1984 (Science Council of Canada, 1984a). The intended curriculum, planned curriculum, and taught curriculum were described under the headings of Curriculum Guidelines: What do they prescribe?; Textbooks: What do they teach?; Teachers: Who are they and what do they think?; Classrooms: How is science actually taught? Another component initially mentioned in the study, "What do children actually learn?" (the learned curriculum) was not addressed by the Study.

According to the Study, curriculum guidelines are constructed in each of the provinces. These specify which subjects must be offered, how much time should be spent on each subject, the requirements for graduation, and so on. For each science subject, they also specify aims, content and, to a certain extent, teaching strategies to be implemented in schools.

1.3.1.1 The Intended Science Curriculum. Collectively, the curriculum guidelines across Canada suggest the following reasons for teaching science:

- To teach students the basic concepts in science in a way that will enable them to understand and manipulate scientific information.
- To develop skill in using the methods and tools of science.
- To promote an understanding of the relationship between science and society.
- To teach students about the nature of science and its value as a way of learning and communicating about the self, the environment, and the universe.
- To help students develop as autonomous and creative individuals who live in a scientific and technological society.
- To develop in students attitudes characteristic of scientists (intellectual honesty, openmindedness, desire for accurate knowledge) and appropriate attitudes towards science in general (enthusiasm, appreciation, excitement).
- To prepare students to take advantage of career opportunities in technology, industry, commerce, and business (Orpwood and Souque, 1984b, pp.7-8).

The Science Council study indicates there is a considerable consensus among ministry guidelines as to aims of science education in the early years of schooling with consensus decreasing toward the senior years.

Of even greater importance to this study, the guidelines were found to:

- contain few references to the need for Canadian context.
- ignore the relationship of science to other curriculum subjects.
- ignore the interaction of science (as well as technology) and society.
- be strangely mute when it comes to suggesting how science should be taught.
- influence how teachers taught by approving textbooks at each grade and subject level (Orpwood and Souque, 1984b).

1.3.1.2 The Planned Science Curriculum. In all the provinces the textbook is usually the vehicle for achieving the intended curriculum. Although ministries decide which textbooks can be used, and school boards and schools may have some say, the manner in which the textbooks are actually used in the classroom rests with the teacher. Across Canada, 6 of every 10 teachers of early grades use no science textbooks in their classrooms. (There is considerable variation here, as this statement applies to 90 percent of Ontario teachers, but to only 3 percent of Newfoundland teachers). By contrast, textbooks are used by 75 percent of teachers in the middle years and 90 percent of teachers in the senior years. Teachers rely heavily on textbooks (which they generally find to be of acceptable quality) for planning their courses. They make surprisingly little use, however, of ministry guidelines and other materials not produced specifically for teachers (Orpwood and Souque, 1984a, p.17).

Teacher satisfaction with the textbooks used was found to be generally quite high, particularly in the case of physics, biology, and chemistry textbooks used in the senior years. It should be noted that low marks are given for the use of Canadian examples and for accounts of the applications of science (Orpwood and Souque, 1984b, p.11).

The following observations about teachers from the Science Council of Canada study are of significant interest to this study. Strong support is given by early-years teachers to those objectives that involve attitudes, science process skills, and social skills. The learning of scientific content is valued more highly by those with less than 10 years' experience than by those with more. Middle-years teachers strongly support the teaching of science content, the relationship between science and society, the practical applications of science, skill in reading and understanding scientific literature, and the value of science for building and expressing students' understanding of the world. 'Relating science to the needs and interests of both men and women' and 'learning about the practice of science in Canada' are both valued more highly as educational objectives by female than by male teachers (Orpwood and Souque, 1984a).

Most teachers feel that learning the content of science is more important in higher grades than in the lower. 'Science and Society' objectives are rated highly by all teachers, but these same teachers assign little importance to increasing students' awareness of science as it is practised in Canada. Science is not taught in schools as being part of the cultural fabric of Canadian society.

Objectives that focus on teaching the nature of science receive little support from teachers, who feel that only the brightest students can achieve them. Personal growth objectives are considered important at lower levels, less so at higher levels. Objectives implying that special attention be given to the needs of girls in science education receive little support, indicating that teachers, as well as ministries, are generally unaware of (or if aware, are not concerned about) the low participation of women in the professional science community.

1.3.1.3 The Taught Science Curriculum. The Science Council survey of teachers across Canada attempted to discern the essence of science education in the classroom. The following points seem to be significant for this study and should be noted:

(a) In the early years of schooling, to save time and arouse student interest, some early-years teachers integrate science with related topics.

(b) In the middle years, the emphasis is on covering a considerable body of material in the time available. 'Covering the material' means that the 'correct' explanation must be included in students' notes.

(c) Teachers in the middle years complain that at this level, students are not easy to teach: class control is a central concern. They worry that students have become afraid of science because of teachers' attitudes in the early years. For them, accuracy is at the heart of what they believe to be a scientific approach to problems. This emphasis on approved explanations and the right answer is at odds with the process of inquiry and the conceptual and tentative status of knowledge in science.

(d) Teachers of senior grades view science as a precise method, as a system of exact numbers, and as highly organized bodies of information and specialized terminology. Their concern is to provide students with the notes and with the practice in solving problems that will result in high marks on examinations and allow the student to move through high school to university. Work in the laboratory is geared toward illustrating facts and theories presented in the classroom, confirming what is discussed in class, obtaining precise results and getting the right answers to problems. Activities are designed to develop in students habits of diligence, self-reliance and tidiness (Orpwood and Souque, 1984a, pp.21-23).

Though many of these observations seem to point an accusing finger at the teacher, one must keep in mind the following:

> On the whole, teachers are faced with the task of teaching large numbers of children whose abilities and home support vary considerably, and of doing so not always with scientific training or ample resources in a society that lacks a clear consensus about what schools are for. The demands placed on teachers are enormous. They counter this situation by the way they themselves continue their task and the means they use to perform it. Confronted with uncertainties about subject matter, student behavior and educational goals, teachers approach their work in ways that will make it less uncertain, thus accommodating complex situations over which they have no control. (Orpwood and Souque, 1984a, p.24).

If this is indeed the case, then there seems to be a need to provide teachers with modified materials which reflect a Canadian context and a manageable methodology which shows them how to incorporate more of them in the instructional materials they are already using.

1.3.1.4 Recommendations for Improving Science Education. Following the analysis of the state of science education in Canadian schools, the Science and Education Study recommended eight major initiatives, along with 47 recommendations to implement these, which they stress are urgently needed for the 'renewal' of science education. The initiatives include guaranteeing science education in every elementary school; increasing the participation of young women in science education; challenging high achievers and science enthusiasts;

presenting a more authentic view of science; emphasizing the science-technology-society connection; setting science education in a Canadian context; introducing technology education; and ensuring quality in science education (Science Council, 1984a, p.11).

It may be noted that one of these initiatives speaks directly to setting science education in a Canadian context while three reflect elements of the proposed clue structure used as the basis for this study (Mrazek, 1982): presenting a more authentic view of science, emphasizing the science-technology-society connection, and introducing technology education (see Appendix I). The Study elaborated on its initiatives in Summary of Report 36 (1984b). Here only three elaborations are included because they relate to science teaching in a Canadian context:

- Emphasizing the science-technology-society connection: Science should be taught at all levels of school with an emphasis and focus on the relationships of science, technology, and society in order to increase the scientific literacy of all citizens. The Science Council strongly believes the future citizens need to understand science and technology and the impact of both of these on Canadian society.
- Setting science education in a Canadian context: Science education in elementary and secondary schools should take into account the Canadian reality. Every Canadian student should know some of the history of science and technology in Canada and appreciate the importance of Canadian science and technology activity at local, regional and national levels.

- Learning about the accomplishments and impact of science in their own country: The Council believes that science should be set in a Canadian context that includes both historical and social dimensions. Students need to learn how science and technology have helped shape this country and about the landmarks in our scientific heritage (Science Council, 1984b, pp.7-8).

For purposes of the study Canadian context in science textbooks was 'The body of the information contained in the textbook that is unequivocally related to Canadian circumstances in all forms, and to whatever is unique therein.' (Orpwood and Souque, 1984a, p.202). Within this definition, the degree to which a Canadian context is present was determined using three dimensions of the context:

1. Physical Dimension: composed of all the messages that include a reference to the Canadian geographic environment.
2. Historical Dimension: involves all messages concerning the history of scientific or technological activity in Canada.
3. Sociocultural Dimension: all those messages that bear an impact of scientific and technological activity on the economic, political, social, and cultural aspects of Canadian life (Orpwood and Souque, 1984a).

It is interesting to note that each of these dimensions is elaborated and defined in the clue structure Mrazek (1982) used in this study. Therefore, the Council's following observations certainly are relevant:

- Science education in elementary and secondary schools should take into account the Canadian reality. Every

Canadian student should know some of the history of science and technology in Canada and appreciate the importance of Canadian science and technology activity at local, regional, and national levels.

- Children in Canadian schools should learn how science and technology have contributed to the shaping of this country. They should learn about the men and women whose achievements and discoveries have been landmarks in Canada's scientific heritage. To encourage this teaching, an information bank about these people should be set up and made available to teachers, to teacher educators, and to the writers of school textbooks; access to the bank will also encourage publishers to include this information in their books.
- The move of science education toward an emphasis on the science-technology-society interaction must be set in the context of Canadian reality. Although scientific knowledge is international in nature, it is supported economically, produced, applied, and taught in a specific national context.
- It is time to reinstate geology, agriculture, botany, and health science, and engineering as basic to education in elementary and junior secondary schools. (Science Council, 1984a, pp.39-41).

1.3.2 The Second International Science Study.

The results of this study by Connelly, Crocker and Kass were published as A Case Study of Science Curriculum in Canada (1984a). It reinforces many of the findings of the Science and Education Study sponsored by the Science Council of Canada. The eight volumes describe historical and current contexts for science education including components of the mandated curriculum, related curriculum activities including student assessment, and teacher education. The description of each of these components provides a well documented overview of the structure of the foundations and administration of science education in Canada. The areas of investigation undertaken by this study with respect to teacher perceptions of science teaching (Connelly, Crocker, and Kass, 1984a) should be noted since they reveal teachers' perceptions of a Canadian context. Based on a sample of 1,952 science teachers across Canada, the study makes a number of observations in Volume VII which are significant for this study:

1. Teachers tended to agree with the proposition that science teaching is constrained by many external pressures. There was strong agreement with the statement that science teaching could be improved substantially if teachers had more time to prepare. This suggests that preparation time is at least one deterrent to teachers making progress towards what they view as more ideal circumstances for science teaching.
2. There is a clear consensus that teachers are, and ought to be, responsible for selecting lesson materials, evaluating achievement, determining homework, and establishing discipline rules. In the latter case, however, there are grade differences which suggest a preference for more collective teacher responsibility at the high school level.

3. The factor which most strongly influenced teacher judgment of the curriculum was its associated teaching methods. Strong differences favouring small group over whole class teaching methods were found. Teachers also tended somewhat to favour a curriculum which includes a student text. Although teachers earlier had indicated a strong preference for schools with high ability students, the type of student for which the curriculum was designed did not strongly influence their judgments of the curriculum. Finally, it appears that the scientific basis on which the curriculum is constructed does not significantly influence teacher judgment.

The study by Connelly et al., (1984a) offers a number of interpretations, two of which in particular are of importance to a Canadian context for science: First, a primary basis for teacher translation of curriculum would be to make that curriculum more compatible with the students to whom it must be taught. A further extension of this argument may be developed if one considers that any intended curriculum, as an instrument devised by some central authority, is unlikely to match the characteristics of all students for whom it is intended, no matter how carefully it is chosen or how narrowly the target student group is defined. It is thus almost inevitable that many teachers will view any curriculum as being limited in applicability. All of this would suggest that teachers likely engage in extensive curriculum modification, and that the translated curriculum is likely to be rather idiosyncratic to an individual teacher or even to a particular group taught by that teacher. Second, results suggest that teachers are not likely to focus on the scientific formulations of the curriculum as a criterion for translation. Instead, the focus seems to be on teaching methods. Thus, it can be hypothesized that teachers would attempt to redirect a curriculum in a way that would yield teaching methods compatible with their own teaching styles.

In a subsequent publication by Connelly, Crocker, and Kass in 1985, Science Education in Canada: Policies, Practices and Perceptions, their earlier findings are developed further. A detailed topic outline was done of all science curricula for all provinces and territories, inclusive of grades K — 12. This document provides a superb overview of the historical and developmental relationships between science, science education as defined in terms of science curriculum, science teacher preparation and science teachers' perceptions. For the purpose of the current study, their discussion of 'Environmental Issues among the Science Disciplines' should be noted because of the perceived relationship between environmental issues and a Canadian context in science education. They suggest:

Concerns about the environment have become a major issue in science studies across Canada. There are at least two reasons for this trend. First, the demand to include more "Canadian" content in the curriculum of all subject areas often results in studies of local issues, such as the environment. Second, issues related to the conservation of resources, pollution, and the quality of air and water are important societal issues in the 1980's and lend themselves to classroom discussion on the practical applications of scientific principles.

A sub-study, conducted by Mrazek of the University of Alberta, examined the extent to which "Canadian Studies" (i.e., topics related to local, provincial, regional or national issues) were included as required, suggested or optional topics in the junior and senior high school science curriculum documents of the western provinces, namely British Columbia, Alberta, Saskatchewan, and Manitoba. The results (Connelly, et al., p. 163) indicate that:

1. The majority of topics which could be defined as "Canadian Studies" were related primarily to environmental concerns (i.e., biotic and abiotic factors and their effect on biomes, communities and populations) and secondarily to geological concerns (i.e. land formation, erosion, soils, and mineral

extraction), even if such topics appeared in a chemistry or physics curriculum.

2. The majority of such topics were included in earth or life science units at the lower secondary level or in earth science or biology courses at the upper secondary level.

Examination of the regional view of Canadian science education just referred to (the Mrazek, 1983 sub-study is included in Appendix II) would indicate that because of inadequate emphasis the geology curriculum area identified as the vehicle for application of the methodology in this study should be quite appropriate. As well, the findings of both the Science Council of Canada and the study by Connelly, Crocker and Kass certainly support the timeliness of the present study.

2. Canadian Context in Science Education

In the past, the different provincial science curricula in Canada had been substantially influenced by an interest in the structure of the disciplines as described by Bruner (1960), Schwab (1964) and others where emphasis is placed on fundamental concepts and the associated methods of inquiry. The term 'inquiry' has become the slogan identifying the structuralist school and the hallmark of curriculum projects such as the Physical Science Study Committee (PSSC) and the Biological Science Curriculum Study Group (BSCS), which were developed in the United States and imported more or less intact into Canadian schools (Stevenson and Wilson, 1977). Unfortunately, even where limited efforts had been made to provide Canadian examples in project materials, no attention had been given to their extensive modification for inclusion of a Canadian context.

How can one account for the Canadian context in the science instructional materials used in Canadian schools? There is a complex of reasons for this which was discussed in detail by Mrazek (1982). Suffice it to say at this point that a good case can be made for a proper emphasis of Canadian context in science instruction. But above all, what is needed, as was noted by Massey (Gov. of Canada, 1951) as early as 1948, is a belief in things which are Canadian and a confidence in Canadian institutions. There is no shortage of achievements by Canadians to be proud of. For example, Greaves and Williams (1981) provide an impressive list of 53 Canadians who have made significant contributions to science and technology in Canada. We even have scientists such as Leopold Infeld and Norman Bethune who are of political as well as scientific significance on both the national and international scene.

Because of the way the responsibility for education has evolved in Canada and because of the current neglect of appropriate Canadian context in science in schools, one looks to science teachers to accept the challenge of making proper amends. Of course, the entire educational system, and indeed Canadian society as a whole must accept the importance of giving due attention to Canadian context in science education and provide the science teachers with appropriate support. A major purpose of this study is to give some stimulus and guidance to what undoubtedly will be a long process of "rectification" of a missing aspect in Canadian science education.

2.1 Defining 'Canadian'

To define 'Canadian' is a complex and elusive task. Canada may be described as a northern, vast, and regionally divided country with a broad natural resource base composed of both renewable and non-renewable resources; that has industrial, technological and urbanized society which is multi-ethnic and culturally diverse, with two historically predominant linguistic and cultural groups. We surely must acknowledge that Canada is unique as a country, not because of any single feature but because of the sum of these and many other basic and interrelated features. When we consider the term "Canadian environment" we must consider the whole of the physical, social, and cultural characteristics of Canada.

There are those who contend that "While it might be possible to assess the national character of societies where there is a common culture and where there has been very little social change, Canadian society is so complex and has changed so rapidly that there are likely to be few uniquely Canadian characteristics common throughout the society" (Matthews, 1980, p.57). This would suggest that the most distinctive feature of Canadian social organization is not its unity but rather its diversity which may be attributed to three aspects of Canadian social life; namely its ethnicity, social class, and regional divisions. In fact, there is strong support for the notion that Canadian nationhood was attained, not by the making of different peoples into one, or by the strengthening of forces of consensus, but by fostering the differences between people within the nation and thereby securing the differences between Canadian and American people. This is quite different from the notion that Canada is sustained by nationalism based on experience, and destroyed by nationalism based on cultural belief. We may attempt to bridge this difference of perspectives by assuming a menu similar to that of Clark (1976) where society cannot be fully understood except in relation to how it developed, in other words. Canadian society can be understood only if viewed within a historical perspective.

Attachment to Canada is often defined in terms of the physical attributes of the Country and not necessarily in terms of its political institutions yet opposition to a unique Canadian nationalism is usually in the form of American continentalism and Canadian particularism — both forces which are identified by Creighton (1972) as being extremely powerful and pervasive. The conscious movement for the defense of a Canadian identity and nationalism seems to have had its origin in the debate over the trans-Canada pipeline in a parliamentary session of 1956. The debate centered over national policies for a nation that was perceived to becoming increasingly solitary and unprotected. The decline of the British Empire Commonwealth and the increasing dominance of Western Europe and Americas added more fears that Canada's identity and control of its own destiny might be threatened, thereby further confusing what is meant by 'Canadian.' It is considered by some that with the coming of a continental economy dominated by the United States "the moral and cultural personality of Canada — the sum total of its values, standards, traditions, and beliefs — was assailed on all sides by the pervasive influence of the mass media — newspapers, periodicals, books, radio, television, and movies — of the American Republic" (Creighton, 1972, p.273). This view still seems to be strongly active in 1988 in the heated 'Free Trade' debate.

It is also suggested that many Canadians have abandoned the inherited Canadian belief in an ordered and peaceful society for the American philosophy of life which has as its central doctrine the belief that progress is the only good in life and that progress means the liberation of man through the progressive conquest of nature by technology. This doctrine of continual economic growth allegedly prepares Canadians to "sacrifice their independence, pillage their natural resources, contaminate their environment, and endure all the hideous evils of modern industrialization and urbanization" (Creighton, 1972, p.281).

Further insight into the problem of defining Canadian may be found in the view that when politics is not based on class, but on regional and ethnic divisions, the personal troubles of ordinary people are not readily transformed into political issues. Further, our obsession with the question of national identity shows that we do not necessarily want to be different, but we have conflicting and undeveloped notions about the substantive content of the difference. In the midst of this confusion, Smiley (1967) suggests that the requirement of the Canadian political nationality is for Canadians to find and commit themselves to a group of common objectives which they pursue in equal partnership. This relationship may explain the strong international feeling many Canadians maintain. "For Canada, unlike the heroic nation-state of old, national survival is not the highest priority of foreign policy. The survival of the world or at least of our kind of civilization, comes first" (Smiley, 1967b:133). In light of this, Smiley contends that the Massey Commission's work became the charter of Canadian cultural nationalism. It seems this period of the fifties was a period of genuine devotion to national concerns which rose above regional and provincial concerns.

During the 1970's and 1980's however, many would contend that the predominant view of Canada is that of a composition of 'islands' where island vantage point outlooks are bounded, local feelings are intense and ignorance of other circumstances is considerable. Though larger regions are referred to (i.e., Central Canada, Maritimes, the Prairies, the West, the East, and the North) Harris (1981) insists that among all the different scales of Canadian sentiment, the provinces have become increasingly dominant. Therefore, even if Harris's "islands" can be defined easily enough, the archipelago (Canada) may not. Thus arises the issue of regionalism within the parameters of federalism.

The nature of the assimilation and nationalizing process in Western Canada, for example, may have contributed to the strength of regional feeling in the

Canadian West since there were no local traditions based on years of local and regional loyalties such as that which existed in older parts of Canada (Bercuson, 1980). Many have attempted to identify the nature of this regional composition. Westfall (1980) attributes Canada's rigid and constant regional structure to the rigidity of Canada's physical features and the relative constancy of her climate. These factors may also have been responsible for the apparent weakness of the Canadian nation-state with the land and climate nurturing strong regions and creating a barrier against national unity. Others consider that the regional character of an area such as the prairie provinces is not produced simply from the impact of a relativity common environment but instead grows out of a pattern emerging from the drawing together of formal regions within the area, such as grain growing regions, ethnic regions, political regions, and others. This regionalism "focuses upon the parts rather than the whole: it emphasizes the pluralistic character of Canadian culture and the limited nature of the Canadian identity" (Westfall, 1980:13).

Provincial governments have been labelled as the main spokespersons for regional interests. This results, by their institutional nature, in their becoming 'narrow-minded' since they are elected to serve their constituents in matters of provincial, not federal, jurisdiction. Compounding this ambiguity is the consideration that regionalism is only one of a number of allegiances that people have at this same time, including neighbourhood, civic, provincial, national, and even international identities. If this is indeed the case then it becomes evident that the responsibility for science education in Canada must be shared by all levels of government although provincial governments have the primary responsibility. In turn, the interests of each of these levels should be noted. In this way 'Canadian' encompasses local, regional, and national interests. For this study, in order to come closer to linking 'Canadian' with science education, it is advantageous to next look at 'Canadian' in terms of a theoretical perspective which links science education, the sciences and scientific endeavours.

2.2 Mrazek's Study

In a previous study, Mrazek (1982) developed a theoretical perspective and a subsequent clue structure in order to describe accurately a Canadian context for science education. The clue structure can be used to determine the extent to which instructional materials used in science teaching reflect a Canadian context. In addition, the clue structure could be used to guide the enhancement of materials being used or development of new materials with appropriate emphasis on Canadian context.

The development of the theoretical perspective and clue structure was accomplished in five stages. In Stage I an initial draft of a theoretical perspective for a Canadian context in science education was developed based on Roberts' and Russell's (1975) analytical structure. This involved an informal analysis of information obtained from an extensive search of the science, science education, education, and Canadian cultural literature.

In Stage II reaction to this initial theoretical perspective by a limited sample of 20 science educators and science graduate students at the University of Alberta was obtained, both in the form of written responses and oral reaction session. The main gist of this reaction was that the theoretical perspective reflected a too nationalistic and polemical stance and that it was in need of substantial clarification of terminology and ideas.

In Stage III, on the basis of the Stage II reaction and further literature research and informal analysis, a revised edition of the theoretical perspective was prepared. This lengthy document is included in the report of the first study (Mrazek, 1982).

Stage IV involved the validation of the revised theoretical perspective by a national sample of 120 validators. Attempts were made to have a representative sample with regard to geographical distribution and distribution among those individuals integrally involved or affiliated with science education in Canada (scientists, science educators, classroom teachers). Although only 44 validators (36.7 percent of the total sample) responded, a considerable amount of written reaction was obtained. Several major ideas were emphasized by the validators. First, a high level of support was noted for the theoretical perspective. Second, a great deal of controversy surrounded the issues of national identity and the national versus international views of science. Third, there was support for inclusion of technology in science education, stressing the interrelationships of pure and applied science; inclusion of the science-society interaction; and maximum use in science teaching of the local environment and applications of science to the student's immediate environment.

In Stage V, the elements of a clue structure were identified in the revised theoretical perspective. A total of 15 elements were identified (Appendix I), ten of which were content and five were methodological in nature as perceived in terms of a science curriculum which would adequately reflect a Canadian context for science education.

If one compares in more detail the reaction of the three validation groups used in this study, a number of significant points may be identified:

(a) A concern emerged that nationalism was implicit in the notion of Canadian context. The negative reaction of some of the validators to Canadianism may have been rooted in a misconception that the theoretical perspective advocated the exclusion of other contexts for science instruction (e.g., laboratory orientation, conceptual content). The clue structure which was developed in the study by Mrazek (1982) did not do that; it merely did not address elements other than those of Canadian context. That is, this study did not ask for removal of other contexts — only the inclusion of a Canadian one. "Canadianism" seemed acceptable if it meant that science and technology was viewed as showing their value to all people by applying them first of all to the local setting. If nationalism is defined as the doctrine that national interests, security, etc., are more important than international consideration then it is a human foible to be cautious of. Inversely, if nationalism refers to national quality or character, that is what distinguishes Canadian society and culture from others, then it must be considered as an integral component of a Canadian context for science education.

(b) The issue of nationalism versus internationalism in science was a controversial one for all three groups of validators.

(c) The elements most favored are those which suggest relevant application of science to the students' immediate environment and show the interrelationship of science and society. This may be the result of the recent realization of those involved in science education that there is a distinct need to relate science to the students' immediate world and show the relevance of science through emphasis of the science-society interaction. It may also be noted that each of these implies Canadian content, yet the selection for inclusion of these elements in instructional materials may be based on necessity to use the most relevant example rather that an association with a national identity.

(d) In general, the study by Mrazek (1982) showed that a theoretical perspective and clue structure for a Canadian context in science education can be formulated.

3. Sources of Information for Dealing with Canadian Context in Science Education

The sources of information used in this study for dealing with Canadian context in science education include physical and human resources.

The physical resources were limited to print and non-print materials which would be readily accessible to the science teacher. Although the union list of scientific serials in Canadian libraries alone in 1985 contained a list of the 40,733 scientific and technical journals held in 200 Canadian libraries, and this number would undoubtedly have grown in the past three years. One must be very practical regarding the information teachers would access. The majority of print materials used include resource books, texts, and reference materials available through in-service programs and local school boards in the province. It was found that there were many readily available resource books such as Alberta's Prehistoric Past (Chevraux, 1980), Landscapes of Alberta (Hoffman and Redhead, 1980), The Landscapes of Southern Alberta (Beaty, 1975), Alberta Archealogy: Prospect and Retrospect (Moore, 1981) and many others. These resources provided an excellent background series of readings for the teacher and could be used in many cases directly by the students. Textual materials such as Canada: A New Geography (Krueger and Corder, 1974) and Introduction to Physical Geography (Strahler, 1973) were found to be readily available and easily implemented in the classroom. In many cases however the materials had not been enriched for a Canadian context. Other references could be found to enrich specific aspects of a Canadian context. If teachers had encountered the book Great Canadians (Berton, 1965), they might include in their teaching the biographies of the people of science such as Sir Frederick Banting, discoverer of insulin; Alexander Graham Bell, inventor of the telephone and phototone; Sir Sanford Fleming, inventor of standard time; and Sir Charles Saunders, development of resistant wheat strains such as marquis wheat. Canadians Contributions to Science (Greaves and Williams, 1981), in addition to an impressive list of 53 Canadian scientists and individuals who have made significant contributions to science in Canada, draws attention to the leading role Canada has played in exploration of areas such as nuclear power, pioneering jet aircraft, electron microscopy, and many others. Documents from other provincial curriculum branches such as Lectures on Earth Science: With Emphasis on Newfoundland Examples (Neale, 1982) provide excellent ideas for presentation of different regional perspectives.

Beyond a doubt one of the richest and most bountiful sources of relevant information was found to be those materials produced through in-service programs, school board materials, and resources provided through specific government agencies. Superior examples include: The Rundle Park Geology Unit (E.P.S.D., 1982) produced by the Science Services Division of Edmonton Public School District and local science teachers in Edmonton; EDGEO (Godfrey, 1980) a series of materials produced by John Godfrey and the Edmonton Public Schools; Kananaskis Country Series (Gov. of Alberta, 1986) a part of the Kananaskis Country environmental education library; and the SEEDS (SRA, 1980) materials produced in Alberta. These materials were especially attractive in their formatted presentation which combined conceptual development, appropriate learning activities for the students, and background reference information for the teacher. The same could be said for the Curriculum Resources Information Bank C.R.I.B. (Nay et al, 1971) which also has an excellent cross-referencing system for utilizing the teacher resource sheets, hand-outs and student activity sheets.

Non-print resources include audio-visual materials and samples which are readily accessible through school boards, regional office, or distributors in the province. For use in this study Color Slides of Canadian Geology (Alta. Soc. of Petroleum Geologists, 1976) prove to be in great demand by teachers. These slides produced by the Alberta Society of Petroleum Geologists at the Institute of Sedimentary and Petroleum Geology, of the University of Calgary are an excellent resource which can be used as a total package by drawing on a few appropriate slides when needed throughout the year. Films and videos available through ACCESS and The National Film Board of Canada round out the resources reviewed. Films from the The Planet of Man series were particularly helpful.

The human resources included sources of information regarding programs or program materials gathered from science teachers, scientists, and science educators. In many cases this included relevant field trip information which could be applied to the course of studies or aspects of improving methodologies for increasing relevance to the local environment of the concepts presented.

The outcome of this phase of the literature research and interviews will be elaborated in Chapter V (Stage III) and its utilization will be dealt with in Chapter VI (Stage IV).

4. The Research Techniques Employed in the Study

Since this study is primarily methodological in nature, it does not fall neatly into one of the three major research paradigms, namely empirical-analytical, situational-interpretive and critical-reflective. Rather, an eclectic approach was necessary in regard to the research design, including selection of techniques. Three standard techniques were used in this study for gathering data, all used quite intensively: questionnaires, interviews and literature research.

A questionnaire was used in Stage I (refinement and further validation of the clue structure) and Stage III-1 (collecting information from teachers on the coverage of Canadian context in the Grade 8 geology component). Mouly (1979) indicates the following advantages of questionnaires:

1. May elicit more candid replies.
2. Permits more considered answers.
3. Allows greater uniformity in the way questions are asked.
4. Ensures greater comparability in the responses.

To this one might add that questionnaires permit solicitation of information from a large number of people for a minimum of time and money. The disadvantages Mouly sees are:

1. The investigator is not able to note reluctance or evasiveness of respondents.
2. The investigator is not permitted to follow through on misunderstood questions or inadequate answers.

To this may be added the disadvantage of a poor rate of returns. Mouly suggests that a combination of open and closed questionnaire should be used to try to reduce the impact of the disadvantages. The closed part of the questionnaire allows for greater coverage of the research information sought and more systematic tabulation. With its list of alternatives, it structures the problem under study and reduces the risk of misrepresenting it. On the other hand, the open questionnaire allows respondents more leeway in stating their position and giving reasons for the choices made. Doran (1980) and Mouly (1979) note that inventories of this kind allow better answers to complex aspects of a problem since they frequently elicit more valid responses and are less frustrating to the respondent.

The questionnaires used in both Stages I and III had a closed and opened section. In the closed part of the one used in Stage I, there were statements representing the elements in the clue structure for a Canadian context in science education. A selected sample of respondents were asked to rate each one for *relevance* to a Canadian context on a five-point Likert scale. There was space under each statement for written comment.

The closed portion of the questionnaire used in Stage III had the same statements for the elements of the clue structure that were used in the Stage I instrument. However, in Stage III, the respondents (science teachers) were asked to indicate their perception on a five-point scale of the degree that it was *evident* that each element was covered in the mandated textbooks and supplementary materials. In the open part, spaces were provided for the respondent to give examples of how he or she used these materials for covering a given element while teaching geology.

In both stages, the questionnaire returns were quite low. This is deemed not to be a serious problem for the purposes of this study. In neither stage was the focus on obtaining an authentically representative account of the thoughts of respondents. In Stage I, validation for the clue structure was sought in terms of relevance and clarity of expression of its elements. However, the validators' position as a group did not have any bearing on whether an element would be retained or not. Its retention was dictated solely by the theoretical perspective. In Stage III the focus was on garnering information on the extent of inclusion of each element of the clue structure in the mandated Grade 8 geology component. More important for the study than the extent of agreement as to inclusion were the examples sought in the open aspect of the questionnaire.

The interview technique was used extensively in this study. It was used as a follow-up to the Stage III questionnaire to probe more deeply into the thoughts of a selected sample of respondents (science teachers) for clarification and expansion of their responses on the questionnaires. Science educators and scientists were also interviewed in depth, with guidance provided by a list of questions presented to the interviewee beforehand. This focusing of the interview has considerable merit providing it is tempered by constant vigilance for possibilities to explore new lines of thought.

The search of the relevant literature went beyond the conventional limits in this study. This was required for expansion and refinement of the clue structure in Stage I. However, most important was the use of print and non-print reference material for ideas for enhancing the teaching of the geology component in Grade 8 science within a Canadian context. A novel feature perhaps in this aspect of the literature search was that it was guided by an assessment model at the heart of which was the clue structure for a Canadian context in science education.

CHAPTER III

STAGE I: REFINEMENT AND FURTHER VALIDATION OF THE CLUE STRUCTURE

Stage I was based on the theoretical perspective for a Canadian context for science education developed by Mrazek (1982) and the clue structure derived from it. Further work could be done in refining the theoretical perspective. However, such refinements seemed unlikely to change significantly the scope and substance of the clue structure for which it provides a base. Hence the clue structure and its validation provided the starting point for Stage I. It is the heart of the methodology developed for evaluation and modification of curricular materials. Therefore, a decision was made to subject the clue structure to further refinement and validation.

1. Expansion, Refinement and Detailing

Examination of the theoretical perspective (Mrazek, 1982) was undertaken to assure that all possible clue structure elements relevant to Canadian context in science education that could be perceived by the author had been identified. No new ones were evident, but it was realized that the 15 clue structure components in the initial version (Appendix I) could be collapsed into eleven as shown in Table 1. The content-methodological sub-grouping was retained. Component 1.6 in Table 1 (science as inquiry) caused some difficulty since, in science education, inquiry is considered both curriculum content and instructional methodology. It was decided to keep it as a single entry in the clue structure, bearing in mind its dual character. The clue structure revisions concentrated on "content validity" rather than support of the clue structure by the validators.

The reduction of the number of components in the clue structure was followed by an indepth definition of each component. For this purpose the information provided by the validators in the Mrazek study (1982) was used. In addition provincial curriculum guides and relevant information appearing since the 1982 study were perused for relevant information (including the Science Council of Canada reports, and the I.E.A. reports on Canadian science education). The result of this phase was the revised and elaborated clue structure presented in Appendix III.

TABLE 1
Clustering of Clue Structure Components Used in Stage I

Element from Mrazek (1982) (Appendix I)		Corresponding Clue Structure Component
	1.	<u>Content Components of Science Education in a Canadian Context</u>
1	1.1	Interdisciplinary Nature of Education
2,3	1.2	Canadian Science-Canadian Society Interaction
4,5,6	1.3	History of Canadian Science
7	1.4	Philosophy Underlying Canadian Science
8	1.5	Pure Science, Canadian Applied Science and Their Interrelationship
9	1.6	Science as Inquiry
10	1.7	Canadian Science Policy, Current Research Emphasis in Canada and Their Interaction
	2.	<u>Methodological Components of Science Education in a Canadian Context</u>
11,12	2.1	Maximum Use of the Local Environment
13	2.2	Canadian Science Instructional Materials
14	2.3	Adaptation of Foreign Instructional Materials to a Canadian Context
15	2.4	Problems of Regionalism

2. Further Validation

The next part of Stage I consisted of the validation of the revised clue structure (Appendix III) by means of a validation questionnaire sent to a national sample of validators.

First, the eleven components of the clue structure shown in Table 1 and detailed in Appendix III were translated into 77 items in the validation instrument presented in Appendix IV. The required response was one of indicating relevance on a five point Likert scale ranging from 1 (totally irrelevant) to 5 (extremely relevant). Validators were also requested to respond in an open subjective style to ensure that they were not restricted in their reaction. Indeed, they were asked to react to the clue structure by stating their contentions, support, criticisms, and comments regarding each element of the clue structure and its statement of elaboration.

The first draft of the validation questionnaire for the clue structure and the attached instructions was used with a pilot group of twenty science teachers, geographically distributed throughout the province of Alberta. Each teacher was asked to complete the instrument, as well as to indicate if they understood the instructions and what they perceived the task to be. Only two of the twenty teachers had slightly differing impressions of the intended task. Based on this response, the final draft of the validation questionnaire included in Appendix IV was prepared.

Validation was based on the expert judgement approach, i.e., the opinions of established professionals in the field were taken as indication of the relevance of the item in articulating the domain of Canadian context. The main validator sample consisted of selected members of the science and science education community across Canada. Three criteria were established for the selection of the validators, with a person having to satisfy at least two:

1. The validator is or has been actively engaged in teaching science or in a support area of science education.
2. The validator is familiar with the state of science education in Canada.
3. The validator is familiar with the state of science in Canada.

The list of 441 validators was compiled from an inspection of available lists of science educators and scientists, lists of members of the Canadian Science and Technology Historical Association, members of provincial science teachers' associations, and lists of science education consultants and supervisors who, because of publication or known work, seemed to meet the criteria to constitute an "expert" group.

To provide as representative a sample as possible of those sectors in science and education who have an interest in the context of science education in Canada, the validators were placed in three categories. The first category included professional science educators who were not teaching in elementary or secondary schools: university and college instructors, workers in educational research institutions, government consultants, supervisors, graduate students, etc.. The second category included science teachers, who were teaching elementary or secondary science in publicly-supported and private schools. The third category included scientists, science historians and philosophers and others — those involved in scientific research or areas related to science or science education.

No attempt was made to obtain a random sample of validators. Due to the difficult task of identifying suitable people in the time available, it was not possible to obtain a geographically representative sample in each of the three categories. In the case of the science teachers, the attempts to contact provincial science teachers' associations did not for various reasons, always yield the names of teachers interested in taking part in this study. Therefore, the researcher had to rely on his ability to contact science teachers in Alberta to make up for this particular group hence the preponderance of Alberta science teachers, 74% of teachers who responded. For the third category, preference was given to those scientists, historians, etc. who have indicated some interest in the past in science education, through publication or related activities.

The distribution of validators selected for Stage I is shown in Table 2. We note that each of the provincial regions has representation in at least one of the three categories. It is also evident that 29 percent of the selected validators are from Alberta with the next greatest representation from Ontario and British Columbia. This is primarily due to the imbalance in the science teacher category and the relative availability of individuals in the three designated categories.

TABLE 2

Geographical and Percentage Distribution of Validators Selected for Stage I

Category	Number / Percent	Geographical Distribution										
		B.C.	Alta.	Sask.	Man.	Ont.	Que.	Nfld.	P.E.I.	Nova Scotia	New Brunswick	*Other
Canadian Science Educators	115	22	22	9	7	24	9	6	1	9	4	2
	100%	19%	19%	8%	6%	21%	8%	5%	1%	8%	3%	2%
Canadian Science Teachers	269	57	90	20	6	40	15	15	0	16	10	0
	100%	21%	33%	7%	2%	15%	6%	6%	0%	6%	4%	0%
Scientists, Historians Philosophers and Significant Others	57	4	14	3	0	25	4	0	1	2	0	4
	100%	7%	25%	5%	0%	44%	7%	0%	2%	3%	0%	7%
TOTAL	441	83	126	32	13	91	28	21	2	27	14	6
	100%	19%	29%	7%	3%	21%	6%	5%	0%	6%	3%	1%

***Other** includes areas in the Northwest Territories, Yukon, or those who now live outside of Canada but are still involved in aspects of Canadian science education or science which they were initially involved with in Canada.

Each of the 441 validators received a copy of the questionnaire and was asked to respond according to the instructions in covering letters (see Appendix IV). Two slightly different letters were sent to respondents. Selected science educators were sent a copy of basically the same letter as the rest; however, they were asked to assist in reaching science teachers in their area. This resulted in an increased representation in the science teacher categories for Ontario and British Columbia.

A follow-up letter (Appendix IV) was sent to non-respondents encouraging them to submit their reactions to the clue structure. A period of one month was allowed for late returns. In the final count, of the 441 validators who were mailed a validation questionnaire, 142 replied (see Table 3).

3. Summary of Responses by Validators

Among the three categories used to classify the national validators, the least responsive was the Canadian science teachers group with 74 of the solicited 269 for a 27 percent response. Canadian science educators were next with 38 of 115 for a 33 percent response and then scientists, historians, philosophers and significant others were most responsive with a 53 percent response based on 30 returns of 57 solicited.

The Likert responses were analyzed and the mean ratings are reported in Table 10 in Appendix V. These means are summarized in Table 4 in which ranges are indicated for each of the response categories. A total of 841 free comments were made in the questionnaire. There are summarized in Appendix V.

The major reactions of the validators indicated in Appendix V to the revised and elaborated clue structure (Appendices III and IV) are as follows:

(a) The responses reflect a high level of agreement with the clue structure as articulated. From Table 4 it can be noted that none of the 77 elements of the eleven clue structure components was deemed not relevant. 117 of 231 of the responses from the three groups were in the "quite relevant" category. Several validators agreed totally with the expanded clue structure presented. However, the majority of the validators implied varying degrees of support for the clue structure elements. They would object to some but

TABLE 3

Geographical and Percentage Distribution of Stage I Validators Responding to the Clue Structure (Response Rate = 32%)

Category	Number / Percent	Geographical Distribution: B.C.	Alta.	Sask.	Man.	Ont.	Que.	Nfld.	P.E.I.	Nova Scotia	New Brunswick	*Other
Canadian Science Educators	38	5	9	4	1	7	4	1	0	3	2	2
	33%	23%	41%	44%	14%	29%	44%	17%	0%	33%	50%	100%
Canadian Science Teachers	74	3	55	4	3	3	1	0	0	4	1	0
	27%	1%	61%	20%	50%	8%	7%	0%	0%	25%	10%	0%
Scientists, Historians Philosophers and Significant Others	30	0	14	1	0	13	0	0	0	0	0	2
	53%	0%	100%	33%	0%	52%	0%	0%	0%	0%	0%	50%
TOTAL	142	8	79	9	4	22	5	1	0	7	3	4
	32%	10%	63%	28%	31%	24%	18%	5%	0%	26%	21%	67%

***Other** includes areas in the Northwest Territories. Yukon. or those who now live outside of Canada but are still involved in aspects of Canadian science education or science which they were initially involved with in Canada.

TABLE 4

Summary of Likert Responses Indicating Clue Structure Relevance

(Total number of items in Validation Questionnaire = 77)

GROUP	Range of Response Means, $\bar{x}$				
	1.00 - 1.49 Totally Irrelevant	1.50 - 2.49 Not Really Relevant	2.50 - 3.49 Slightly Relevant but may need revision	3.50 - 4.49 Quite Relevant	4.50 - 5.00 Totally Relevant
Science Educators	0	0	17	57	3
Science Teachers	0	0	18	59	0
Others	0	0	5	61	11
TOTAL	0	0	40	177	14

support others. From Table 4 one gets the impression that strongest support came from the "others" group which includes scientists, historians, philosophers, etc..

(b) The science teachers and science educators were not significantly different from each other in their total response. The apparent differences in support of the teachers and science educators is consistent with support shown for the initial theoretical perspective for a Canadian context in science education (Mrazek, 1982).

(c) The written comments made by the validators often seem somewhat at odds with the associated Likert responses. Indeed some responses expressed considerable disagreement, especially with components dealing with Canadian culture and Canadian science policy. Yet collectively, none of the response means registered non-relevance on these components.

(d) The elements in the seven content components which were perceived to have the highest relevance as indicated by the comments and which were consistent with the average Likert scale support are as follows: (total mean for all respondents is indicated in parentheses behind the element)

- *Interdisciplinary Nature of Science Education* elements 1.1.1 (4.05), 1.1.5 (3.74) 1.1.6 (4.26), and 1.1.9 (4.11) were well supported within a Canadian context and reflect the interdisciplinary nature of science; a combination of study areas to develop perspectives of national identity; promotion of understanding and appreciation; and development of intellectual tools including critical mindedness and decision making skills.
- *Canadian Science — Canadian Society Interaction* elements 1.2.1 (4.06), 1.2.6 (4.01), 1.2.7 (3.86), and 1.2.11 (4.27) were perceived to be of greater relevance. These elements address why students should

take science, development of an understanding of the impact of science on contemporary Canadian life, and decision making for resolving science related social problems.

- *History of Canadian Science* elements 1.3.4 (3.90) and 1.3.6 (3.83), promoting the development of an awareness and appreciation of the role of Canadian scientists and the scientific community play in Canada, received the greatest support in this area.
- *Philosophy Underlying Canadian Science* element 1.4.2 (4.02), limitations of human knowledge, was perceived as an important element.
- *Pure Science, Canadian Applied Science and their Interrelationship* element 1.5.4 (4.01), putting science concepts in everyday affairs where students could confront them, was well supported.
- *Science as Inquiry* elements reflecting learning as inquiry and the opportunity to apply inquiry strategies, elements 1.6.1 (4.19), 1.6.2 (4.18), 1.6.3 (4.11), and 1.6.6 (3.97) received excellent support.
- *Canadian Science Policy, Current Research Emphasis in Canada and Their Interaction* element 1.7.1 (3.79), the effects science and technology have on Canada's position in the world community, was moderately supported in a general area which received little support.

(e) The elements in the four methodological components which received the greatest support by validators are as follows:

- *Maximum Use of the Local Environment* elements 2.1.1 (4.31), 2.1.2 (4.74), and 2.1.6 (4.25), promoting relation of abstract knowledge to concrete situations, experiences and examples as concrete illustrations and commitment to careful use of natural resources, were seen to be mandatory.

- *Canadian Science Instructional Materials* elements 2.2.1 (4.31), 2.2.2 (4.09), and 2.2.3 (4.19), emphasizing relevant instructional material of high quality containing Canadian examples, received solid support.
- *Adaptation of Foreign Science Instructional Materials to a Canadian Context* elements 2.3.1. (4.08) and 2.3.2 (4.01), though well supported, validators preferred to have Canadian produced materials.
- *Problems of Regionalism* element 2.4.4 (4.04) indicating the interrelationship of regions was considered to be necessary.

(f) Those elements which tended to be rated as most relevant include areas where development of different thought processes are encouraged and had to be used under a variety of situations in the students' immediate environment, the Canadian scene.

(g) Those areas which were deemed to be of least relevance as indicated by the means and the comments include two major areas:

- *Philosophy Underlying Canadian Science*: Values, ethics, scientific legacy and science having a special place in Canadian society and culture as reflected in elements 1.4.4 (3.44), 1.4.5 (3.11) and 1.4.6. (3.13) seemed to get moderate support on the Likert scale while showing disagreement and opposition in the comments.
- *Canadian Science Policy, Current Research Emphasis in Canada and their Interaction*: elements 1.7.3 (3.21), 1.7.4 (3.16), 1.7.5 (2.87), 1.7.7 (2.97) and 1.7.9 (3.28) including science policy debate, science policy formation, changes in science policy and its adequacy were seen as inappropriate, and received little support, while collecting the most opposition found in the comments made by validators.

(h) Those areas which were perceived to have the least relevance seem to be those which deal somewhat with social issues and Canadian science policy. As well, some historical contexts were opposed. According to some validators, emphasis should be placed on the present.

(i) There seemed to be some ambiguity in support of elements dealing with Adaptation of Foreign Science Materials to a Canadian Context. Though there was support in terms of the Likert responses, 2.3.1 (4.08) and 2.3.2 (4.01), most respondents indicated by their comments that they felt teachers should be able to adapt the information on their own.

4. Preparation of the Final Version of the Clue Structure

It was heartening to obtain a high level of support for all 77 elements in the clue structure, especially as indicated by the high response means on the questionnaire. The validators' comments were of assistance in pointing out sources of ambiguity, confusion and duplication. It should be noted here that the degree of support or lack of support thereof for a clue structure element was not the most important influence in the final revision. The main benefit of validator response for the final draft of the clue structure was to ensure that all possible facets of the clue structure were identified, were deemed to have some relevance, and that each element could be expressed, elaborated, and clarified in a comprehensive manner. The sole criterion for the initial formulation and subsequent retention of an element in the clue structure was whether or not it encompassed a sufficiently significant component of Canadian context as defined in the theoretical perspective. There is no intention to rank the elements in order of importance.

The final revision of the clue structure presented in Appendix VI resulted from the following decisions:

(1) There was no change made in the two major subdivisions and eleven components presented in Table 1.

(2) The validators' comments seemed to imply that it would have been preferable to phrase each element as a positive statement, rather than in the

form of a question. This was done as is evident from the phrasing of the elements in Appendix VI.

(3) In the content component of the clue structure shown in Appendices III and IV, the following changes were made as a result of the validators' comments (see Appendix V):

- In component 1.1 (*Interdisciplinary Nature of Education*), element 1.1.7 was removed because of the overlap with elaborations of other elements thereby reducing the number of elements in 1.1 from 10 to 9.
- In component 1.2 (*Canadian Science-Canadian Society Interaction*), element 1.2.5 was perceived to mean the same as 1.2.6, therefore the two were combined, reducing the number of elements in 1.2 from 13 to 12.
- In component 1.3 (*History of Canadian Science*) elements 1.3.3, 1.3.5, and 1.3.7 were deleted since they were considered too ambiguous and redundant, having already been covered by other elements, reducing the number of elements in 1.3 from 7 to 4.
- In component 1.4 (*Philosophy Underlying Canadian Science*), elements 1.4.4., 1.4.5, 1.4.6, 1.4.7, 1.4.9, 1.4.10, and 1.4.11 were seen to be too specific and better reflected in other elements, which decreased the number of elements in component 1.4 from 11 to 4.
- In component 1.5 (*Pure Science, Canadian Applied Science and Their Interrelationship*), there was no change.
- In component 1.6 (*Science as Inquiry*), elements 1.6.3 and 1.6.2 were perceived to be the same, so were combined. 1.6.5 was removed from this section as it was out of place and was already

covered under another element. Thus the number of elements in component 1.6 was reduced from 6 to 4.

- In component 1.7 (*Canadian Science Policy, Current Research Emphasis in Canada and their Interaction*), elements 1.7.3, 1.7.4, 1.7.5, 1.7.7 and 1.7.9 were deleted for the same reasons as those above under component 1.4 reducing the number of elements in 1.7 from 9 to 4.

(4) The following changes were made in the methodological components as a result of the validators' comments (See Appendix V):

- In component 2.1 (*Maximum Use of the Local Environment*) there was no change.
- Component 2.2 (*Canadian Science Instructional Materials*) was rephrased to be consistent in formatting with the other components. Element 2.2.4 was deleted since it did not properly reflect the intended interpretation of the theoretical perspective, thus the number of elements in 2.2 was reduced from 4 to 3.
- In component 2.3 (*Adaptation of Foreign Instructional Materials to a Canadian Context*) there was no change.
- In component 2.4 (*Problems of Regionalism*) 2.4.2 was deleted due to duplication with 2.4.4, again reducing the number of elements from 4 to 3.

Considering the evolution of this clue structure, one may be tempted to claim it to be a general clue structure for Canadian context which should be applicable in the assessment and enhancement of instructional materials in any science area at any grade level, and for guiding the development of new instructional materials with an adequate Canadian context. In this study the clue structure is itself under further critical assessment. It is being tested for its adequacy as a foundation for the assessment and enhancement process by applying it to the analysis of a specific instructional program.

5. Summary and Critique of Stage I

The purpose of Stage I was the refinement and validation of the clue structure which is to be used in the subsequent stage for the assessment and enhancement of Canadian context in the instructional materials for the Alberta Grade 8 geology component. Although the elements in the clue structure were accepted as relevant by the national panel of validators, the process also assisted in identifying problematic areas. One of these was the identification of a number of components which overlap and which create potential problems in classification. The other contribution was the greater clarity in expressing the elements of the clue structure that resulted when validators exposed confusing statements and ideas through their comments.

A number of possible modifications of this stage warrant comment for future use of the procedure:

1. Most of the components in the clue structure have both a content and a methodological aspect, making classification somewhat difficult and arbitrary. The inquiry component offered most difficulty in this regard. There is merit in retaining the content-methodology classification, but probably within components rather than as sub-categories for all of the components. For example, in the final version of the clue structure it may be more plausible to drop the content-methodology sub-categories and label the clue elements as to whether the main thrust is on content or on teaching method. Consequently, in component 1.6 (*Science as Inquiry*), elements 1.6.1 (*inquiry in relation to scientific literacy*), 1.6.2 (*learning science as inquiry*), and 1.6.3 (*methods of inquiry used by Canadian scientists*) may be considered to be more content-oriented. On the other hand, element 1.6.4 (*application of inquiry strategies by students*) is in the realm of teaching methodology.
2. There was no need for different wording of the revised clue structure and the questionnaire. Indeed, the wording of the elements as in the final

version of the clue structure can be identical in a questionnaire or in an assessment instrument of the type used in Stage II for assessing the Canadian context in the Alberta Grade 8 geology component. Incidentally, this eliminates the need to translate the clue structure into the questionnaire items and reduces confusion in reporting Stage I.

3. The piloting of the questionnaire should be retained but perhaps should be more rigorous than it was in this study. Points 4 to 6 that follow speak to this.
4. The lack of congruence between the Likert response and written comments is bothersome. One might attempt to ask validators to justify their selection of a Likert response for each item. However, as was stated before, the validators' input was not necessarily used in deciding whether to retain or drop an element from the clue structure. It is important to re-affirm here that the theoretical perspective is the sole basis of decision-making in regard to the elements in the clue structure because it is rooted in the theory and practice of science education.
5. The diversity of reaction from validators points to the need for both a geographical sampling as well as sampling of the three categories of respondents (science teachers, science educators, and others whose professions actively relate to science education). A researcher should allow enough lead time to be able to identify suitable people from which to choose a representative sampling, both geographically and professionally. In the case of the science educators, this may indeed be the entire population as their numbers are limited.
6. If appropriate sampling could be achieved as described in point 5 above, one may not need nearly as many validators as was used in this study.

CHAPTER IV

STAGE II - PROCEDURE FOR APPLICATION OF THE CLUE STRUCTURE TO ASSESSMENT OF INSTRUCTIONAL MATERIALS

1. Development of the Assessment Procedure

Two major strategies can be used for assessing any instructional material in science (in this case the Grade 8 geology component) for aspects of Canadian context:

1.1 It is possible to transform the final clue structure (Appendix VI) into a questionnaire. Such an instrument would need to be completed by a representative sample of teachers who have substantial experience in teaching the curriculum being analyzed. Statistical analysis of the responses would yield a direct indication of the extent to which each specific element of the eleven components of Canadian context is being addressed.

However this approach has several drawbacks. First of all, the evidence is qualitative, even though a "count" is made of the teachers' perception of the extent to which each element of Canadian context is being covered. Each teacher will be responding subjectively in estimating the coverage of each element. The second drawback is that the instrument would have to be completed for each specific resource material. If there is a fairly large number of these resources to analyze, the task of assessing all of them becomes cumbersome. To have them assessed collectively raises questions about the validity of the assessment since there is no assurance that all of the teachers are conversant with all of the materials. The final drawback to this approach is that each teacher must have the same understanding of each aspect of the eleven components of the clue structure and be able to interpret it in terms of the instructional material being analyzed. This would require training of the teacher-assessors and the establishment of adequate interrater reliability.

1.2 It is possible to get a quasi-quantitative assessment of an instructional resource for Canadian context by analyzing it in small portions at a time. Each small portion can be coded with the appropriate elements of the eleven components of the clue structure. A "portion" could be defined as a "fixed" number of pages of a textbook, a complete activity such as an investigation/experiment, a single audio-visual aid, and so forth. A total frequency count can be made of each element in the clue structure in all portions of the specified instructional material being analyzed. These totalled frequencies can then be used to make generalizations about the coverage of Canadian context in the resource. Ideally, a panel of assessors should do this assessment, and inter-rater reliability should be established. However, as with the method described in 1.1 above, the panel would have to be put through an appropriate training session.

External assessors were not involved in the analysis of instructional materials for Canadian context in the current study. Instead the researcher did the analysis of Grade 8 geology material himself to establish its feasibility, using the following procedure. First, a careful detailed analysis was made of the instructional materials for this area according to the method described in 1.2 above. A brief description of each designated portion was prepared: nature of the instructional material (textbook, etc.), a brief annotation including subject matter, nature of the activities, way in which the Canadian (or other) context is reflected. Then each portion was coded in terms of the elements of the clue structure that was expressed in it. Finally, the Likert categories in the questionnaire (Appendix VII) were used to express the extent to which each portion reflected the element in the clue structure for Canadian context. An element was labelled as extremely evident (EE) if specific information on or examples of the element were included; quite evident (QE) if it was clear that attention was being given to the element; slightly evident (SE) if it could be inferred that the element was being addressed; not evident (NE) if there was no mention of the element but that it could be incorporated; and not evident and not applicable (NA) if the element does not apply to the situation. A frequency count was then made of the extent to which each element (hence component) was present in the instructional material being analyzed. Examples are presented in Appendix IX of how this modified method was applied in the assessment of the Canadian context in the Grade 8 geology program.

2. Analysis of the Geology Component in Alberta Grade 8 Science

The major geology concepts and sub-concepts in both the core and elective sections of Grade 8 science are listed in Appendix VIII (Alberta Education, 1976). Analysis was done only on the prescribed primary textbooks; Challenges to Science: Earth Science (metric and American editions) by Heller at al., and Spaceship Earth: Earth Science by Jackson and Evans. The publication Learning Resources for Junior High School Science (Alberta Education, 1978) lists a host of supplementary print and non-print materials for teaching the major concepts given in Appendix VIII. The resources from the resource manual which were related to the geology components were included in the analysis, except for the additional textual references. The latter were examined for ideas on teaching geology in a Canadian context in Stage III.

The assessment data obtained for these instructional materials, following the modified procedure described above, are presented in Appendix IX. This analysis was done on the concept-by-concept basis, outlined in Appendix VIII. A summary of this analysis is given in Table 5. The table shows the sum of the frequencies with which the elements which form a component in the clue structure appeared in the total resource being analyzed. Since there were 40 concepts identified in the geology area for Grade 8, the minimum number of opportunities for inclusion of elements was set as 40 within each of the frequency counts in Table 5.

A few comments about Table 5 are in order. The total number of entries for all eleven components for Challenges to Science: Earth Science are as follows: extremely evident none; quite evident 42; slightly evident 84; not evident 2032; not evident and not applicable none. The data on the other textbook and the learning resources are similar, indicating that very limited attention is given to Canadian context in them. It is interesting to note that there are no entries in Table 5 under "not evident and not applicable." This implies that it is possible to incorporate Canadian context, as defined by the clue structure, in the teaching of all 40 concepts of the geology component of Grade 8 science, but that the instructional materials analyzed barely touch on this aspect. The books are clearly American, and contexts are intended for an American audience.

During the analysis it became readily apparent that the only difference between the Canadian SI version of the Challenges to Science: Earth Science text and the U.S. version was the conversion to SI units. Even the photographs remain the same. These photographs were not always specifically American, with some examples that could be found in a number of places. However, the strong majority were U.S.. As well, texts reviewed seem to be written in a manner in which the same clue structures pertain to each concept. There appeared to be a strong sense of internal consistency of presentation for all information reviewed. Therefore, it appeared that where Canadian context was avoided, it was more by design than by chance. For example, materials written in the U.S. reflected the immediate locale of that country and in general the examples tended to support a U.S. context. In some cases it appeared that examples were selected in order to capture the attention of the student by using examples that were out of the ordinary. This is not unexpected, since the U.S. materials would be designed to reflect a U.S. context.

On the basis of the data in Appendix IX and the summary in Table 5 the following conclusions are reached about the extent to which each of the eleven components of the clue structure emphasizes Canadian context in the Alberta Grade 8 geology program:

- 1.1 *Interdisciplinary Nature of Science Education* was almost entirely absent from the materials perused. Both textual materials had only three occasions

TABLE 5

Summary of Evidence in Appendix X for Canadian Context in the Grade 8 Geology Component

Instructional Material Analyzed	Extent Evident	Frequency of Elements in the Instructional Material Analyzed: COMPONENT 1.1									
		1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	1.1.9	**Total**
Challenges to Science: Earth Science (Metric Edition)	EE										
	QE										
	SE			1					1	1	**3**
	NE	40	40	39	40	40	40	40	39	39	**357**
	NA										
Spaceship Earth: Earth Science	EE										
	QE								1	1	**2**
	SE						1				**1**
	NE	40	40	40	40	40	39	40	39	39	**357**
	NA										
Miscellaneous Non-print Materials	EE										
	QE	1	1	1			1			5	**9**
	SE			1	2		1			1	**5**
	NE	39	39	38	38	40	38	40	40	34	**346**
	NA										

TABLE 5 (cont'd)

Instructional Material Analyzed	Extent Evident	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	1.2.8	1.2.9	1.2.10	1.2.11	1.2.12	**Total**
		Frequency of Elements in the Instructional Material Analyzed — COMPONENT 1.2												
Challenges to Science: Earth Science (Metric Edition)	EE													
	QE													
	SE	3	1	2		3	8		3			3	1	**24**
	NE	47	39	38	40	37	32	40	37	40	40	37	39	**456**
	NA													
Spaceship Earth: Earth Science	EE													
	QE													
	SE								2					**2**
	NE	40	40	40	40	40	40	40	38	40	40	40	40	**478**
	NA													
Miscellaneous Non-print Materials	EE								2					**2**
	QE		1						6					**7**
	SE			1		2	3		3					**9**
	NE	40	39	39	40	38	37	40	29	40	40	40	40	**462**
	NA													

TABLE 5 (cont'd)

Instructional Material Analyzed	Extent Evident	Frequency of Elements in the Instructional Material Analyzed									
		COMPONENT 1.3					COMPONENT 1.4				
		1.3.1	1.3.2	1.3.3	1.3.4	**Total**	1.4.1	1.4.2	1.4.3	1.4.4	**Total**
Challenges to Science: Earth Science (Metric Edition)	EE										
	QE										
	SE		2			**2**	3	3		3	**9**
	NE	40	38	40	40	**158**	37	37	40	37	**149**
	NA										
Spaceship Earth: Earth Science	EE						3				**3**
	QE						4	1			**5**
	SE										
	NE	40	40	40	40	**160**	33	39	40	40	**152**
	NA										
Miscellaneous Non-print Materials	EE							1			**1**
	QE		1		1	**2**	1	2			**3**
	SE						2	1		1	**4**
	NE	40	39	40	39	**158**	37	36	40	39	**152**
	NA										

TABLE 5 (cont'd)

Instructional Material Analyzed	Extent Evident	Frequency of Elements in the Instructional Material Analyzed										
		COMPONENT 1.5						COMPONENT 1.6				
		1.5.1	1.5.2	1.5.3	1.5.4	1.5.5	**Total**	1.6.1	1.6.2	1.6.3	1.6.4	**Total**
Challenges to Science: Earth Science (Metric Edition)	EE											
	QE							15	15			**30**
	SE	3	2	1			**6**				1	**1**
	NE	37	38	39	40	40	**194**	25	25	40	39	**129**
	NA											
Spaceship Earth: Earth Science	EE							10	10			**20**
	QE				1		**1**		1		1	**2**
	SE											
	NE	40	40	40	39	40	**199**	30	29	40	39	**138**
	NA											
Miscellaneous Non-print Materials	EE				1		**1**					
	QE		1		1		**2**					
	SE	2	4		1	1	**8**					
	NE	38	35	40	37	39	**189**	40	40	40	40	**160**
	NA											

TABLE 5 (cont'd)

Instructional Material Analyzed	Extent Evident	Frequency of Elements in the Instructional Material Analyzed											
		COMPONENT 1.7					COMPONENT 2.1						
		1.7.1	1.7.2	1.7.3	1.7.4	**Total**	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	**Total**
Challenges to Science: Earth Science (Metric Edition)	EE												
	QE	2				**2**	3	3	2	2			**10**
	SE		3		3	**6**	6	6	6	6	1		**25**
	NE	38	37	40	37	**152**	31	31	32	32	39	40	**205**
	NA												
Spaceship Earth: Earth Science	EE				2	**2**	6	7	1				**14**
	QE						1	1	1	2			**5**
	SE		1			**1**							
	NE	40	39	40	38	**157**	33	32	38	38	40		**221**
	NA												
Miscellaneous Non-print Materials	EE				1	**1**			1				**1**
	QE	1			2	**3**			1	1	1	1	**4**
	SE				2	**2**			1		1		**2**
	NE	39	40	40	35	**154**	40	40	37	39	38	39	**233**
	NA												

TABLE 5 (cont'd)

Instructional Material Analyzed	Extent Evident	Frequency of Elements in the Instructional Material Analyzed										
		COMPONENT 2.2				COMPONENT 2.3			COMPONENT 2.4			
		2.2.1	2.2.2	2.2.3	**Total**	2.3.1	2.3.2	**Total**	2.4.1	2.4.2	2.4.3	**Total**
Challenges to Science: Earth Science (Metric Edition)	EE											
	QE											
	SE								2	3	3	**8**
	NE	40	40	40	**120**	40	40	**80**	38	37	37	**112**
	NA											
Spaceship Earth: Earth Science	EE											
	QE											
	SE											
	NE	40	40	40	**120**	40	40	**80**	40	40	40	**120**
	NA											
Miscellaneous Non-print Materials	EE	3			**3**							
	QE											
	SE											
	NE	37	40	40	**117**	40	40	**80**	40	40	40	**120**
	NA											

for integration of these elements out of the possible 360 opportunities in each case. Non-print materials fared slightly better than the textual materials, however here again there were only 14 occasions for use of the components of a possible 360. Where attempts were made to include this component it was generally under element 1.1.9, an attempt to make Canadian science education a relevant and functional experience. There was no coverage at all for elements 1.1.5 and 1.1.7.

- 1.2 *Canadian Science - Canadian Society Interaction* was better represented in Challenges to Science, than in Spaceship Earth or the non-print materials. However, when one is comparing 24 inclusions to 2 or 18 out of 480 opportunities for its use, this must still be considered a very dismal showing. Of the attempts made to use elements from this component, element 1.2.8 (presentation of science in a way which promotes getting to know ourselves and our universe) could apply to most of the concepts given because it allows the student to get to know the earth that she or he is living on. This is due more to the selection of the earth science component rather than the intentional purpose of the author. Depending on one's frame of mind, one could argue that all concepts within the confines of the textual materials could have 1.2.8 mapped onto them. However during this analysis some attempt to assist students in doing this was required before it was noted. Therefore, it would have to be stated that in the presentation of the concepts included in this program the materials used do not take into account component 1.2 *Canadian Science - Canadian Society Interaction,* since there is a little coverage given to elements 1.2.6 and 1.2.8 while there was no coverage at all given to elements 1.2.4, 1.2.7, and 1.2.10. American books do not deal with Canadian material, and there is no reason to do so. However, when these are edited for Canadian schools, Canadian material should be introduced.

- 1.3 *History of Canadian Science* must definitely be considered to be one of the most glaring omissions in all of the materials whether print or non-print. Of 480 opportunities within the textual and non-print materials only four occasions for inclusion of any of these elements could be noted. Of these cases the inclusions ranged from slightly to quite evident. There was no coverage for elements 1.3.1 and 1.3.3.
- 1.4 *Philosophy Underlying Canadian Science* fared only slightly better than the previous component. Of 160 opportunities for inclusion of elements in this component, there were a maximum of 25 occasions identified for use of the elements. The majority of these were included under element 1.4.1, an attempt to make science relevant in personal terms. Spaceship Earth provided the only opportunities where this element could be noted as being extremely evident. Investigation of questions of values and ethics related to science without feeling threatened (element 1.4.3) received no coverage.
- 1.5 *Pure Science, Canadian Applied Science and their Interrelationship* again suffered a dismal fate. In Spaceship Earth only one occasion of its inclusion could be noted. Non-print materials fared slightly better with 11 inclusions out of a possible 200, with the majority in a slightly evident category. This is particularly shocking since inclusion of issues of Canadian concern relating to science and technology in the classroom experiences of students and an attempt to make students aware how pure and applied science can be used to interpret critically what is taking place around them (elements 1.5.3, 1.5.5) can apply to almost any concept if Canadian examples are included.
- 1.6 *Science as Inquiry* fared the best of any of the components, if one is to be happy with 31 inclusions of a possible 160 opportunities. Challenges to Science provided the most inclusions; however Spaceship Earth provided the

most obvious examples with 20 inclusions identified as extremely evident. This again is due to the type of presentation within the text. Even here element 1.6.3 received no coverage whatsoever. Non-print materials were void of this component entirely.

- 1.7 *Canadian Science Policy, Current Emphasis in Canada and their Interaction* again was virtually absent with a maximum of 8 inclusions which ranged from slightly evident to quite evident in Challenges to Science. Even in the non-print materials only 6 of a possible 160 inclusions were found. This is not entirely surprising considering the fact that for this component to be present it must be recognized and deliberately included. The absence of element 1.7.3 provides proof of this.
- 2.1 *Maximum Use of the Local Environment* did best. Due to the nature of the activities included in Challenges to Science there were 35 inclusions of a possible 240 opportunities. Non-print materials had the least number of inclusions with 7. The reason this component fared better may be because of the inclusion of elements 2.1.1 (encouragement of students to relate abstract knowledge to concrete situations which they have encountered) and 2.1.2 (provision of opportunities for experience and examples which will serve as concrete illustrations and reinforcement of the science concept being learned). If component 1.6 Science as Inquiry is included these elements should follow naturally. Even here, element 2.1.6 needs reinforcement.
- 2.2 *Canadian Science Instructional Materials* was not included at all in either textbook. The only occasions for inclusion of 120 opportunities were 3 in the extremely evident category noted in the non-print materials section.
- 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context* has the distinction of being the component where there were absolutely no inclusions noted.

- 2.4 *Problems of Regionalism* had very poor representation with only 8 slightly evident inclusions in Challenges to Science and none whatsoever in Spaceship Earth or the non-print materials.

3. Needed Revision of the Instruction of the Alberta Geology Component

It becomes readily evident that considerable deficiency in terms of a Canadian context for science education exists within the primary instructional materials used in teaching the geology components included in the Alberta Grade 8 Earth Science Program. Stage II has certainly confirmed the researcher's suspicions that there was definitely an appalling situation where Canadian context is concerned. The only components where a reasonable number of inclusions were identified are 1.6 *Science as Inquiry* and 2.1 *Maximum Use of the Local Environment.* Even these should be expanded considerably. However, the main focus for revision should be on the other nine components which suffer greater omission.

A major task then in the remainder of this study is to identify appropriate instructional materials for increasing the Canadian context in the geology component in Grade 8 science (Stage III), and show how each is related to the components of the clue structure (Stage IV). In addressing this task, a number of caveats need to be stated:

1. The information identified in Stage III should be easily accessible to teachers.
2. The instructional resources must be pedagogically sound, and suitable for the prescribed geology curriculum.
3. The information should be interesting and motivating. There is some evidence (as cited by teachers responding in Stage I) that certain kinds of knowledge (e.g., history, science policy) is found boring by students and unchallenging to teach by teachers. It is important to develop ways of presenting such materials in the most interesting manner possible.
4. It is likely not possible (and it may not even be desirable) to address each of the eleven components in the clue structure to the same degree.

5. The expansion of the Canadian context in the Grade 8 geology component should not be done with a narrowly nationalistic frame of mind. An attempt should be made to get an appropriate and defensible balance of the national and the international context, with due emphasis being given in the latter on examples and illustrations from the U.S.A. and elsewhere. This is done with the recognition that there are many geological similarities and a few important differences between our two large neighboring countries sharing the North American continent.

4. Summary and Critique of Stage II

In terms of methodology, Stage II - Procedure for Application of the Clue Structure to Assessment of Instructional Materials was successful in confirming the researcher's earlier impressions of the sparseness of instructional materials in terms of a Canadian context in the Grade 8 geology component. This confirmation was done on the basis of quantitative evidence. In addition, the assessment method enables one to gain a sense of the relative deficiencies in the many aspects defining Canadian context. Using a five-point scale along with the clue structure seems to be a positive feature of this assessment procedure.

A key task in enhancing Canadian context in Grade 8 geology is to substitute at least one inclusion for each entry of *not evident* (NE) in Table 5. This may be very difficult or even impossible to do for some of the elements in relation to some of the geology concepts, at least in a manner that seems appropriate. Whether such an objective is possible to achieve can be determined only by attempting to do it.

Stage II as used in this study has one drawback. The researcher found the analysis of the Grade 8 instructional materials to be very intensive, laborious and time-consuming as well as extremely frustrating when Canadian context materials could not be found. This was especially true in terms of screening the non-print materials. One can imagine the assessment task becoming increasingly more onerous and time-consuming as the number of concepts in the curriculum and of the instructional materials for them increases. Stage II really requires the collective effort of teachers who are actively teaching the science curriculum, with each doing a part of the task. Of course, this would require due attention to the training of the teachers in the assessment method and to inter-rater reliability. Such a collective approach should be the responsibility of education ministries as part of their evaluation of the potential suitability of materials. Alternately, publishers of materials who wished to have their materials authorized for classroom use should be asked to provide such analyses for Canadian context as part of the documentation supporting their request for authorization.

CHAPTER V

STAGE III: SOURCES OF INFORMATION FOR ENHANCING THE CANADIAN CONTEXT IN SCIENCE INSTRUCTION

In Stage III procedures and sources were identified and explored for collecting information for enhancing the Canadian context in instructional materials. This was done in the spirit of developing a methodology for improving Canadian context in instructional resources in science. The sources identified are those which may be used to translate and enhance the curricula defined by Alberta Education Curriculum Guides for students in Alberta. These sources are science teachers, scientists, science educators at universities and regional offices of Alberta Education, and available print and non-print reference materials. The procedures will be discussed below for covering specific information from each source, sifting it for relevance to the geology component of the Grade 8 science program, and relating it to the clue structure for Canadian context in science education. In addition, some judgment will be made on the adequacy of the procedure and the worth of the information gathered from each source for dealing with the gaps and the weaknesses identified in Stage II in the two prescribed references and related resource materials for teaching the geology component in a Canadian context.

1. Science Teachers as a Source of Information

As was indicated in Figure 1, information for enhancing the Canadian context in the Grade 8 geology component was sought from teachers who were teaching Grade 8 science. They were asked for suggestions for modifying and/or supplementing the prescribed geology curriculum material in the area of a Canadian context. Information was sought both in written form and in interviews.

1.1 Survey of Science Teachers

A province-wide survey directed to all teachers assigned to teach Grade 8 science in the province was used to obtain as much information as possible. The survey instrument (the same as was used in Stage II and included in Appendix VII) was sent to all science teachers in this subject area in the province in the hopes that biases that may result from other sampling techniques could be minimized. Four hundred and seventy-five teachers assigned to teach Grade 8 science in Alberta and registered with Alberta Education at the time of the survey, were asked by letter and by accompanying survey instrument to indicate in what manner they enhanced the Canadian context for each of the geology concepts indicated in Appendix VIII and in addition what else they thought might be done. In the covering letter sent with the list of major geology concepts the following example was enclosed:

CONCEPT C8.7

1. Common materials are found within the earth's crust.

What is done. Mention is made of Canada's role as one of the leading mineral producers in the world. Canada was the world's largest producer of asbestos, nickel, zinc, and silver in the 1970s. Canada was second in production of potash, molybdenum, gypsum, uranium, and sulphur.

What could be done. Development of this area could include a depiction of how science and technology can be used to alter the economic and political situation in Canada, promotion of an awareness of the role of Canadian scientists, mineralogists, geologists, and technologists in Canada's growth and development, and recognition of contributions made by Canadian scientists and geologists to international science.

Prior to the requested deadline, a follow-up letter was sent to non-respondents encouraging them to submit information. By the final cut-off date 120 teachers had submitted ideas on teaching the geology component, a return rate of approximately 25%. These were collated and summarized. The summary of the 80 typed pages of comments is presented in Appendix X in which the ideas are organized under the concepts and sub-concepts in the geology component of Grade 8 science (Appendix VIII). The major points in this summary are presented in terms of specific suggestions for enhancing Canadian context in terms of the concept/sub-concepts of the Grade 8 geology program; desirability and relevance and feasibility of giving adequate attention to Canadian context and its implementation.

1.1.1 Specific Suggestions Regarding the Teaching of the Geology Concepts

The first step in making sense of the thousands of comments made regarding the teaching of geology in Grade 8 was to sort out the comments which did not seem to apply to any of the concepts of the geology program. Then a grid was set up based on the concepts in the geology component (See

Appendix VIII). Comments were all listed under the appropriate concepts to which they seemed to refer with a notation to the teacher to whom the response belonged (e.g., T10). This enabled the researcher to identify teachers for interviewing in Stage III. Next, under each of these geology concepts and sub-concepts, the responses were sorted according to commonalities of information or methodologies being suggested. These were then summarized as indicated in Appendix X. The suggestions from each of the concepts and sub-concepts were then classified in terms of the clue structure elements and components which seemed to be promoted. A running tally of the frequency of elements covered by information presented by the teachers in the survey portion of Stage III was kept and recorded in Table 6. In this way it could be quickly noted which elements were receiving coverage and which were not. It was necessary to differentiate between information already covered in Stage II and new information being presented by the teachers in Stage III. Wherever it was obvious that teachers took ideas from the two texts and the suggested resource materials and reported it in Stage III, this information was not included in Table 6 nor the summary in Appendix X. This process reduced totals most noticeably in two major areas. These include component 1.6 *Science as Inquiry* which moved from 55 to 39 and component 2.1 *Maximum Use of the Local Environment* which went from a total of 100 to 82. It becomes apparent that teachers did take some direction from these mandated materials.

If one studies Table 6 and Appendix X some general features emerge from the data:

- It would appear that with a total of 52 occurrences of elements related to component 1.1 *Interdisciplinary Nature of Science Education*, that this area was well represented. It must be remembered that there were 9 elements within this component and with 40 concepts and sub-concepts under which the suggestions were listed, this means that 52 elements

TABLE 6

Summary of Frequency of Elements Covered by Information Obtained in Stage III

Source of Information	Frequency of Elements Covered by Source of Information									
	COMPONENT 1.1									
	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	1.1.9	**Tctal**
Survey of Science Teachers	3			3	1	2	12	7	24	**52**
Interview of Science Teachers		2		1		2	2			**7**
Interview of Scientists	2	2	1	4		2	3		7	**21**
Interview of Science Educators										**0**
Print and Non-print Materials	16	10	19	17	6	18	16	15	30	**147**

TABLE 6 (cont'd)

Source of Information	Frequency of Elements Covered by Source of Information												
	COMPONENT 1.2												
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	1.2.8	1.2.9	1.2.10	1.2.11	1.2.12	**Total**
Survey of Science Teachers			1	3	4		1	32	2		1		**44**
Interview of Science Teachers		1	2		2	2						2	**9**
Interview of Scientists	1	2	1	4	2	3	4	1	1				**19**
Interview of Science Educators													**0**
Print and Non-print Materials	6	3	7	10	14	15	16	34	10	6	2	4	**127**

TABLE 6 (cont'd)

Source of Information	Frequency of Elements Covered by Source of Information									
	COMPONENT 1.3					COMPONENT 1.4				
	1.3.1	1.3.2	1.3.3	1.3.4	**Total**	1.4.1	1.4.2	1.4.3	1.4.4	**Total**
Survey of Science Teachers			2	3	**5**	19			1	**20**
Interview of Science Teachers					**0**	4				**4**
Interview of Scientists	5	2	4	5	**16**	7	3	1		**11**
Interview of Science Educators					**0**					**0**
Print and Non-Print Materials	14	14	15	15	**58**	38	6	4	5	**53**

TABLE 6 (cont'd)

Source of Information	Frequency of Elements Covered by Source of Information										
	COMPONENT 1.5						COMPONENT 1.6				
	1.5.1	1.5.2	1.5.3	1.5.4	1.5.5	**Total**	1.6.1	1.6.2	1.6.3	1.6.4	**Total**
Survey of Science Teachers						**0**	18	21			**39**
Interview of Science Teachers		1		2	1	**4**	1	1			**2**
Interview of Scientists		4	2	4	2	**12**	1		1		**2**
Interview of Science Educators						**0**					**0**
Print and Non-print Materials	6	9	15	13	15	**58**	21	25	18	18	**82**

TABLE 6 (cont'd)

Source of Information	Frequency of Elements Covered by Source of Information											
	COMPONENT 1.7					COMPONENT 2.1						
	1.7.1	1.7.2	1.7.3	1.7.4	**Total**	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	**Total**
Survey of Science Teachers	5			5	**10**	28	26	27			1	**82**
Interview of Science Teachers	1			2	**3**			2	2	2	1	**7**
Interview of Scientists	2	1	1	4	**8**	5	5	5	8	2	1	**26**
Interview of Science Educators					**0**							**0**
Print and Non-print Materials	9	7	7	11	**34**	26	31	39	35	11	7	**149**

TABLE 6 (cont'd)

Source of Information	Frequency of Elements Covered by Source of Information										
	COMPONENT 2.2				COMPONENT 2.3			COMPONENT 2.4			
	2.2.1	2.2.2	2.2.3	**Total**	2.3.1	2.3.2	**Total**	2.4.1	2.4.2	2.4.3	**Total**
Survey of Science Teachers				**0**			**0**		1	2	**3**
Interview of Science Teacher	1	1	1	**3**	1	1	**2**				**0**
Interview of Scientists	3	3	3	**9**	1	1	**2**	1	1	2	**4**
Interview of Science Educators				**0**			**0**				**0**
Print and Non-print Materials	39	39	39	**117**			**0**	8	11	9	**28**

representative of this component were integrated into teaching these concepts of a possible 360 opportunities. Elements 1.1.7 *an understanding and appreciation of humankind's interrelatedness with the natural and social environment* and 1.1.9 *making Canadian science education a relevant and functional experience*, were well represented while the rest of the elements within this component were poorly represented. Elements 1.1.2 *through an interdisciplinary treatment, show that all living things interact with and are interdependent upon each other in their environment*, and 1.1.3 *study of the functional relationships in phenomena which go beyond the individual characteristics of the parts usually studied within the limits of one discipline*, were not represented at all. This is not surprising since this was an area where many of the respondents had no desire to treat the subject matter in an interdisciplinary fashion. Some believe that this cannot be done while others agreed with teacher T42 who felt "identity and social matters are better taught in social studies."

- Component 1.2 *Canadian Science - Canadian Society Interaction* was represented in 44 out of 480 opportunities. The majority of the suggestions were classified under element 1.2.8 *presentation of science in a way that promotes getting to know ourselves and our universe* (32 of the 44 occasions). Elements 1.2.3, 1.2.4, 1.2.5, 1.2.7, 1.2.9 and 1.2.11 were poorly represented and 1.2.1, 1.2.2, 1.2.6, 1.2.10 and 1.2.12 were not represented at all. This again was consistent with a number of general comments made by teachers to the effect that many of the elements in this component were too difficult for the Grade 8 student to comprehend. Science was considered to be universal whereas anything relating to social aspects was considered to be social studies. This was definitely reflected in their lack of suggestions which cover this component.

- The suggestions made regarding specific concepts in the geology program reflects almost a total absence of components 1.3 *History of Canadian Science*, 1.4 *Philosophy Underlying Canadian Science* and 1.5 *Pure Science, Canadian Applied Science and their Interrelationship.* Component 1.3 could be identified only in 5 of 160 possible opportunities with 1.3.1 *attention given to the many important achievements in science* and 1.3.2 *attention to the impact of science/technology had historically upon Canadian life*, being given no attention at all. Component 1.4 would only have had suggestions in one concept area if it had not been for element 1.4.1 *making science relevant in personal terms.* Of the 20 occasions where component 1.4 was identified, this element was responsible for 19 of these. None of the suggestions noted under specific geology concepts could be identified with component 1.5.
- Component 1.6 *Science as Inquiry* certainly reflects the general comments made by teachers about the level of student with which they were working and their own perceptions of science. Overall there were 39 of a possible 160 inclusions related to component 1.6. All of these were identified with elements 1.6.1 *promotion of inquiry as a major element in what many refer to as scientific literacy* and 1.6.2 *promotion of learning of science as*

inquiry. There was no relationship at all between the suggestions made by teachers and elements 1.6.3 *dealing with specific achievements of Canadian scientists paying attention to the methods of inquiry used* or 1.6.4 *application of inquiry strategies when students are dealing with Canadian problems which require scientific or technological solution (e.g. in environmental degradation, resource depletion)*. Reasons given for this include: don't want to be bothered, don't see the relevance, don't know how to do this, or lack the resources to do this.

- Component 1.7 *Canadian Science Policy, Current Emphasis in Canada and Their Interaction* received a similar split when identifying suggestions relevant to elements of that component. Elements 1.7.1 *study of the effects science and technology have on Canada's position in the world community* and 1.7.4 *inclusion of the areas identified as being a specific interest to Canada: communication, management of the oceans (including the Arctic), transportation, oil and gas technology for severe climatic and geographic conditions, resource development, etc.*, each received 5 of the total of 10 inclusions for component 1.7 whereas elements 1.7.2 *study of why there is emphasis on certain areas of research in pure and applied science* and 1.7.3 *addressing some of the determinants of Canadian science policy*, showed no indication of being addressed.
- In terms of methodological components of science education in a Canadian context, component 2.1 *Maximum Use of the Local Environment* fared quite well compared to other components. Of a possible 240 opportunities, suggestions could be identified with

this component on 82 occasions. Here again there was a distinct split in those elements within the component that were being presented by teachers and those that were not. Elements 2.1.1 *encouragement of students to relate abstract knowledge to concrete situations which they have encountered*, 2.1.2 *provision of opportunities for experience and examples which will serve as concrete illustrations and reinforcement of the science concept being learned*, and 2.1.3 *development of an understanding and appreciation of the natural and social world in which the students live*, each received over 26 inclusions that comprise 98% of the representation of this component. Elements 2.1.4 *application of basic scientific laws and concepts to the study and understanding of the students' immediate environment*, 2.1.5 *study of topics and problems of current local scientific significance with discussion of feasible action and suggested solutions*, and 2.1.6 *development of a commitment to the careful use of natural resources in a locality and to the preservation and improvement of their environment*, were not in evidence.

- From the suggestions offered by teachers, there was no indication whatsoever of attention given to elements from component 2.2 *Canadian Science Instructional Materials* or 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context*. Component 2.4 *Problems of Regionalism* was virtually unrepresented with only 3 inclusions of a possible 120 opportunities.

Appendix X and Table 6 not only provide an ongoing record of coverage in terms of the clue structure for a Canadian context, but also allows the opportunity to make note of relationships or trends which seem to be developing. If one looks back at Stage II and Table 5 within Chapter 4, one would find that within the very sparse representation within the textual materials of any representation which was found, when element 1.1.9 *making Canadian science education a relevant and functional experience*, was noted, so were elements 1.2.8 *presentation of science in a way which promotes getting to know ourselves and our universe*, and 1.4.1 *making science relevant in personal terms*. Element 1.6.1 *promotion of inquiry as a major element in what many refer to as scientific literacy* and 1.6.2 *promotion of learning of science as inquiry* received the highest indication of evidence along with elements 2.1.1 *encouragement of students to relate abstract knowledge to concrete situations which they have encountered*, 2.1.2 *provision of opportunities for experience and examples which will serve as concrete illustrations and reinforcement of the science concept being learned*, and 2.1.3 *development of an understanding and appreciation of natural and social world in which the students live*. This presence within the primary instructional materials corresponds exactly to the frequency of elements indicated in the suggestions obtained in the survey of science teachers. In order to explain this we should look at the different suggestions that are presented in Appendix X. A quick count of the summary statements indicative of various methodologies reveals the laboratory experiments and demonstrations are prominent in 18 of the 40 concepts/sub-concepts areas, field trips within 25, films/film strips/audio-visual resources in 27, making models within 4, and reference to local resources in 8. The selection of the activities used to supplement primary resources would most certainly promote elements 1.6.1 and 1.6.2 of the *Science as Inquiry* component and elements 2.1.1, 2.1.2 and 2.1.3 of the component *Maximum Use of the Local Environment*. If one looks at some of the supplementary materials being used by teachers such as CRIB (referred to later in this Chapter), one would note that there are definite opportunities provided for inclusion of certain elements. One such case deals with the elements that fall under component 2.1 *Maximum Use of the Local Environment* and *Science as Inquiry*. These areas are reinforced by suggestions for teachers to use - field trips, labs, models, or demonstrations are specific for the local environment.

It also becomes quite evident that certain concepts/sub-concepts are more conducive to representation by a greater diversity of elements from the clue structure for a Canadian context in science education. This is especially true of concept *E8.1 Materials from the crust have had an important influence on mankind's daily living*, where reference is made specifically to the impact of fossil fuels and their products on the economy of Alberta and management of exploitation for maximum benefit. It would appear that if teachers are provided with directions for inclusion of such components, they will respond in some manner, however small.

1.1.2 Desirability and Relevance of Canadian Context

The teachers surveyed identified a definite need for a Canadian context. Thirty-one teachers made specific comments relating to the necessity for improved Canadian examples and promotion of Canadian textbooks. These comments ranged from "I applaud your efforts to identify and promote the *Canadian* in science instruction" (T58) to "I sincerely hope your efforts bear fruit and I look forward, with anticipation, to the day when our science program will reflect true *Canadianism*" (T19). Some comments were very specific to what the teacher perceived as being necessary in terms of a Canadian context such as "Better Canadian relevant textual material would be beneficial to schools with limited resources" (T94).

1.1.3 Feasibility and Implementation of Canadian Context

Although teachers supported the Canadian context for science education, they were quick to point out that there were a number of concerns in terms of feasibility and implementation of Canadian context within a geology program. These are as follows:

- Twenty-two respondents commented on the Grade 8 science curriculum as being very intense, where often the teachers do not have time to elaborate on the concept development much beyond the presentation by the textual materials. This is shown in comments such as "The Grade 8 course is so ambitious in school one must limit the depth to which any concept can be developed" (T201) and "The Grade 8 science course is so heavy that it would lack relevance to any Grade 8 student in any country" (T194). There was almost unanimous presentation of the problem of time constraints. This extended to the survey itself where many comments were made that a greater response, a greater effort could be put into the survey if it had been done at a different time of year. However teachers did not mention when would have been a better time.

- Teachers pointed out that many have difficulty teaching this subject matter because they themselves are having difficulty with the material or lack the time to understand the concepts. This stems from the fact that many of these teachers are teaching geology in Grade 8 earth science with no background and no idea of how these concepts apply to the real world of the student. They have never spoken to a geologist. Examples of this were abundant and include "I regret this is so brief. I find this the most difficult of all the science courses to teach. I lack the expertise to deal with it" (T61) and "To broaden anything requires a good deal of knowledge not only in science, but in the broadening area as well. I find I lack the inspiration" (T67).
- Another concern in terms of implementation of Canadian context in science education was related to teachers' perceptions of what science is. This was demonstrated by comments such as "I believe - especially at the junior high level - that science is

science and interdisciplinary studies quite another" (T88) or "My teaching responsibilities, as a rule, do not cross over the political-social-economic realm you are studying. I am concerned, as you are, with the geology program, but I refer to the practical needs of the day-to-day lesson plan" (T59).

1.2 Interview of Science Teachers

The six teachers interviewed were selected on the basis of response to the survey instrument. The survey called for specifics in teaching the geology component yet was open enough to solicit information which could identify teachers who make an attempt to include a Canadian context in their approach to the geology component of the Grade 8 science program. Thus, in the covering letter to teachers seeking information, a request was made for volunteers for indepth interviews. The six teachers selected for this purpose on the basis of the attention they seem to give to a Canadian context are gratefully acknowledged.

The interviews were conversational in nature. The researcher prepared guiding questions based on the teachers' written responses (See Appendix XI). The overall conversation was taped after gaining permission of the interviewees. The interviewer attempted to obtain details on what the teachers are doing to modify and supplement curriculum materials to include and update the Canadian context; in other words to obtain details on what takes place at the interface of the curriculum as planned and the curriculum as implemented. Towards the end of the interview the researcher summarized for the teacher the main points of the conversation to check the authenticity of the information. Later, these tapes were transcribed and the transcribed notes were collated and summarized in Appendix XI.

It will be noted in Appendix XI that the teachers' interview comments again fell into three broad categories used above in discussing the survey results: specific suggestions related to teaching the geology concepts, desirability and relevance of Canadian context in the geology component, and feasibility and implementation of Canadian context in the geology component.

1.2.1 Specific Suggestions Regarding the Teaching of the Geology Concepts

The statements summarizing the interview comments relating to the teaching of geology are classified in Appendix XI according to the concept covered. These statements are then classified according to the appropriate elements of the clue structure. The frequency of attention given to each element is included in Table 6 alongside the frequency count of elements covered in the survey.

Appendix XI and Table 6 indicate trends in coverage by the interviewed science teachers as follows:

- Though the frequency of elements within components is smaller due to the fact there were only six teachers involved in the interviews as compared to 120 in the surveys, we can see that some of the gaps in the coverage are beginning to be covered.
- No information was obtained on the teaching of some of the geology concepts. These concepts include C8.7.3 (rocks can be categorized into three main groups), C8.8.1 (landforms are being built up by movements within the crust), C8.8.2 (weathering weakens rock formations), C8.8.4 (dynamic processes are at work within the earth), E8.2.1 (age determinations can be estimated on the basis of rates of changes of crustal materials), and E8.2.2 (fossil evidence can be used to relate past events in the history of the earth from one place to another).
- In component 1.1 *Interdisciplinary Nature of Science Education* the 7 occasions where this component was addressed are spread throughout the elements, including element 1.1.2 *through an interdisciplinary treatment, show that all living things interact and are interdependent upon each other and their environment* which was not included before. There was a shift away from the

predominance of suggestions or responses which supported element 1.1.9 *making science education a relevant and functional experience.*

- A similar situation was found dealing with component 1.2 *Canadian Science - Canadian Society Interaction* where in the survey we had a predominance of 32 of 44 responses in the component reflecting element 1.2.8 *presentation of science in a way which promotes getting to know ourselves and our universe.* Instead we have a more even distribution of the 9 inclusions to cover three more elements: 1.1.2 *study the effects (ills and benefits) that science technology have on the Canadian workplace, 1.2.6 use of examples and illustrations of the impact of science and technology from contemporary life,*, and 1.2.12 *attention to the variety of roles the high school students as adults will play in the future Canadian society and how science can prepare them for those roles.*
- 1.3 *History of Canadian Science* was not touched upon at all in the interviews with the teachers.
- The coverage in component 1.4 *Philosophy Underlying Canadian Science* remained similar to the survey results in that only element 1.4.1 *making science relevant in personal terms* was included in the interviews.
- The coverage of elements within component 1.5 *Pure Science, Canadian Applied Science and their Interrelationship* was improved somewhat in terms of the number of elements covered. In the survey of science teachers none of the five elements were suggested. In the interviews, we now find four inclusions

covering elements 1.5.2 *study of various views of the relationship of pure and applied science in terms of science attempting to describe the world while technology is seen by some as the means by which humans adapt the environment to suit their needs, 1.5.4 use of applied science to put science concepts in everyday affairs where the students may confront them*, and 1.5.5 *make students aware of how pure and applied science can be used to interpret critically what is taking place around them* supported on Likert scale indications which were then supported appropriately by open-ended responses.

- In component 1.6 *Science as Inquiry* elements 1.6.1 *promotion of inquiry as a major element in what many refer to as scientific literacy* and 1.6.2 *promotion of learning science as inquiry* each received one inclusion in the interviews while elements 1.6.3 and 1.6.4 received none (the same coverage as in the survey).
- Component 1.7 had three more inclusions in the interviews, adding to the five inclusions in the same two elements as in the survey, namely, 1.7.1 *study of the effects science and technology have on Canada's position in the world community* and 1.7.4 *inclusion of areas identified as being of specific interest and benefit to Canada.*
- There was some improvement of coverage of methodological components as a result of the interviews. For component 2.1 *Maximum Use of the Local Environment*, which in the survey had a very heavy emphasis on elements 2.1.1 *encouragement to relate abstract knowledge to concrete situations encountered*, 2.1.2 *experience and examples which will serve as concrete*

illustrations and reinforcement of the science concept being learned, and 2.1.3 *development of an understanding and appreciation of the natural and social world in which students live*, the emphasis shifted in the interview of science teachers toelements 2.1.3, 2.1.4 *application of basic scientific laws and concepts to the study and understanding of the students' immediate environment*, 2.1.5 *study of topics and problems of current local scientific significance with discussion of feasible action and suggested solutions* and 2.1.6 *development of a commitment to the careful use of natural resources in the locality and to the preservation and improvement of the environment.* Component 2.2 *Canadian Science Instructional Materials* and 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context* received some coverage of elements. There was one inclusion for each of the elements involved: in the survey, component 2.4 *Problems of Regionalism* received some coverage (three inclusions) while none were added in the interviews.

A look at some of the summary statements provided in Appendix XI reflect the ideas expressed that indicate coverage. Among these are:

- Students should be challenged to write reports.
- Students should be allowed to work independently to inquire about a mineral.
- Look at river flooding and the implications that it has on manmade structures and development.
- Look at the relationship between geologic processes and implications for human development.

- Deal with the issues in such a way that includes the relationship of science, economy and politics.
- Use resource people and the local environment to learn about resources.
- Students must be made aware of the limitations of our resources.

From the above we can see that the shift in emphasis for these suggestions is more towards the *Interdisciplinary Nature of Science education* and *Canadian Science - Canadian Society Interaction.*

1.2.2 Desirability and Relevance of Canadian Context

Teachers interviewed perceived that having students learn about Canadian scientists is important. It was felt that there is a certain science that is common no matter what country you are in, but we must also identify things that are uniquely Canadian wherever we can.

Other major points include:

- It is important to differentiate between Canadian content and Canadian context.
- Promoting a Canadian context is getting down to the needs of the students rather than saying it's Canadian.

1.2.3 Feasibility and Implementation of Canadian Context

A portion of the interviews was on teachers' concern about feasibility and implementation of Canadian context:

- If one is working in a Canadian context then it is necessary to ensure that the Canadian focus in terms of subject matter, as in geology, has to be localized to one's own region, the region of the school.
- In curriculum guides there are prescribed and recommended textbooks. As long as supplementary materials are viewed as secondary resources, teachers are not likely to use it.

- The teacher must be given ways of finding materials and implementing these in their immediate environment without having to develop these as they would elective units.
- There is a need to utilize local resource personnel to a larger degree than we are now.
- Teachers must be provided with an appropriate in-service education to facilitate integration of Canadian context for science education.

1.3 Usefulness of Interview Information from Teachers

The first reaction one gets from the summary of the interview data in Appendix XI and Table 6 is that not too much was gained in regard to teaching geology with enhanced Canadian context. The interviews seemed to focus more on desirability and relevance of Canadian context and the feasibility and implementation of it in the geology course. The statements on desirability and relevance would be useful for Stage I of the methodology if a decision had been made to deal with implementation comprehensively in the study.

The researcher had difficulty keeping the interview focused on the methods and materials for enhancing the Canadian context in the geology component. This may have been partly due to the fact he unconsciously allowed himself to be diverted from the main interview purpose and partly that the teachers being interviewed may have felt that they did not have more to offer beyond what was stated in their response to the questionnaire. However, their tendency to focus on desirability, relevance, feasibility and implementation undoubtedly reflects serious misgivings about a heavier emphasis on Canadian context (see quotations in Appendix XI). These misgivings certainly must be addressed at some stage if indeed there is to be more attention given to Canadian context.

The following conclusions from the interview data and its treatment are important to the methodology:

1. The interviews in Stage III must focus more sharply on methods and materials for teaching geology in a Canadian context. Prior to an interview, the researcher must go through the responses of the interviewee on the questionnaire and ferret out the specific questions that need to be asked on the methods and materials indicated. These questions must be the main focus in the interview.
2. Interviews of validators should be considered for Stage I since much more detailed information can be gathered on the desirability and relevance on a Canadian context than will be provided in a written form.
3. It may be necessary to give comprehensive attention to feasibility and implementation in the methodology of enhancing Canadian context in science instruction, starting with a treatment of these two aspects in the theoretical perspective.

2. Scientists as a Source of Information

Based on their knowledge of the earth sciences, publication within the area, and general interest expressed in assisting science teachers, three practicising geologists in Alberta were identified as being able to supply useful information for the study. These scientists were affiliated with three different universities within Alberta as well as having research components outside of these institutions. Interviews were conducted with each of the scientists in an attempt to obtain information on availability and relevance of supplementary materials for teaching the geology component in Grade 8 science, and the feasibility of implementing a methodology for assessment and improvement of science instructional materials for Canadian context.

Prior to the interview the questions used to guide the arranged interviews (Appendix XII) were provided to each of the interviewees to ensure that they were comfortable with the content of the interviews and would thereby provide relevant information more efficiently. The transcribed information from the three interviews was collated and summarized in Appendix XII. These earth scientists tended to be quite enthusiastic about their field, hence tended to go beyond specific comments pertaining to the concepts and sub-concepts of the geology program.

The summary of the interviews of scientists presented in Appendix XII and Table 6 reveals the same three clusters of information that was obtained from the science teachers. These are now discussed in detail.

2.1 Specific Suggestions Regarding the Teaching of the Geology Concepts

The scientists provided a wealth of specific ideas for enhancing Canadian context in the geology component of Grade 8 science, as can be quickly noted from the suggestions included in Appendix XII. These suggestions are coded according to element covered in the clue structure, and tallied in Table 6. Appendix XII and Table 6 reveal the following contributions from the three scientists:

- The 21 occasions reflecting component 1.1 *Interdisciplinary Nature of Science Education* were spread throughout its elements (Table 6) and provided coverage for another element which had not been previously referred to, namely, 1.1.3 *study of the functional relationships and phenomena which go beyond the individual characteristics of the parts usually studied within the limits of one discipline.*
- The same was true with component 1.2 *Canadian Science, Canadian Society Interaction* where the 19 occasions were shared by the first 9 components leaving only 1 element, 1.2.10 without previous attention from either the teachers or the scientists. Element 1.2.1 *demonstration to students of the benefits derived from taking science* now was covered for the first time.
- Components 1.3 *History of Canadian Science*, 1.4 *Philosophy Underlying Canadian Science* and 1.5 *Pure Science, Canadian Applied Science and their Interrelationship* received a much needed shoring up.

The 16 occasions where aspects of component 1.3 were included were spread throughout the four elements providing new coverage for the first time for elements 1.3.1 *attention to the many important Canadian achievements in science* and 1.3.2 *attention to the impact of science/technology had historically upon Canadian life.*

- In component 1.4 coverage was provided for the first time for elements 1.4.2 *portraying the nature of science as a cautious view of knowledge, making us mindful of the limitations of human knowledge* and 1.4.3 *investigation of questions of values and ethics related to science without feeling threatened.*
- In the 12 occasions where component 1.5 received much needed shoring, element 1.5.3 *inclusion of issues of Canadian concern relating to science and technology in the classroom experience of students* received coverage for the first time, leaving only element 1.5.1 *study the nature of both pure science and of applied science* without coverage.
- Component 1.6 did not receive much direct attention from the scientists, with only two inclusions compared to a total of 41 from the teachers. Part of this may be due to the fact that the inquiry component is in effect subsumed in the suggestions made by the scientists and is implicit rather than being explicit. Element 1.6.3 *dealing with specific achievements of Canadian scientists paying attention to the methods of inquiry used* which had not previously been supported had one inclusion in the interviews of the scientists. This left only element 1.6.4 *application of inquiry strategies when students are dealing with Canadian problems which require a scientific or technological solution* without coverage.

- Component 1.7 *Canadian Science Policy, Current Emphasis in Canada and their Interaction* now had coverage of all of its elements with the addition of support for elements 1.7.2 *study of why there is emphasis on certain areas of research in pure and applied science* and 1.7.3 *addressing some of the determinants of Canadian science policy.*
- The 26 inclusions for component 2.1 *Maximum Use of the Local Environment* were distributed amongst its 6 elements.
- With a total of 15 inclusions from the interviews of scientists (compared to a total of 8 from the teachers), all elements within components 2.2 *Canadian Science Instructional Materials*, 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context* and 2.4 *Problems of Regionalism* now had full coverage. Element 2.4.1 *provision of opportunity for development of the conception of regional scientific and technological needs in relation to national needs* received coverage for the first time.

When one looks at the summary of comments provided in Appendix XII a few very strong messages are being conveyed. One of these speaks to the necessity to make geology programs relevant to the students:

- Try to remove the abstract presentation of geology from the classroom.
- In order for students to understand abstract concepts and processes they must work from familiar situations to the unfamiliar ones.
- Students must be shown the interrelationships of geology with the everyday world around them.
- Instead of focusing on abstract concepts, focus on geological context principles.

Another message that comes through very clearly is that we must integrate the concepts related to the geology program in a manner where a context for science is provided showing the interrelationships of science, society and technology:

- Canadian context is talking about research in chemistry and metallurgy.
- Once you start with landscapes and other interesting components which could fit into a Canadian context, you can plug in the rocks and minerals later on.
- We must teach concepts and principles in context rather than the a, b, c's of rock identification.
- Students must learn to understand earth processes within a context such as time.
- This area is a perfect opportunity for students to see the interrelationship between geology, society, and the world around them.

The scientists stressed the need to include Canadian scientists and scientific achievements when discussing the field of geology:

- In the earth sciences there are a number of areas within the general geological field where Canada is rightfully known. Students should be made aware of the contributions of Canadian scientists within these areas.
- In teaching geology, and in particular about processes and structure, we have to teach in a way that is useful and meaningful. Though the principles are universal, we have to make them come alive, and there is no better way than to put it into the context of their own lives and integrate it with the Canadian scientific achievements.

Scientists seem to differ with teachers in one area of perception — that of the opportunity to provide a Canadian context within specific geology areas:

- No matter what the teacher's background there are abundant resources available to supplement for a Canadian context in the geology component of the Grade 8 earth science program. This includes opportunities for field trips.

2.2 Desirability and Relevance of Canadian Context

Very little of the interviews of scientists focused on the relevance and desirability of having Canadian context in geology education. Only one summary statement was gleaned from the transcripts:

- There is a definite need for literature and materials which presents geology in a Canadian context.

Of course this omission should not be construed as suggesting that the geologists were not supportive of Canadian context. Indeed, they were, as the summaries in Appendix XII testify. They seemed to take it for granted that such a context was both necessary and possible when they spoke of ways of enhancing geology instruction. Such support for Canadian context would be expected from scientists whose object of research is primarily the local, provincial and national scene.

2.3 Feasibility and Implementation of Canadian Context

In terms of directions and suggestions for feasibility/implementation for greater Canadian context in the geology component, scientists were quite direct with their views as this summary of their ideas indicates:

- Geology teachers should make better use of human resources available.
- Canadian context should be an integral part of university training, in particular for teachers.
- To effectively teach the geology component of the earth sciences, local, regional, national and ultimately world-wide examples must be used.
- For teachers to promote a Canadian context in earth sciences in geology the two major points which should be emphasized are the relevance of geology to the world that the student lives in and the background knowledge that teachers need to possess in this field to make geology exciting and interesting to students.

- Educators and scientists should work together to develop educational packages focusing on a Canadian context for geology which can be used in workshops throughout the province to assist the teachers to incorporate a Canadian context for geology in their classrooms.
- Teachers involved in geology programs should be given the opportunity to increase their knowledge which they may not have had the opportunity to get in their undergraduate training.

2.4 Usefulness of the Interview Information from Scientists

As the evidence in Appendix XII and Table 6 indicates, the three scientists interviewed in this study provided substantial information for enhancing the Canadian context in the teaching of geology. It is interesting to note that they focused heavily on actual ways of doing this in the classroom and also sensed the need to deal with implementation questions. The emphasis on the content and methodology of teaching geology obviously stems from the rich background and experience these people have in both the geology and the teaching of it.

It is also noteworthy that the scientists spoke about the special assistance practicing geologists can provide in enhancing the instruction in geology in general, and in a Canadian context in particular. Scientists indicated that they would be willing to help to develop educational packages focusing on a Canadian context for geology as well as assist in workshops throughout the province. The workshops also extend to their interest in providing more assistance in the pre-service training of teachers. This is best indicated by comments by the scientists themselves such as "I think it is possible for a team of geologists to formulate a very effective team that could really go to work in Alberta and lift geology up by the bootstraps and see the soles were made in Canada. The EDGEO program which came to Edmonton from Ontario, is an example that shows it can be done." (S20)

3. Science Educators as a Source of Information

Five Alberta science educators were identified to solicit information about teaching the geology component under study. One of these educators was a science education professor teaching general and physical science methods at a university; the other four worked for Alberta Education Regional Offices in the role of science consultants with responsibility for the in-service education of science teachers. A copy of questions (see Appendix XIII) for guiding the interviews was sent to each interviewee prior to the meeting. The information solicited in the interview focused on the application of the clue structure for Canadian context to science instructional materials, in particular that within the Grade 8 earth science geology component, the feasibility of implementing a methodology for assessment and improvement of science instructional materials for Canadian context, as well as perceptions of their role in encouraging and assisting teachers to assess and modify their instructional materials to include more of Canadian context. The information from the 51 pages of transcribed notes from the taped interviews was collated, summarized and included in Appendix XIII.

Though the researcher attempted to solicit information that was specific to the geology concepts in the Grade 8 science program in terms of enhancing the Canadian context in science instructional materials, virtually none was obtained. The suggestions offered by the science educators were very general and could not be applied to the specifics of teaching the content components. The suggestions did however speak to some of the areas in a round-about way by focusing on implementation of the science education within the Grade 8 science program as noted in the summaries. The value and effectiveness of this set of interviews will be discussed in the summary and critique at the end of the chapter.

3.1 Desirability and Relevance of Canadian Context

Science educators were very supportive of inclusion of Canadian context for science education:

- There is a need for a Canadian context for science education and we must respond to this.

3.2 Feasibility and Implementation of Canadian Context

Science educators spent most of the interview time discussing how one may be able to effectively promote a Canadian context in science education. Among appropriate vehicles mentioned for doing this were:

- A Canadian context for science education should be included in the school system in an interdisciplinary manner.
- A Canadian context for science education must be integrated and infused across the curriculum and all people working with the curriculum, whether they be teachers, authors of resource materials and textbooks, or curriculum developers, must all be aware of its presence.
- The teacher's delivery is still the essential point in the whole issue of delivery of science education in a Canadian context to the students.
- A Canadian context for science education should be built right into the frameworks and guides provided by Alberta Education to teachers.
- If we are to consider implementation of the Canadian context the key will be that teachers need information, resources, and education themselves.
- To promote effectively a Canadian context for science education, it must be integrated into the core materials being used and not left in a supplemental form.

4. Print and Non-Print Reference Materials as a Source of Information

The examination of the relevant print and non-print materials (guides, published instructional materials, periodicals, curriculum and instruction textbooks, geology related materials, etc.) was undertaken to provide a substantial resource package, which together with suggestions from the science teachers, scientists and science educators, can serve as a basis for enhancing Canadian context in the geology component of the Alberta Grade 8 earth science program (Stage IV). Criteria for selection of these resources included:

(a) suitability for grade level.

(b) Materials focus on Alberta/Canada rather than *in general* or American or British examples.

(c) Weaknesses and gaps identified in previous source of information discussed in this chapter, with attention being given to coverage of both the geology concepts and the elements of the clue structure.

(d) Provision of a variety of instructional activities and of both print/non-print resources.

Initially over 85 different print resources and 25 non-print resources, including slides, films, videos and investigation kits (i.e. rock samples) were looked at over a number of months. It became readily apparent that one could go on forever because there was so much information available. As expected, some of the resources were above or below the Grade 8 level. If one wanted, these could be included as they certainly can provide the teacher with an overview of the subject material or assist in developing a Canadian context at a different cognitive level and would therefore assist with remedial or enrichment components of the program. For the purpose of this study it was necessary to become more selective. In the end, 25 print resources (some of which are sets of materials such as the Kananaskis Country series) and 13 non-print resources, including slides, films and videos, and kits, were included as exemplars of the kind of materials to seek and utilize. The one area which is noticeably absent from the resource listing or the analysis is that of computer software. Reviews of computer courseware evaluations, including those provided by Alberta Education, revealed no computer programs which could make a significant contribution for enhancing the Canadian context in science education. If any have been developed, it must be on a local basis, and the researcher was not aware of these.

A listing of the materials studied for this purpose and a brief description of each are presented in Appendix XIV. The analysis is based on the concepts and sub-concepts of the Grade 8 geology components (see Appendix VIII) and coded with the elements of the clue structure for Canadian context which the teaching/learning activities cover. A count of the frequency of each element being addressed by the selected print and non-print materials is included in Table 6.

It is perhaps best to discuss the wealth of information for enhancing the Canadian context in the Grade 8 geology component from the point of view of the four selection criteria stated earlier for the print and non-print materials listed and analyzed in Appendix XIV. The matter of suitability for grade level was alluded to above, where it was indicated that materials would be included which might be too difficult for Grade 8 students but might be useful for the teacher.

Regarding criterion (b) above, a deliberate attempt was made to find both print and and non-print materials which focused on the Alberta/Canadian geological scene. It is gratifying to know that there is a wealth of such high quality material available. Prior to the identification of the materials to be included in this section of Stage III a perusal of the previous contributions made by the other sources of information in Stage III included in Table 6 revealed a number of areas which still lacked coverage or had the barest of coverage (one inclusion). These areas included elements 1.1.3, 1.1.5 *Interdisciplinary Nature of Science Education*; 1.2.1, 1.2.10, 1.2.11, 1.2.12 *Canadian Science Canadian Society Interaction*; 1.4.3, 1.4.4 *Philosophy Underlying Canadian Science*; 1.5.1 *Pure Science, Canadian Applied Science and their Interrelationship*; and *1.7.2, 1.7.3 Canadian Science Policy, Current Emphasis in Canada and Their Interaction.* Although the intent was to initially identify resources which would cover these gaps in the coverage, it soon became evident that the materials were so rich in opportunities for provision of Canadian context that all areas could be covered. Many of the resources could be used extensively under each of the geology concepts listed, in particular those that have been identified by the scientists. For example, in 1960 the Alberta Society of Petroleum Geologists embarked on a program of gathering and condensing all available geologic knowledge pertaining to Western Canada and Canada and synthesizing under it one cover. The results, contributed by nearly 40 geologists, were published in 1964 in a large Atlas called Geological History of Western Canada. This extremely technical volume is constantly referred to by geologists working in Western Canada. Unfortunately, although the book is a comprehensive work on the geology of the country, the very technical language dissuades its use by the layman or the teacher. The Face of Time written by Samuel Nelson attempts to take the very specialized body of knowledge contained in the Geological History of Western Canada and translate it to the form understandable to a layman. This atlas is particularly aimed at teachers who are instructing various levels of geology in the schools. In its discussions and presentations, everything from minerals, geologic time, the mountains and the plains, economic geology and fossils are discussed. In discussing economic geology, mineral deposits of Western Canada including potash deposits of Saskatchewan and mineral fuels, the concepts are presented in a manner which draws upon all the elements of Canadian context presented in the clue structure. When one finishes with material such as this, it is hard not to be aware of Canadian context. A similar case was found with the Color Slides of Canadian Geology produced by the Alberta Society of Petroleum Geology which provides the teacher with key examples throughout Canada for all of the geology concepts identified in Appendix VIII. This readily available s: is accompanied by a well-documented description of each slide.

In terms of availability of these materials to the teacher, one has only to look in the school library for readily available resources which promote all aspects of Canadian context for science education in the earth sciences. Alberta: A Natural History produced by Hurtig Publishers from Edmonton was developed by Alberta Education and provides a wealth of information for the teacher to describe the 2-1/2 billion years of history of Alberta inscribed in the rocky framework of the landscape in relevant and interesting ways to captivate the attention of any student. It should be noted that all films and video films in this study are available in Alberta through ACCESS.

Criterion (c) above is related to the gaps or weaknesses in coverage of Canadian context in the materials prescribed for Grade 8 geology and which were analyzed in Stage II. When one looks at Table 6 and the impact that the analysis of the print and non-print materials as a source of information has on the coverage of all elements, the following are noted:

- Coverage of each of the components far exceeds the contributions made from any other source except in the case of component 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context.* Since basically Canadian produced materials were used in the analysis, there was no emphasis in this area, yet component 2.2 *Canadian Science Instructional Materials* coverage moved from none at all with the survey of science teachers to 129 inclusions.

- There were a number of areas where it was more difficult to provide good coverage even though some coverage was provided. These included elements 1.2.2, 1.2.11, 1.2.12 (under *Canadian Science - Canadian Society Interaction*) and 1.4.3, 1.4.4 (under *Philosophy Underlying Canadian Science*). These were aspects of the decision-making processes for resolving science related social problems, ethics and values, social conscience and the role of the student in future Canadian society. It would appear that these are areas that a teacher must make a conscious effort to provide a context within which these elements could be covered.
- It is apparent that certain concept areas lend themselves better to inclusion of many elements. These concept areas are E8.1 *Materials from the crust have had an important part influence on mankind's daily living* and E8.2 *Evidence for determining the past history of the earth comes from a study of the crust.* This is quite noticeable in looking at the analysis provided in Appendix XIV.
- As the analysis of the print and non-print materials unfolded and the researcher identified the elements of the Canadian context which were related to the suggestions and information provided, three patterns or relationships began to emerge. Where materials were identified as having promoted element 1.6.1 *promotion of inquiry as a major element in what many refer to as scientific literacy*, then element 1.6.2 *promotion of learning of science as inquiry* would follow naturally. Similarly where element 2.1.1 *encouragement of students to relate abstract knowledge to concrete situations which they have encountered* was present, so were elements 2.1.2 *provision of opportunities for experience and examples which will serve as concrete illustrations and reinforcement of the science concept being learned*, 2.1.3 *development of an understanding and appreciation of the natural and social world in which the students live* and (generally) 2.1.4

application of basic scientific laws and concepts to the study and understanding of the students' immediate environment. Probably the most striking case of this kind of relationship occurs in component 2.2 *Canadian Science Instructional Materials*. In all cases the presence of element 2.2.1 *inclusion of local or nationally produced instructional materials which contain Canadian content that students can relate to their own life and their environment* involves elements 2.2.2 *inclusion of locally or nationally produced instructional materials which include, wherever relevant, information on Canadian science and scientists, the Canadian science Society interrelationship, etc.* and 2.2.3 *inclusion of locally or nationally produced instructional materials which are of high quality in terms of content selection, organization and presentation.*

Criterion (d) mentioned above for selection of print and non-print resource materials focuses on variety of resources and instructional activities incorporated in them. As was mentioned earlier, the researcher could deal with only a fraction of the materials identified. Obviously, each new useful resource would add to the potential for enhancing the Canadian context in the geology component of Grade 8 science. The matter of a variety of instructional activities is however of some concern here. It is evident from the material that laboratory work, field trips and audio-visual materials have a profound impact on enhancing the Canadian context in science programs. It was also found that those materials which were rich in inquiry oriented exercises (for example CRIB) not only assisted in development of Canadian context, but they were also excellent for developing problem solving skills and critical thinking abilities which assisted in providing coverage for those elements which in most cases were difficult to do so.

5. Summary and Critique of Stage III

In terms of methodology, Stage III (procedure for collecting information for enhancing the Canadian context in science instructional materials) revealed its crucial role in any attempt to enhance the Canadian context in any science area.

A critical comparison of the information provided by each of the four sources would indicate the following emphasis:

- The science teachers had something to say about each of the categories of information identified: specific suggestions regarding the teaching of the geology concepts, desirability and relevance of a Canadian context in geology education, and feasibility and implementation of a Canadian context in science.
- The geologists had much to offer in the way of instructional ideas and some ideas on implementation in which they perceived themselves to have a role.
- The science educators contributed mainly ideas on implementation. It is not surprising that they did not dwell on the desirability and relevance since they were involved in Stage I and perhaps had little more to add in this regard.
- The print and non-print resources that were selected focused entirely on the teaching of geology. Undoubtedly there are materials that might also speak to the question of desirability and implementation, but the researcher did not seek this kind of information in this stage.

Science teachers as a source of information did not provide the quantity or quality of information anticipated, considering the survey included all Grade 8 earth science teachers in the province. The areas covered in terms of elements of Canadian context were similar to those where emphasis was placed by the primary resources in Stage II. This may be an indication that teachers had taken most of their ideas from the prescribed sources and some ideas from other sources, with little that was "invented" by them. This might be attributed to lack of experience with this subject matter, teacher preparation (pre-service and in-service), preferred emphasis on other science subject matter and previous lack of emphasis on earth science. The questionnaire survey did not really help to fill in the gaps or shore the weaknesses identified in Stage II. In terms of the way the survey was done (the considerable expenditure of effort and finances to conduct it in relation to the low quantity and quality of responses) it certainly cannot be considered to be cost effective.

Similarly, the interview of science teachers did not reap the kind of preferred information expected. There may be a number of reasons for this. First the survey may not be the best selection process with which to identify teachers for the interviews. In some cases the ideas put forward in the questionnaire by teachers were interpreted by the researcher to be the starting point for discussion when in actuality they may have been the total contribution available from them. The interview would then be used by the teacher as an opportunity to reinforce one or two pet areas, or focus on their concerns on desirability and implementation. A second downfall may have been the interview technique itself. Though attempts were made to direct specific questions to the concepts and elaboration of the information provided by the teachers in the survey, the interviewer may still have been too much in a mode of thought which was indicative of Stage I (the refinement and further validation of the clue structure). Though this was not done consciously, it may have affected the interview technique where in order to get the teachers to go beyond the written comments on which they were selected, the interviewer felt that it was necessary to begin on a much broader base. The researcher should have been more persistent in drawing the focus back of the interviews back to the teaching of specific concepts.

The use of science teachers for collecting information cannot be considered a failure. It did indicate that the teachers in the main were using the prescribed resources, and also pointed out where there are gaps in coverage regarding a Canadian context for science education in terms of actual classroom practice. Whether a sampling of teachers as opposed to blanket coverage by the questionnaire would have provided the same kind of input can only be surmised. Identification of a suitable sample in order to get the same kind of results from the survey would be difficult unless administrators and those knowledgeable of what teachers are doing in their classrooms were willing to put forward names of teachers they felt could make valuable contributions. Such a sampling procedure would also be arduous and cumbersome and would probably not be more productive than the one used in this study.

The interview of scientists proved to be an abundant source of information. In many ways the structure of the interview actually started broader than that with the teachers yet very quickly tended to focus more on the elaboration of Canadian context opportunities in the geology program than the previous interviews. Not only did this information help to provide coverage for elements previously not referred to, they also opened a number of different avenues of investigation regarding print and non-print materials at the end of Stage III. No changes would be suggested for the actual interview with scientists as this approach proved to be very successful. However, adding more scientists to the sample being interviewed should be considered as part of Stage III methodology, to see at what number one would encounter the law of diminishing returns in information. Some attention needs to be given to ascertain that each scientist is not only highly knowledgeable in his field as it relates to teaching science in the Canadian context, but also has some knowledge of pedagogy and a desire to see instruction in the schools improved. For the purpose of selection, it might be useful to first circulate for response a questionnaire of the type used with the science teachers.

Science educators proved to be the least valuable source of information for this stage of the methodology. Two reasons are offered for this situation. First, it may be that the "wrong" people were selected, especially if they had no or little *recent* experience in the teaching of Grade 8 science, or had a weak or no academic background in geology. Second, four out of five science educators had professional responsibility for the implementation of the mandated science curricula and the improvement of science instruction. Hence, it is not surprising that most of their comments were about feasibility and implementation and nothing on the teaching of geology. Whatever the reason, in terms of productivity related to the methodology and of time and effort, this source of information cannot be identified as being helpful in this study in overcoming the weaknesses and gaps identified in Stage II prior to Stage IV. Undoubtedly there are science educators at universities, in school systems and government agencies who could make an important contribution. A method has to be devised to identify them.

Print and non-print reference materials as a source of information proved to be the most useful in overcoming the weaknesses and gaps in instructional resources identified in Stage II. The main drawback to the use of this source of information is its labor-intensiveness and consumption of time. If a more exhaustive search and evaluation of print and non-print resources was to be made it would require a collective effort of teachers of the type worked out in practice for the Curriculum Resources Information Bank (CRIB) by Nay et al. (1971).

The method of collating and reporting the information for enhancing the Canadian context in Grade 8 geology seems to be satisfactory. For the sake of manageability and clarity it is important to use a consistent double classification scheme in Stages II, III and IV, namely, the geological concepts to be taught in Grade 8 and the related elements in the clue structure for a Canadian context that the specified sources of instructional information address. The emphasis given to each of the elements is graphically revealed in a table (such as Table 6), with any remaining gaps and weaknesses in coverage quickly detected. This tabulation also gives a quasi-quantitative indication on the relative merits of each source of information for enhancing Canadian context.

Before closing this critique, attention should be focused on the implementation question that was raised by science teachers, geologists and science educators. Undoubtedly, any kind of method for enhancing the Canadian context in science education that is solely based on teaching techniques and resources may not make much headway in the classroom unless attention is given to the implementation of ideas. This matter will be considered again in Stage V.

CHAPTER VI

STAGE IV: PROCEDURES FOR ENHANCING THE CANADIAN CONTEXT IN SCIENCE INSTRUCTION

1. Introduction

The main purpose of this stage of the methodology is to identify and describe specific procedures for enhancing Canadian context in instructional materials. The intent is not to present a comprehensive treatment of these procedures but rather to sketch them and illustrate how the assessment of the Alberta Grade 8 geology component (Stage II) and the compilation of information in Stage III can be used. On the basis of this study and knowledge of how curriculum change and instructional improvement occur, the following procedures are identified:

1. Making information available to teachers on a variety of instructional materials which focus heavily on Canadian context. In this procedure, the onus is on teachers to access and become acquainted with these suggested materials and use them as they see fit (e.g., by substitution and supplementation of the prescribed resources).
2. Enhancing the mandated curriculum for Canadian context by an official revisions committee (composed mainly of teachers), set up either by the Department of Education and/or a school system. The objective of this committee would be to provide classroom teachers with a resource guide for injecting greater Canadian context into the mandated curriculum. A "special" case of this procedure would be the Canadianization of adopted textbooks from foreign countries.
3. Development of an entirely new science course to replace the old one, based on the clue structure for a Canadian context in science. Again this would be a task assigned to a curriculum committee (composed mainly of teachers) with the objective being to make available a complete program to teachers.

In addition to sketching the above mentioned procedures for enhancing Canadian context, a few exemplars of each are included in Appendix XV. In presenting these exemplars, an attempt is made to address the following factors:

1. Filling in the perceived gaps and strengthening the weaknesses in coverage of the elements in the clue structure (Stage II data). No attempt will be made to cover all of the gaps and weaknesses, but an attempt will be made to provide an exemplar or two to cover elements which are not covered even by the Stage III information.
2. Enhancing the Canadian context in the instruction of those geology concepts which have not been adequately covered for Canadian context in Stages II and III.
3. Using a variety of teaching methods and instructional materials. The intent in the design of these materials is to have the students involved actively. Therefore an attempt is made to have a good balance of laboratory activity, field trips, audio-visual aids, research reports, discussions and so forth.
4. Attempting an appropriate balance between local focus, provincial focus and national focus.

2. The Use of Stage II and Stage III Results

In Stage II an assessment was made of the extent to which the two mandated textbooks and the suggested resource material covered the elements of the clue structure for a Canadian context in science. This assessment is summarized in Table 5. It is quite evident that the coverage for Canadian context is not very good. Knowledge of this inadequate coverage should be valuable to a teacher of Grade 8 science if he or she attempts to enhance the Canadian context in the geology component.

In Stage III, a search was made for teaching activities and resources that would help cover some of the gaps and weaknesses of coverage by the mandated textbooks and associated resources. Two of the sources tapped (geologists and print and non-print materials) were very productive, as is testified by the summary of additional elements of the clue structure covered (see Table 6). Undoubtedly, this additional instructional information would be most useful to a Grade 8 teacher of science who is embarking on a greater Canadian emphasis.

A teacher who wishes to have a greater Canadian emphasis in the geology component of Grade 8 science should know how the resources dealt with in Stages II and III cover Canadian context collectively. A graphic indication of this is obtained by combining the data in Tables 5 and 6 to give Table 7. Note that the geology concept rather than the source of information is one of the variables. For purposes of combining the two tables, the cut-off in the frequencies in Table 5 is at *somewhat evident* (SE). Totals are given for coverage of all 56 elements for each concept, and for all 11 concepts for each element. This gives a total of 616 cells in Table 7.

In discussing the salient features in Table 7 the following arbitrary scale is used to define adequacy of coverage of both geology concepts and Canadian context elements: *very adequate* where a cell has more than two inclusions, *adequate* where a cell has one or two inclusions, and *none* where a cell has no coverage of any kind. The justification for this scale is that the first category offers a teacher or a curriculum developer some choice in selecting activities covering that cell. The *adequate* category does not give much choice but the cell can be covered. The last category is obviously a most undesirable one, and would require a teacher or curriculum developer to make a further search for activities to cover the cell or "invent" some.

According to the above scale, there are 223 cells which are *very adequate*, 207 which are *adequate* and 186 which have *none*. This is roughly one third of the cells in each category. This of course means that any exemplar presented in this study based on curriculum data analyzed in Stages II and III will not address those combinations of geology concepts and elements of the clue structure for which no activities were found. In spite of this limitation, there is more than ample information on which to devise exemplars.

Before leaving Table 7, a few more salient features should be noted:

1. A perusal of the cells in Table 7 shows that every geology concept is covered to a substantial degree by the materials analyzed in Stages II and III. There are, however, "pockets" of inadequacy; in particular, for

TABLE 7

Summary of Coverage of the Clue Structure in Relation to the Geology Concepts in Grade 8 Science Using Stage II and Stage III Data

Geology Concepts	Frequency of Elements Covered by Instructional Activities									
	COMPONENT 1.1									
	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	1.1.9	**Total**
C.8.7(1) Common minerals in Earth's crust	1		1	3	1	3	3		6	**18**
C.8.7(2) Rocks are formed from minerals			1	1			1	1	3	**7**
C.8.7(3) Rocks can be classified into three groups	2	2	2	5		4	5	7	13	**40**
C.8.8(1) Landforms are caused by movement in the crust	1	1	3	1		1	2	2	5	**16**
C.8.8(2) Weathering weakens rocks		1	1				1		6	**9**
C.8.8(3) Erosion changes the landforms	1	2	2	1		1	3		12	**22**
C.8.8(4) Dynamic processes within the Earth	2	3	5	2	2	1	3		4	**22**
E.8.1(1) Fossils are important economically	4	1	2	5	1	5	6		4	**28**
E.8.1(2) Exploitation of resources must be managed	3	1		4		4	5	3	2	**22**
E.8.2(1) Age of Earth can be determined from study of crust	2	1	1	1		1	1	4	4	**15**
E.8.2(2) Fossils are used in study of Earth's history	6	3	5	4	3	7	3	7	10	**48**
Total for all Concepts	**22**	**15**	**23**	**27**	**7**	**27**	**33**	**24**	**69**	**247**

TABLE 7 (cont'd)

Geology Concepts	Frequency of Elements Covered by Instructional Activities												
	COMPONENT 1.2												
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7	1.2.8	1.2.9	1.2.10	1.2.11	1.2.12	**Total**
C.8.7(1) Common minerals in Earth's crust			1	1	3	2	2	1	1				**11**
C.8.7(2) Rocks are formed from minerals					1		1	3	1				**6**
C.8.7(3) Rocks can be classified into three groups				1	2	6	3	17	2	1			**32**
C.8.8(1) Landforms are caused by movement in the crust			1	1		2	2	11		1	1	2	**21**
C.8.8(2) Weathering weakens rocks	1				1			7					**9**
C.8.8(3) Erosion changes the landforms	1	1		2	1	1	1	15		1			**23**
C.8.8(4) Dynamic processes within the Earth				1	1	4	2	4					**12**
E.8.1(1) Fossils are important economically	1	3	4	4	6	6	2	3	4		1	1	**35**
E.8.1(2) Exploitation of resources must be managed	2	1	4	4	5	4	2	2	3	1	2	2	**31**
E.8.2(1) Age of Earth can be determined from study of crust	1							9		1			**11**
E.8.2(2) Fossils are used in study of Earth's history	4	3	4	3	7	6	6	11	2	1	2	2	**51**
Total for all Concepts	**10**	**8**	**14**	**17**	**27**	**31**	**21**	**83**	**13**	**6**	**6**	**7**	**243**

TABLE 7 (cont'd)

Geology Concepts	Frequency of Elements Covered by Instructional Activities									
	COMPONENT 1.3					COMPONENT 1.4				
	1.3.1	1.3.2	1.3.3	1.3.4	**Total**	1.4.1	1.4.2	1.4.3	1.4.4	**Total**
C.8.7(1) Common minerals in Earth's Crust	2	2	2	2	**8**	6	1			**7**
C.8.7(2) Rocks are formed from minerals					**0**	4				**4**
C.8.7(3) Rocks can be classified into three groups	2	3	4	2	**11**	12				**12**
C.8.8(1) Landforms are caused by movement in the crust	3	1	2	4	**10**	10	3		1	**14**
C.8.8(2) Weathering weakens rocks					**0**	10	1			**11**
C.8.8(3) Erosion changes the landforms	1			2	**3**	10	2		1	**13**
C.8.8(4) Dynamic processes within the Earth	4	5	3	4	**16**	8	5	2		**15**
E.8.1(1) Fossils are important economically	1	1	3	3	**8**	6	1		1	**8**
E.8.1(2) Exploitation of resources must be managed			2		**2**	2	1		2	**5**
E.8.2(1) Age of Earth can be determined from study of crust	1	2	1	2	**6**	4	1			**5**
E.8.2(2) Fossils are used in study of Earth's history	5	5	4	5	**19**	9	2	3	5	**19**
Total for all Concepts	**19**	**19**	**21**	**24**	**83**	**81**	**17**	**5**	**10**	**113**

TABLE 7 (cont'd)

Geology Concepts	Frequency of Elements Covered by Instructional Activities										
	COMPONENT 1.5						COMPONENT 1.6				
	1.5.1	1.5.2	1.5.3	1.5.4	1.5.5	**Total**	1.6.1	1.6.2	1.6.3	1.6.4	**Total**
C.8.7(1) Common minerals in Earth's crust	1	2		1		**4**	3	5	2	2	**12**
C.8.7(2) Rocks are formed from minerals				1		**1**	4	4			**8**
C.8.7(3) Rocks can be classified into three groups	3	4	2	3	4	**16**	12	13	2	3	**30**
C.8.8(1) Landforms are caused by movement in the crust		1	2		4	7	9	10	1	1	**21**
C.8.8(2) Weathering weakens rocks		1	1	1	2	5	7	8			**15**
C.8.8(3) Erosion changes the landforms	1	2	4	4	3	**14**	15	13	2	2	**32**
C.8.8(4) Dynamic processes within the Earth		1	1	2	2	**6**	4	5	3	2	**14**
E.8.1(1) Fossils are important economically	3	2	3	4	1	**13**				1	**1**
E.8.1(2) Exploitation of resources must be managed		2	1	3		**6**				1	**1**
E.8.2(1) Age of Earth can be determined from study of crust		2			1	**3**	6	8	3	1	**18**
E.8.2(2) Fossils are used in study of Earth's history	3	4	4	4	2	**17**	6	7	6	7	**26**
Total for all Concepts	**11**	**21**	**18**	**23**	**19**	**92**	**66**	**73**	**19**	**20**	**178**

TABLE 7 (cont'd)

Geology Concepts	Frequency of Elements Covered by Instructional Activities											
	COMPONENT 1.7					COMPONENT 2.1						
	1.7.1	1.7.2	1.7.3	1.7.4	**Total**	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	**Total**
C.8.7(1) Common minerals in Earth's crust	3			2	**5**	5	4	7	4			**20**
C.8.7(2) Rocks are formed from minerals				1	**1**	3	2	3	3			**11**
C.8.7(3) Rocks can be classified into three groups	2			4	**6**	10	15	18	10		1	**54**
C.8.8(1) Landforms are caused by movement in the crust		1		3	**4**	11	9	14	8	1		**43**
C.8.8(2) Weathering weakens rocks					**0**	11	9	9	5	1		**35**
C.8.8(3) Erosion changes the landforms				2	**2**	14	14	14	5	2		**49**
C.8.8(4) Dynamic processes within the Earth	2		1	1	**4**	4	2	4	3			**13**
E.8.1(1) Fossils are important economically	5	2	2	8	**17**	2	2	2	3	4	2	**15**
E.8.1(2) Exploitation of resources must be managed	3	3	2	5	**13**		2	1	1	3	5	**12**
E.8.2(1) Age of Earth can be determined from study of crust		2	1	1	**4**	9	10	6	6	1		**32**
E.8.2(2) Fossils are used in study of Earth's history	5	4	2	5	**16**	6	10	8	8	6	3	**41**
Total for all Concepts	**20**	**12**	**8**	**32**	**72**	**75**	**79**	**86**	**56**	**18**	**11**	**325**

TABLE 7 (cont'd)

Geology Concepts	Frequency of Elements Covered by Instructional Activities										
	COMPONENT 2.2				COMPONENT 2.3			COMPONENT 2.4			
	2.2.1	2.2.2	2.2.3	**Total**	2.3.1	2.3.2	**Total**	2.4.1	2.4.2	2.4.3	**Total**
C.8.7(1) Common minerals in Earth's crust	3	3	3	**9**			**0**	1	2	1	**4**
C.8.7(2) Rocks are formed from minerals	1	1	1	**3**			**0**			1	**1**
C.8.7(3) Rocks can be classified into three groups	7	6	6	**19**			**0**		4	4	**8**
C.8.8(1) Landforms are caused by movement in the crust	5	4	4	**13**			**0**	1	3	2	**6**
C.8.8(2) Weathering weakens rocks	3	3	3	**9**			**0**	1	1		**2**
C.8.8(3) Erosion changes the landforms	7	6	6	**19**			**0**	1	2		**3**
C.8.8(4) Dynamic processes within the Earth	4	4	4	**12**			**0**				**0**
E.8.1(1) Fossils are important economically	3	3	3	**9**			**0**	3	2	2	**7**
E.8.1(2) Exploitation of resources must be managed	1	1	1	**3**			**0**			2	**2**
E.8.2(1) Age of Earth can be determined from study of crust	4	4	4	**12**			**0**	1		1	**2**
E.8.2(2) Fossils are used in study of Earth's history	5	5	5	**15**			**0**	3	2	2	**7**
Total for all Concepts	**43**	**40**	**40**	**123**	**2**	**2**	**2**	**11**	**16**	**15**	**42**

concepts C8.7(2) **Rocks are formed from minerals** for clue structure components 1.3 *History of Canadian Science*, 1.5 *Pure Science, Canadian Applied Science and Their Interrelationship*, 1.7 *Canadian Science Policy, Current Emphasis in Canada and Their Interaction*, 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context*, and 2.4 *Problems of Regionalism*; C8.8(2) **Weathering weakens rocks** for component 1.7 *Canadian Science Policy, Current Emphasis in Canada and Their Interaction*, and 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context*; C8.8(4) **Dynamic process within the Earth** for components 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context* and 2.4 *Problems of Regionalism*; E8.1(2) **Exploitation of resources must be managed** for components 1.3 *History of Canadian Science*, 1.6 *Science as Inquiry*, and 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context.*

2. Component 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context* is very poorly covered by the materials analyzed in Stages II and III for all eleven geology concepts. This was probably due to the emphasis given to component 2.2 *Canadian Science Instructional Materials* when tapping the various sources of information in Stage III. In addition, there are also isolated elements within components that were not covered, especially the following: *1.1.5 use of science to assist students in developing their perspectives of national identity and the role of science in defining that identity; 1.2.2 study the effects (ills and benefits) that science and technology have on the Canadian workplace; 1.2.10 attention to the scientific, technological and social problems facing Canada and the world and the ways of resolving these issues; 1.2.11 attention to the various points of view concerning processes of decision making for resolving*

science related social problems; 1.2.12 attention to the variety of roles that high school students as adults will play in the future Canadian society and how science can prepare them for those roles; 1.4.3 investigation of questions of values and ethics related to science without feeling threatened; and 2.1.6 development of commitment to the careful use of natural resources in their locality and to the preservation and improvement of their environment.

3. Procedures for Enhancing the Canadian Context in Science

The three procedures identified in the introduction are now discussed in detail.

3.1 Making Information Available to Teachers on Resource Materials for Enhancing Canadian Context

Teachers rely heavily on resource materials in their teaching. Primarily, this reliance is on prescribed textbooks and suggested supplementary materials if they are available. They do not have the time and energy, usually, to search for additional materials. However, they are receptive to new information on the teaching of a subject. The survey of science teachers and the follow-up interviews of selected teachers in Stage III confirms this position.

In Stage III the researcher showed how information could be obtained for enhancing a curriculum emphasis, in this case the Canadian context. The geologists and print and non-print materials were especially fruitful sources of information for teaching Grade 8 geology. The researcher decided to put the information in Appendix XIV into a resource package and make it available to teachers. The package covers both the core and elective parts of the geology program. It is not included as an appendix, partly because it is repetitious of Appendix IV and partly because of its bulk.

In putting together this package, feasibility of implementing the activities in Grade 8 geology was constantly kept in mind. Specific attention focused on ensuring that all films and video films used were readily accessible through

ACCESS (or regional film libraries), that the kits mentioned were available through School Boards (if they were not already in the classroom) and that activities suggested could actually be carried out including field trips where applicable. Sixty-six suggestions for implementation were included.

3.1.1 Validation of Resource Information by Teachers

The researcher decided to get the reaction of teachers to the information gathered in Stage III which was incorporated into the resource package. The six earth science teachers who were interviewed in Stage III were asked to "validate" the ideas in the resource package. The focus of the validation was not on the support given by the teachers or necessarily on the relevance or desirability of each specific suggestion - this question was already settled in Stage I on the basis of the clue structure. Rather, the validation focused on such dimensions as feasibility of implementation of each suggestion, determinants underlying the implementation of each suggestion, suggested modifications to improve potential for implementation, alternate methods of presentation in the classroom, and so forth. This validation exercise also gave the researcher insights as to how the teachers felt about his suggestions and what they were prepared to do about them in their own classroom. The teachers are the ones that provide the starting point for discussion of implementation and the value of each of the suggestions in terms of the courses they teach. Geologists and science educators cannot do this.

Each of the six teachers was provided with a copy of the resource package, allowed sufficient time for a critical reaction and then interviewed to obtain their critical reaction. Since some of the materials referred to in the package were not easily reproducible or were the researcher's only copy (such as the The Face of Time, Color Slides of Canadian Geology and The Prospector's Set of Rock Chips) these materials were shown to the teachers during the interview and discussed at that time. Other information was provided as well during the interviews. Tapes were made of the interviews and were transcribed. The response by the teachers was overwhelmingly favorable, but the interviews did little to provide critical reaction to the suggestions. This validation feedback from the interviews is summarized and classified below in a similar manner to that in earlier stages.

3.1.1.1 Desirability and Relevance of Suggestions The following points were evident in the interview data:

- There was unanimous support for all the suggestions provided. Because of each of the teacher's own interests in the geology component they could perceive few difficulties in implementing the suggestions. This was evident in comments such as "Wow! I wish I had this material earlier in the year. My job would have been a lot easier", and "Great stuff!".
- Each of the validators supported a view of ownership of the suggestions provided. Because they had participated in earlier stage of this process, they were eager to begin to modify and implement the suggestions provided though comments such as "I can't wait to adapt a lot of these things" were not followed by specific comments as to how they would modify or adapt. This reinforced the idea that teachers cannot be expected to develop resources, materials in the curriculum without a framework or guidelines to help their activity.
- In terms of the greatest support for any of the suggestions offered, all of the teachers interviewed requested a copy of Color Slides of Canadian Geology produced by the Alberta Society of Petroleum Geologists.

3.1.1.2 Feasibility and Implementation of Suggestions The following points were made in the interviews:

- Validators identified an activity oriented approach as a major way to implement and enhance a Canadian context. There was overwhelming enthusiasm for identification of field trips and outings making use of human and physical local resources. This enthusiasm regarding field trips was present in each of the cases where this was discussed, balanced by a realistic view of financial and time constraints. Once provided with examples, many of the teachers had aspects come to mind which they could use for their local area. This is shown by "We could easily do this down at the river bottom" or "We might have to combine our classes, but I don't see why we couldn't use a field trip in that section."
- Validators expressed the view that for most teachers the expanded and upgraded materials would have to be provided with specific curriculum documents from Alberta Education directing their use as shown by "If you wanted these suggestions to be used, then you have to get someone higher up to say, this is what has to be taught. This is what has to be covered."
- Validators considered application of the concepts to the students' own immediate environment to be the suggestion easiest to implement as supported by statements such as "most of this could be done in our own schoolyard" or "it may be difficult to get away for longer field trips, but there

is certainly nothing stopping us from going out in our own neighborhood."

- The necessity for a teacher to feel comfortable with the materials or suggestions provided became increasingly evident. This comfort would be based on the teacher's background knowledge within the area and the familiarity with the process being used. An example of this was a field trip from Lethbridge to Crowsnest Pass which had been included with its accompanying pictures as an opportunity for teachers to integrate most of the concepts covered in a one day outing with their students. The materials provided a comprehensive guide for students including questions relating to specific phenomena encountered on their trip as well as background material and information for the students. Respondents were wholly supportive of the field trip material and were eager to use it in a similar package themselves as shown by "I love this! You don't happen to have one for the Edmonton area do you?" In all cases, however, they would request a workshop which would allow them to accompany someone who had considerable knowledge of the area and that could respond to questions that might arise on the trip. Once they had gone through the trip with the resource person in this manner, they could feel competent that they could then share the experience with their students. "I love to do something like this after I came out with you and walked through it."

- Respondents expressed concern that if each of these suggestions were to be implemented, it would be necessary to provide in-service opportunities which would bring scientists who could serve as local resource persons, educators familiar with the processes used, and the teachers together. Once teachers were familiar with the materials and resources supplied, it would be necessary not only to assure that the materials are available, but that they were actually provided to the teacher. This is shown by "If it was done similar to the EDGEO program with its accompanying workshops and super resource people, then like myself most of the teachers would feel comfortable enough and confident in coming back and implementing these things in our programs."
- Respondents made reference to one of the components of a Canadian context *2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context.* Teachers were quite clear in their preference for having a Canadian text printed rather than seeing foreign materials adapted and supplemented. This is shown by "Teachers really get tired of having to adapt, modify and supplement for the whole class. We have to do enough of that to meet the individual needs of students within our classrooms. If it's important enough to ask us to modify the materials we used, then it should be important enough to build the darn things right into the prescribed text given to us by Alberta Education."

- The respondents thought implementation of enhancement of Canadian context in science would be facilitated by a delivery format similar to that of the Curriculum Resources Information Bank (CRIB) (Nay and Associates, 1972; Nay, 1973, 1978; Ryan and Nay, 1980, 1985; Merrill, 1982). The teachers were very supportive of a system which would provide a detailed background of each concept, alternative methods for teaching the concept, and descriptions of the materials that may be used to assist in their instruction. In this way the Canadian context components would be built right into the materials. "If this was written in the form of lessons plans, even beginning teachers would be very receptive to the implementation of the materials."

3.1.2 The Curriculum Resources Information Bank (CRIB) Procedure

CRIB has been mentioned several times in this study. It has great merit in that it is a collective way, as opposed to an individual one, for searching for, assessing and organizing instructional resources in any subject for any grade level. It is a teacher-based curriculum dynamic. It suggests methods of storage, retrieval and dissemination of curricular information, including the use of personal computers.

The CRIB project began in 1969 as a cooperative venture of junior high school science teachers in the Edmonton Public School System and members of the Department of Secondary Education at the University of Alberta. Details of this dynamic have been given elsewhere (Nay and Associates, 1972; Nay, 1973, 1978; Ryan and Nay, 1980, 1985; Merrill, 1982). Its purpose was "to provide science teachers with ready access to a great variety of teaching resources or information about them, and as a consequence to engender continual rational change in the science curriculum" (Nay, 1973, p.4). The CRIB, for any junior high science area, consists of five sub-banks which may be described as follows. The "Mastercard" sub-bank lists all the curriculum resources in the other four sub-banks according to scientific concept. The "Content Detail" sub-bank provides teachers with background knowledge and with specific references for getting more background knowledge. The "Lesson Plan" sub-bank includes investigations in lessons which were developed by Edmonton teachers and is separated into information that is for the use of the teacher only (LP-T) and that which could be used directly by the students (LP-S). The "Audio-Visual Aids" sub-bank contains information on all types of film material, overhead transparencies, printed materials, models, etc. relevant for teaching the given concept. The "Problems and Test Items" sub-bank is, in effect, a test item bank. In terms of retrieval, the information in the five sub-banks is cross-referenced and printed on keysort cards. Cards are retrieved by the teacher by selecting the appropriate coded cards and using a "needle and shake" method of selection. Besides the sub-bank coding, physical science content for the junior high school curriculum was organized according to three subdivisions, namely Major Area, Concepts, and Sub-Concepts.

In terms of success of the project, evaluations showed that every junior high school in the EPSB system had a copy of each bank produced and that, on average, two-thirds of teachers' lesson-planning was based on the information in the banks. Although teachers certainly wanted to access the banks, the feedback aspect which was to provide for continual revision and expansion of the banks did not materialize. As in the case of many similar curriculum projects, it appears that financial and administrative conditions have prevented province-wide involvement up to this time. The perceptions of the role of the teacher within the CRIB project are consistent with the directions indicated for teachers in Stage III of this study. That is, a teacher first looks to a resource bank for information which best suits his purposes and facilities, and uses this material either in its original or in a modified form. As the teacher's understanding of the potential and dynamics of the resource bank increases, he is then in a position to offer critical feedback in terms of the specific information used, how it was used, its quality and suitability for a specific grade level, and possibly, how it relates to materials previously used by that teacher. Ultimately the teacher is then in a position to join a resource bank curriculum writing committee, similar to that involved in CRIB project.

The CRIB approach includes a dynamic in which each of the stakeholders in science education provides that input which he or she is capable of giving, by virtue of professional academic background and experience. Hence, a role definition of these stakeholders would indicate that practicing teachers would be responsible to develop and update the curriculum banks, in which the available print and non-print resources are incorporated as well as information from practicing scientists who act in a consultative capacity. The role of science educators would be to help organize the curriculum information, and improve its instructional quality by incorporating accepted science education theory and practice. If the researcher's methodology was used as a basis for developing a curriculum bank on teaching science in Canadian context, then science educators would be involved in the updating of the theoretical perspective and the associated clue structure.

From the feedback indicated in Stage III of this study, the Curriculum Resources Information Bank procedure is one very viable approach to enhancing Canadian context in science instructional materials. It would be necessary to include the strategies indicated by Nay (1973), which include development of an in-service program which takes into account teachers' perceived professional needs, continual revision and expansion of the information in the banks to maintain teacher interest, study of the feedback dynamics and inclusion of this in the in-service work and curriculum-writing activity, steps to increase the support and assistance of administrators and support services, and development of effective methods for involving an increasing number of teachers in curriculum writing both during and outside of class time. If these strategies were assured, a Canadian context for science education would become a strong component of science classrooms, at least for those participating in this kind of project.

3.2 Official Enhancement of Canadian Context in the Mandated Curriculum

In both the previous procedure and the one being discussed now, the assumption is made that the mandated science curriculum is not to be replaced for a while. Therefore the avenue for enhancing Canadian context in the current Grade 8 geology component is by supplementation or substitution of the activities based on the two prescribed textbooks and suggested supplementary materials. This can be done either on an individual teacher basis (as described in procedure 1 above), or on an official basis. In the light of the teachers' reaction (mostly negative) to searching for, assessing and utilizing instructional information beyond that which is prescribed or suggested, the official approach to supplementation and substitution seems to be the more productive potentially.

In this new curriculum, Alberta Education or a school system might be convinced that it is desirable to enhance the Canadian context in geology components for the junior high school beyond that possible with the present textbooks and suggested supplementary resources, and that a detailed resource guide would have to be provided to teachers of junior high school science to facilitate this process. To perform the necessary tasks, a revisions committee (composed mainly of teachers) should be set up, similar to that used for design of the new Alberta junior and senior high school curricula. Such a committee should have access to a very wide range of instructional resources (hopefully much greater than those at the disposal of the researcher for this study), and adequate compensation in terms of professional time and money. The revisions committee should be thoroughly familiar with the methodology developed in this study, as well as with the clue structure which is at the heart of it. In the preparation of a geology program which emphasizes Canadian context, the revisions committee should give due attention to the four factors mentioned in the Introduction: filling the gaps and weaknesses in coverage of the clue structure; adequate coverage of all of the geological concepts with a Canadian context; diversity of instructional methods and materials; and distribution of geographical focus. Finally, the resource guide that is produced should go through several field-tests ("validations") before being made available to all of the teachers of junior high school science in the province. Since the geology components are now spread throughout the junior high school grade levels in the 1989 curriculum, it would no longer be only grade 8.

One caveat should be mentioned for the consideration of an official revisions committee. As evident from Table 7, some geology sub-concepts and elements in the clue structure are not covered either by the mandated curriculum for Grade 8 geology or by the researcher's search in Stage III. The solution to this problem, if it is deemed serious, is to make an intensive search of relevant curriculum materials for suitable information or "invent" activities to cover the gaps.

To assist curriculum committees such as those presently revising the Alberta junior and senior high school programs in the objective of preparing a resource guide for enhancing the Canadian context in the geology component, the researcher has prepared the following exemplars which are presented in Appendix XV:

1.a. A lesson based on one of the authorized textbooks and suggested supplementary materials in which there is already some Canadian context.

1.b. A lesson on the same concepts but enhanced for Canadian context by substitution and supplementation with information identified in Stage III.

2.a. A lesson based on one of the textbooks in which American examples are used.

2.b. The same lesson but in which Canadian examples are substituted.

3. A lesson plan based on the integration of several sub-concepts which provides for large scale coverage of Canadian context.

3.3 Development of a New Geology Course with Emphasis on Canadian Context

In this study, the application of the theoretical perspective for a Canadian context in science and its associated clue structure is premised on geology content already mandated. Is it possible that the theoretical perspective and the clue structure can be used to help decide what geological concepts are worth including in a new mandated curriculum or new textbook? One is tempted to answer in the affirmative. An example of one such concept which is not at the present time included in the Grade 8 earth science program is the discussion of the development and classification of soils in Canada. **Concept C8.7 The crust of the Earth is formed of rocks** and **C8.8 The crust of the Earth is constantly being changed** stops short of paying attention to the concept of soil as a natural body integrating the accumulative effects of climate and vegetation acting on surficial materials. In considering a number of the areas related to Canadian context components *1.1 Interdisciplinary Nature of Science Education, 1.2 Canadian Science - Canadian Society Interaction, 1.3 History of Canadian Science, 1.5 Pure Science, Canadian Applied Science and their Interrelationship* and *2.1 Maximum Use of the Local Environment* a great amount of material was encountered in Stage III: Sources of Information for Enhancing the Canadian Context in Science Instruction (in particular the Print and Non-Print Reference Materials) which stressed the relationship between processes of rock formation, weathering and erosion, the processes at work within the Earth, and the processes of soil development. Not only are there many unique aspects of soil formation peculiar to Canada but there exist as well a strong history of Canadian contributions to soil taxonomy on a world-wide basis and rich descriptions of the development of a Canadian system of soil classification beginning with the first soil survey in Ontario in 1914 through to the publication of The System of Soil Classification for Canada in 1970 (Canada Soil Survey Committee, 1978). The inclusion of this sub-concept would assist greatly in establishing relevance of erosion and weathering which, in their present form, seem somewhat isolated. In the new Alberta junior high school science curriculum, there are possibilities of this occuring in the grade 9 unit on environmental quality. In addition, teachers are provided with an excellent example of how efforts within earth science on a local or national basis are integrated with those on an international basis. It is essential to note that the intent is not to produce a course heavily biased toward Canadian context but to produce one that is balanced among all of the curriculum emphases which Roberts and Russell (1975) identified. None of these work in opposition but rather as complements to Canadian context.

The dynamic for developing a new course or course component is essentially the same as that described above for the production of a supplementary resource guide for enhancing the Canadian context in a geology curriculum already in force. There would be the additional important task for the designated curriculum committee of deciding what geology concepts to include and what emphasis to give to Canadian context. Geologists and science educators should have an important role (defined by their expertise) in the work of such a curriculum development process. Unfortunately, to this point geologists have not been appropriately consulted to assist with the new Alberta junior or senior high school science curricula being developed.

4. Summary and Critique of Stage IV

In terms of end result, Stage IV is less complete than the first three stages. Only the first part of procedure 1 (the compilation of a resource package and its validation by teachers) is specific. The remainder of the ideas are exploratory: from the possible use of a CRIB-type process (latter part of procedure 1), to the preparation of an official resource guide for the mandated geology program but geared to greater emphasis on Canadian context (procedure 2), to the development of new geology program components for the new Alberta junior and senior high school science curriculum with a built-in emphasis on Canadian context (procedure 3). Even the first part of procedure 1 was incomplete, due to the need to limit the range of resource materials perused for Canadian context in Stage III and having the teachers do only a cursory "validation" of the ideas in the resource package based on Stage III information. Earlier, the researcher noted that the six teachers involved in the validation were very positive about the ideas in the package but were sparse in critical reaction to them. Undoubtedly, these teachers would have had a great deal to say about the teachability and impact of the ideas in the package if they had had an opportunity to use them when teaching Grade 8 geology.

The restraints on the full empirical development of Stage IV are outside of the control of the researcher because he had a necessarily restricted scope specified for the study. Nevertheless, the study has established the direction and significance of Stage IV in the methodology being devised for giving greater emphasis to Canadian context in science instruction.

CHAPTER VII

STAGE V: REFORMULATION OF THE STRATEGY FOR ANALYZING AND ENHANCING THE CANADIAN CONTEXT IN SCIENCE INSTRUCTION

The focus of this study was on a methodology for assessment and enhancement of Canadian context in instructional materials for science. In its development, it was considered necessary to apply it to a specific subject area. The geology component of the Grade 8 Alberta Earth Science program was chosen for this purpose. At the end of this developmental process, it is deemed necessary to state a final formulation of the methodology for expanding and enhancing Canadian context in science instruction. This formulation must take into account the critical assessments of each stage made on the basis of the experiences obtained in applying it to the Alberta Grade 8 geology component.

1. Description of the Revised Methodology

Because of the experience gained from the previous study done by the author (Mrazek, 1982), and in applying the sequence of steps described in Figure 1, the stage descriptions below will differ in some respects from those presented in Chapter I. To avoid confusion between the stages delineated for this study and the suggested revision of them in this chapter, different stage labels are used in the latter as outlined in Figure 2.

1.1 Stage A - Development and Validation of the Theoretical Perspective

The foundation of the entire methodology is the Theoretical Perspective. This was elaborated at length in Mrazek's study (1982), but a brief review is in order here. The notion of "theoretical perspective" adopted here was proposed as a research paradigm by Roberts and Russell (1975). The model basically takes the important issues associated with everyday science education practice (i.e. authority, knowledge, teaching, scientific theory, status of models) and uses philosophical treatments (especially informal analysis) to get to systematic theoretical

STAGE A

Development and Validation of the Theoretical Perspective

1. Development of the initial draft of the theoretical perspective
2. Validation and revision of the initial draft on a "pilot" basis
3. Validation of the second draft and preparation of the final draft of the theoretical perspective

STAGE B

Development and Validation of the Clue Structure

1. Development of the clue structure
2. Validation and final revision of the clue structure

STAGE C

Procedure for Application of the Clue Structure to Assessment of Instructional Materials

STAGE D

Procedure for Collecting Information for Enhancing the Canadian Context in Science Instruction

1. Science teachers as a source of information
2. Scientists as a source of information
3. Supervisors/consultants as a source of information
4. Science educators at universities and research centres as a source of information
5. Print and non-print reference materials as a source of information

STAGE E

Procedures for Enhancing Canadian Context in Science Instruction

Reformulation of the Methodology for Assessment and Enhancement of Canadian Context in Science Instruction

FIGURE 2

perspectives for understanding issues of education and science. A theoretical perspective is usually too general and philosophical to be of direct use in dealing with any issue in science education at the practical level. However, it can yield a set of specific guidelines or "clues" pertaining to the issue for action. To state the notion in another way, the clue structure is a set of analytical questions or statements which, when answered, will provide specific information about educational phenomena under consideration (e.g., the kind, extent and quality of Canadian context reflected in science instructional materials).

1.1.1 Development of the Initial Draft of the Theoretical Perspective

In this stage a theoretical perspective for a Canadian context in science education is developed on the basis of an extensive search of the science and science education literature. This involves informal analysis of not only the more general theory and practice of science education (e.g., the science — technology — society interrelationships) but also considerations such as the history, tradition, and practice of science education and science in Canada, the meaning of Canadian context and its emphasis in relation to other contexts for science education.

The search for a theoretical perspective must be guided by two considerations. First, the work has to be highly relevant to the concerns of the methodology being developed. Second, since there exist various positions and views as to the definition of Canadian context for science education, it is essential to formulate a theoretical view that is philosophically and professionally acceptable to science educators and teachers.

Some comment is in order here on the scope of a theoretical perspective for a Canadian context in science education. There was no question that from the very beginning in the writing of the perspective the question of Canadian context (e.g., history of Canadian science and the philosophy underlying it, study of Canadian flora and fauna, the science — technology — society interrelationships) should be a central element. Considerable argument is presented for the desirability and relevance of the enhancement of this context component in science education. This naturally leads to methods for incorporating more Canadian context in instructional materials in science (e.g. by adapting foreign textbooks; studying local flora, fauna and geology). Consequently, ways of incorporating more Canadian context into science becomes an integral part of the notion of Canadian context. However, Mrazek (1982), in his earlier study, stopped short of dealing with "Canadian ways" of implementing science programs with enhanced Canadian context. This stance on implementation was reiterated in the current study (see delimitations in Chapter I). Notwithstanding this stated delimitation, the question of feasibility and implementation of science programs with enhanced Canadian context kept appearing in the study, both during the validation stages of the methodology and the tapping of the human sources for information on enhancement of Canadian context in Stage III.

There is ample empirical evidence that the intentions of many well-developed science programs have been dashed to pieces at the implementation stage. Much attention has been given in the research literature (e.g. Fullan and Pomfret, 1977; Glaser, Abelson and Garrison, 1983) to the determinants underlying the success of implementation of an innovative curriculum. Both the literature on curriculum theory and the findings in this study suggest strongly that any theoretical perspective for a Canadian context in science education being developed in the future would have to give due consideration to the question of feasibility and implementation. Such consideration would first have to identify and spell out what is unique in the implementation of science programs in Canadian educational systems (e.g., modes of promoting continuing education), and then suggest how this uniqueness could be used to enhance the teaching of Canadian context in science. It is in this manner that implementation would be recognized as a component of Canadian context in a theoretical perspective.

1.1.2 Validation of the Initial Draft on a "Pilot" Basis and Subsequent Revision

As was defined in Mrazek's study (1982) and in Chapter I of this study, the main purpose of the validation process in the methodology is to shape the theoretical perspective so that it becomes professionally and philosophically sound. The first step suggested in the process is to distribute the initial theoretical perspective to a group of validators for a "pilot" reaction. Ideally, such a group of pilot validators should have representation from each of the four groups described below. No firm suggestion can be given as to the number of validators to use at this pilot stage, but certainly not too many. They should be easily accessible to the researcher so that he can have personal interaction with them in terms of cooperation in the venture, detailed reaction through taped interview and so forth.

Each pilot validator receives a copy of the initial draft of the theoretical perspective and is requested to react to it in writing. The reaction sought would consist of support, disagreement, identification of errors and omissions, required clarification, and so forth. If deemed desirable, the researcher(s) may request in-depth interviews which would be based on the validator's written reaction. There also may be a need for validity checks after the tapes are transcribed. In his earlier study, Mrazek (1982) used science educators and science teachers who were in a graduate program for the pilot validation of his theoretical perspective. He was able to obtain very valuable reactions in a graduate seminar in which his theoretical perspective was discussed (after the validators had had a chance to read and think about it).

On the basis of the reaction of the pilot validation, a second draft of the theoretical perspective is prepared. Mrazek (1982) found that the pilot validation had a profound effect on the substance, emphasis, and formulation of the theoretical perspective.

1.1.3 Validation of the Second Draft and Preparation of the Final Draft of the Theoretical Perspective

In this portion of Stage A, the second version of the theoretical perspective is sent out to selected members of the science education community across Canada. They are asked to respond to the perspective in writing to include their comments, both supportive and critical of the perspective. The methodology at this point is oriented toward the determination of what the status of science education should be in terms of Canadian context, rather than an empirical isolation of causative factors accounting for this status.

Criteria for the selection of the validators across Canada should be established. The major criterion is that the validator is or has been actively engaged in teaching science, or is in a support area of science education, or is familiar with or has a potential interest in the state of science in Canada. In line with this criterion, three categories were used similar to those used in the earlier study done by Mrazek (1982). Experience in this study indicates it may be better to use four categories. The first includes practicing science teachers at all grade levels in public or private schools, as well as science teachers who are pursuing graduate studies but are planning to go back to teaching. The second category consists of educators at universities, colleges and research institutions. The third category consists of science supervisors/science consultants with school systems and departments of education. This would also include staff members in other ministries (e.g., environment) who have a major responsibility in servicing science teaching. The fourth category consists of all those in broader areas of science who have shown an interest in science education, such as teaching in a university science faculty, doing scientific research, studying the history and/or philosophy of science, or working in other science-related areas.

A second selection criterion is that there be a representative sample of the four categories of validators. This does not imply that there be equal numbers from each category, but rather that there be some validators from each sub-group and that the numbers selected reflect somewhat the number of practitioners of each sub-group in Canada.

The third selection criterion is that a representative sample be obtained geographically to ensure that regional concerns and differences will be covered. If possible, the geographical representation should apply also to each of the four validator categories identified above. This may not be easy to achieve as Mrazek (1982) found in his previous study. For a number of reasons, he was not able to obtain the desired geographical representation of science teachers.

No concrete guidance is possible regarding the total number of validators to select. Obviously, the decision will be made on the basis of such factors as research personnel and financial resources available for the project, what is considered to be an adequate rate of returns, and so forth. Mrazek (1982) in his earlier study sent his theoretical perspective to 120 potential validators. He received 44 responses which represents 37 percent of number who received the theoretical perspective. The written reaction was very substantial, consisting of 96 pages of summarized comment. However, the work and co[illegible]volved in selecting such a large group was excessive and not cost effective, especially considering that the "law of diminishing returns" was evident in the repetitiveness of comments.

Having selected a sample of validators, each one is sent a copy of the second draft of the theoretical perspective. A cover letter is included giving a brief summary of the study being conducted, the purpose of the theoretical perspective in this study, a request for a written reaction to it, and a suggested deadline for the response. Every possible effort should be made to obtain a maximum number of responses through follow-up letters, phone calls and, if feasible, proposed interviews.

If Mrazek's experience can be used as evidence, ample reaction will be forthcoming to the theoretical perspective. In addition, further literature research should be done at this point, partly because of the time that has elapsed since the preparation of the first draft and mainly because of the questions of omission, bias, etc. raised by the validators. All of this information is used to prepare the final draft of the theoretical perspective.

It should be noted at this point that the two validations built into the methodology are unlikely to yield a single encompassing definition of Canadian context for science education. Indeed, the strength of the theoretical perspective is related directly to the diversity of views and practices that it encompasses on a science education issue. The researcher's task is to formulate a definition of a Canadian context that is both truthful to the validated theoretical perspective and is also most useful to pursuit of the assessment and enhancement of this context in science education.

1.2 Stage B - Development and Validation of the Clue Structure

As was stated earlier, the theoretical perspective is too general and philosophical to be of direct use in the assessment and enhancement of Canadian context in science teaching. However, it can yield a set of specific "clues" as to what constitutes Canadian context in science education.

1.2.1 Development of the Clue Structure

Following the suggestions of Roberts and Russell (1975) the clue structure should consist of a set of statements which reflect elements of Canadian context in science education. The main criterion used to identify clue structure elements is that they are self evident in the theoretical perspective on a Canadian context for science education (e.g., inclusion of the history of Canadian science in the science curriculum; inclusion of the study of local environment).

In Stage I it was determined that Mrazek's (1982) theoretical perspective yields two kinds of clues: those dealing with Canadian content (e.g., study of Canadian geology) and those dealing with methods of either instruction (e.g., use of local resources) or curriculum development (e.g., adaptation of foreign textbooks). As was indicated above, one should also have "clues" on the implementation of programs with enhanced Canadian context (see Stage A above). However, in this study it was found that these categories of clues are not absolute; that is, the clues do not necessarily pertain to a single clue category. An example is the notion of "inquiry" in science. It can be content oriented as when describing how Canadian scientists go about their work, or it can be methodological as when a student conducts an inquiry into a scientific problem (e.g., why the local population of a species of bird is declining). Component 2.3 used in this study

(Adaptation of Foreign Materials to a Canadian Context) overlaps all three categories in the clue structure. What does adaptation consist of? Primarily, a substitution where possible of Canadian for foreign content. Adaptation is also a method of enhancing Canadian content in science programs. Finally, having in-service programs on the teaching of an adapted textbook would be part of the implementation category. The point being made here is that the theoretical perspective has a multidimensionality which is reflected in the clue structure. Instead of using content/method sub-categories, it may be more useful to label each clue component with the multi-dimensions that it encompasses.

One final point should be made about stating the clue structure. It should be worded in a format that makes it usable directly as an instrument (e.g., questionnaire, assessment instrument). This reduces the potential for error in translation, hence confusion in obtaining and reporting data.

1.2.2 Validation and Final Revision of the Clue Structure

The researcher suggests that the procedure for validating the clue structure in this study was too involved, especially in relation to the purpose of assessment and enhancement of Canadian context in science education. Indeed, the second validation in Stage I was more of a survey of opinions on what constitutes acceptable emphasis on Canadian context than it was a measure of the validity of the clue structure. As a result of the empirical evidence gained in this study, the following possible procedures are postulated for this sub-stage:

1. The researcher can assume that he has translated the theoretical perspective (which was amply validated) authentically and comprehensively into the clue structure, hence seek no further validation. In this situation, he would proceed directly to Stage C.
2. The researcher might want confirmation of his translation of the theoretical perspective into the clue structure by a small sample

of validators. Ideally, these would come from the national group used in Stage A and would be a "representative" sample. The validators are already familiar with the essence of the theoretical perspective and might give an indication of whether the researcher's clue structure reflects the former in an honest and comprehensive manner. The process could be facilitated with a questionnaire (similar to the one in Appendix VII) in which the clue structure statements (elements) are used directly. Validators would be asked to indicate the degree of support for each of the elements, using a Likert response scale and written comment. As was noted in the summary of Stage I, there was a lack of congruence between the Likert responses and written comments. One might attempt to get validators to justify their selection of a Likert response for each item. If the same validators are actually used for both the theoretical perspective and the clue structure, then a measure of validity check is obtained on how authentically their views were represented in the final draft of the clue structure.

Depending on which of the above routes are followed with the validation of the clue structure, there may be need for further revision of the clue structure. In drafting the final version, it must be remembered that it is not the degree of support or lack of support thereof for an element which is the most important influence on revision, but rather the elimination of omission, ambiguity, and confusion in the elaboration of the clue structure.

1.3 Stage C - Procedure for Application of the Clue Structure to Assessment of Instructional Material

In this study it was shown that an effective way to do the assessment for Canadian context is on the basis of the science concepts to be taught (both core and elective). These are usually spelled out in the mandated program of studies and/or the official curriculum guide for a science course. Where non-mandated materials are to be assessed, the science concepts covered can be determined from the table of contents, chapter headings or sub-headings.

Once the content structure of the science program is established and the associated instructional materials (both primary and supplementary) are identified, it is possible to move on to the assessment. The researcher found that this was an intensive and time-consuming task. The assessment becomes increasingly more onerous and time-consuming as the number of concepts in the curriculum and of the instructional materials increases. Stage C really requires the collective effort of many teachers, all of whom are actively teaching the science curriculum being assessed, with each doing a part of the task.

Two strategies were delineated in Chapter IV for assessing instructional materials for Canadian context. One of them involves a questionnaire incorporating the clue structure, which is distributed to a sample of science teachers all of whom are using the materials being assessed. They are asked to indicate their perception of the extent to which the specified materials cover each of the elements in the clue structure. Unfortunately, this yields only general data on the incorporation of Canadian context in all of the materials combined. An additional weakness in the approach is that it is unlikely that all of the teachers in the sample have a similar (and even adequate) understanding of the clue structure and how it relates to the instructional materials. One concludes, therefore, that this method yields information of limited value for assessment purposes.

The second method discussed in Chapter IV provides quasi-quantitative assessment data. It entails careful analysis by a panel of assessors (most of whom are teachers using the materials) of small portions of the instructional resources being assessed for Canadian context. A "portion" is defined as a small section of a chapter of a textbook, a complete activity such as an experiment (investigation), a single audio-visual aid or kit, and so forth. The analytical data for each portion would consist of the nature of the instructional material (textbook, etc.), a brief annotation including subject matter, nature of the activities involved and the way in which the Canadian context is reflected. On the basis of this data, each portion is then coded in terms of the elements of the clue structure that are in it. Finally, Likert categories are used to express the extent to which each portion reflects the element in the clue structure for Canadian context. An element is labelled as extremely evident (EE) if specific information on or examples of the element is included in the portion; quite evident (QE) if it is clear that attention is being given to the element; slightly evident (SE) if it can be inferred that the element is being addressed; not evident (NE) if there is no mention of the element but that it could be incorporated; and not evident and not applicable (NA) if the element does not apply to the situation. A total frequency count is then made of the extent to which each element (hence component) is present in the instructional material being analyzed. These totalled frequencies should be tabulated for each of the materials to give a graphic indication of its coverage of Canadian context. Table 5 illustrates how this can be done using three headings: instructional material analyzed, extent (of element) evident (in portions of the material), and frequency of elements in the instructional materials analyzed. One could also include the total number of portions into which each of the specified instructional materials was divided. This graphic indication of extent of coverage of Canadian context facilitates the search in Stage D for additional materials, especially to provide instructional activities and resources for elements which are not adequately covered.

It should be noted in that it is desirable to establish high inter-rater reliability in the assessment. To achieve this objective, a training program must be provided for the assessors. An assessor would have to commit a substantial amount of time and effort to such a project as described here. Organizationally and logistically such an assessment operation could be part of the responsibility of a Curriculum Resources Information Bank (CRIB) operation described earlier (Nay and Associates, 1972; Nay, 1973, 1978; Ryan and Nay, 1980, 1985; Merrill, 1982). This curriculum dynamic evolved empirically in the Edmonton Public School Board projects in junior high schools science. Considerable attention was given in these projects to rewards systems such as time off from teaching, honoraria and professional satisfaction and recognition.

1.4 Stage D - Procedure for Collecting Information for Enhancing the Canadian Context in Science Instruction

As shown in this study, the sources identified and explored for collecting information for enhancing the Canadian context in science instruction will be found to have differing degrees of usefulness and application. Nonetheless, it is important to tap each one for the "unique" contribution it can make.

1.4.1 Identification of Sources of Information

In this study, three categories of professional people were used to collect information. Because implementation should be included in the theoretical perspective and associated clue structure, it is advisable to separate science educators at universities and research institutions from those doing supervisory/consultative work in school systems and government ministries. Each of these two groups has considerable but somewhat unique information to offer on the implementation process.

In the light of the above argument, it is suggested that the same four categories of people be used at this stage as were used in Stage A (validation of the theoretical perspective), namely, science teachers (who are experienced in using the materials being assessed), scientists who are working in the science area being assessed and enhanced, science educators at universities and research institutions, and science supervisors/consultants. New identified print and non-print instructional materials would also be included as a source. These five sources of information for enhancing Canadian context are listed in Figure 2. There could be some merit in adding the research literature on the teaching of science and curriculum development and implementation. However, hopefully the research-oriented science educators could provide sufficient information on these aspects.

Who is to tap each of the five sources of information relevant for the enhancement of Canadian context in science instruction? Experience in this study suggests that the first four (human) sources should be the responsibility of qualified researchers. Presumably these would be the same ones who formulated the theoretical perspective and the associated clue structure. They would be experienced in the use of questionnaires and interview techniques. Ideally, they should have substantial background in the science area being assessed and enhanced for Canadian context — both in its content and teaching experience. The print and non-print source of instructional materials should be the responsibility of a collective dynamic of the type developed by the Curriculum Resources Information Bank Project (Nay and Associates, 1972; Nay, 1973, 1978; Ryan and Nay, 1980, 1985; Merrill, 1982), and described briefly in Chapter VI. In it, teachers who are teaching the science course being assessed and enhanced for Canadian context would have a dominant role in searching for instructional information in print and non-print materials.

1.4.2 Comments on the Information Sought

A number of criteria should guide the search for information from all five sources which are suitable for the enhancement of Canadian context in science education. The following are suggested:

1. Specific attention should be given to information that addresses the deficiencies in coverage of Canadian context by the mandated instructional materials.
2. A running tally of the type shown in Table 5 should be kept of the elements being covered by the new sources of information. This will facilitate balanced use of human resources, with avoidance of covering some elements too much and some not at all. However, it should be borne in mind that it may be impossible (or even undesirable) to cover all elements in the clue structure to the same degree.
3. The new instructional information should be pedagogically sound in terms of interest for students, range of

teaching/learning approaches and so forth. There is some evidence that certain kinds of knowledge (e.g., history, science policy) is found boring by students and unchallenging to teach by teachers. It is important to develop ways of presenting such materials in the most interesting manner possible.

4. The information should incorporate methods that are feasible and resources that are accessible to teachers.
5. The enhancement of Canadian context should not be done with a narrow nationalistic frame of mind. An attempt should be made to get an appropriate and defensible balance of the national and the international context, with due emphasis being given in the latter on examples and illustrations from the U.S.A. with whom we share a continent and many similarities.

1.4.3 The Interview Technique

Experience in this study shows that the in-depth interview technique is the most productive way to obtain information from human sources on teaching science in a Canadian context. Each of the four sources identified above has a unique "expertise," which should be tapped primarily in the interviews. The more general kind of knowledge and experience common to all four human categories will be of secondary emphasis. The nature of the expertise to be tapped will be described for each of the four sources below. If a questionnaire was used in the selection of a sample of interviewees (see below), then the interview might begin with an in-depth elaboration of the responses and free comments indicated by the person. During the interview, the caution raised in this study must be exercised by the interviewer, namely that it is essential to keep the interview focused with a minimum of digressions. The interview should be taped and transcribed. Returning a copy of the transcript for validity check does not seem warranted since the objective is to amass information on science instruction rather than on a description of how a group of interviewees collectively view Canadian context in science. It should be noted that the interviewer should also strive to get copies of all instructional materials from the interviewee that seem relevant to teaching the science course in a Canadian context. Due credit should be given to the interviewees for materials which they have developed themselves. Of course, where it is appropriate, anonymity must be respected in using interview and questionnaire data.

1.4.4 Science Teachers as a Source of Information

The selection of the sample of science teachers can be guided by the following criteria:

1. The teachers selected have already given some thought to the aspects of Canadian context as expressed by the clue structure, and have made some headway in enhancing it in their own science classroom.
2. The instructional materials that these teachers use for teaching science in the Canadian context go well beyond those mandated for the course.
3. The selected teachers should be accessible to be interviewed. How far from the "home base" of the research project these teachers can be depends on the financial resources available for travel and accommodations. Even with a fairly limited budget it may be possible to interview teachers from every part of the province.

Identifying an adequate sample of such select teachers is not an easy task, but the following two approaches are suggested:

1. The researcher could try to obtain names of suitable science teachers from administrators and science supervisors/consultants of schools, school systems and

government ministries. In the province of Alberta, all schools must be evaluated. Such information might be accessible to help in building up a list of potential teachers for interviewing. Hopefully a fairly long list of teachers would be thus obtained, which then could be reduced to a manageable size through direct contact with them.

2. A survey of the type used in this study could be conducted to identify teachers who might be approached for information on teaching science in a Canadian context. A questionnaire incorporating the clue structure would have to be prepared and distributed, with the response categories expressing the degree to which enhancement is being addressed by the respondent in his or her classroom. It is possible to send such a questionnaire to every teacher in the province who is teaching the science course being assessed. However, the cost may be prohibitive so that instead a random sample would have to be drawn to reduce the number of teachers involved in the selection process. Again, hopefully, enough teachers would respond from which a suitable number could be selected for interviewing. These would be the ones who, on the basis of the questionnaire response, seem to have the most experience in teaching science in the Canadian context.

The information sought from practicing teachers will focus (in order of emphasis) on specific methods and materials for teaching the science concepts involved, desirability and relevance of Canadian context in science education, and feasibility and implementation of Canadian context in their own classrooms, schools and systems. In regard to the first and most important focus, the interviewer should discourage dwelling on mandated materials per se, unless the activities have been "translated" into the local setting.

1.4.5 Scientists as a Source of Information

The most obvious criterion for selecting scientists for interviewing is that they be from the area of science which is being assessed and enhanced for Canadian context. The second criterion is that the potential scientist-interviewees should have exhibited interest in the teaching of their specialization. University professors in science departments are an obvious choice here. However, a second indication of interest in science education is the participation of the scientists in the professional development of elementary and secondary education, sitting on department of education committees, judging at science fairs, and so forth. Scientists from industry and research institutes do participate in such activities.

Obviously, in the selection of a scientist to be interviewed for information on the enhancement of Canadian context, some preliminary background needs to be obtained as to suitability. This can be obtained by direct contact with the scientists and/or by seeking information about them from teachers who might have benefitted from their assistance. The number finally chosen for interview (and it is suggested that this be more than three) will depend on factors such as the number identified as suitable for interviewing, of those who have consented to participate in the project, the range of specializations within a branch of science that need to be tapped, personnel available to interview the scientists, and so forth.

The kind of information that can be provided by scientists is well illustrated by the three geologists who participated in this study. They provided the most useful information of all three groups interviewed on methods and materials for teaching geology in a Canadian context. There was also some comment on the desirability and relevance of teaching science in Canadian context and on feasibility and implementation. The emphasis on the content and methodology of teaching geology obviously stems from the rich background and experience these people have in both the geology and the teaching of it. They spoke about preparation of educational packages (e.g, EDGEO), and integrated implementation with development of materials by suggesting that they were willing to hold workshops for Grade 8 science teachers on the use of these packages.

1.4.6 Supervisors/Consultants as a Source of Information

Four members of this group were used in this study under the science educator category. It was suggested that these be in a separate category from the science educators at universities and research institutions because they have a special "expertise" to offer, especially in regard to implementation.

Supervisors/consultants for the study sample come from two sources: government ministries (mainly education) and school systems (usually only the large urban ones). Generally, these people are promoted to their positions because of leadership qualities demonstrated while they were classroom teachers. However, as was demonstrated in this study, they may contribute little information on instructional methodology and resources. The reasons seem to be a lack of background in the science area being studied and/or no (recent) teaching experience in it. Nonetheless, each supervisor or consultant has a science specialization in his/her background and this should be uncovered and used when a sample is being sought for interviewing. There should also be an equitable distribution of consultants/supervisors in the sample from government ministries and school systems since each views the classroom situation and needed improvement thereof somewhat differently.

Supervisors/consultants seem to be able to contribute ideas mainly on implementation, and on desirability and relevance of the change being promoted by the study (e.g., more Canadian context in science education). This group would have had an opportunity in Stage A to offer ideas on the relevance and desirability of a suggested change in science education. Consequently, it is suggested that at Stage D these people be required to focus on feasibility and implementation. Usually, they have a rich experience in the continuing professional education of teachers, especially in regard to the implementation of the mandated curricula. Consequently, they should perhaps be interviewed after teachers and scientists have been interviewed so that they can react to the ideas from the latter in terms of their implementation.

1.4.7 Science Educators at Universities and Research Centres

Generally, science educators have a multidimensional role at universities including preservice education of teachers, graduate studies, research and service to the field. The major responsibility of science educators at research centres would be research, although occasionally this might have a minor field service component. Most of these science educators have had substantial teaching experience at the elementary and/or secondary school level in specific areas of science. All of these factors must be taken into account when arranging a sample of these people for interviewing. Maximum value will be gained when there is a careful matching of the objectives and means of the study and the expertise of these science educators.

As found in this study, the people in this group have important things to say in their reaction in Stage A to the theoretical perspective, especially in regard to the desirability and relevance of the change in science education being presented. They have important things to say about the feasibility and implementation of the change, but perhaps more from the point of curriculum theory than from practical considerations. They also can provide valuable reaction to the information on instructional methods and resources supplied by the teachers and scientists, and perhaps from a somewhat different frame of reference from that of the science supervisors/consultants. Finally, with their wealth of research experience, they can serve as consultants to the project on the science innovation in question.

1.4.8 Print and Non-Print Reference Material

Print and non-print reference materials proved to be the most useful source of information for overcoming gaps and other weaknesses in coverage of Canadian context in science. One can summarize that this will usually be the case regardless of the nature of the change being sought. Unfortunately, the main drawback to this source is its labour-intensiveness and consumption of time, partly because of the large amount of materials that have to be dealt with and partly because of the careful analytical work that has to be done on each individual item. The solution to this major task is to have it done by a collective of teachers following the organization and dynamics used in the Curriculum Resources Information Bank Project (Nay and Associates, 1972; Nay, 1973, 1978; Ryan and Nay, 1980, 1985; Merrill, 1982). Since this is a fairly complex operation it will not be described here. One would have to go to the original references for detailed guidance. One will learn in the process that the CRIB dynamic has considerable potential for continuing professional education for the teachers who participate in it.

Basically, the following major steps are involved in the CRIB type of search of print and non-print materials for information on teaching science in a Canadian context:

1. A group of teachers is organized, all of whom have had substantial experience teaching the science area being assessed and enhanced for Canadian context. A division of labour is planned on the basis of the needs of the project.
2. An intensive search is made for print and non-print materials that pertain to the teaching of the science area. The selection process for the portions should be guided by the weaknesses in coverage of elements of the clue structure by the mandated materials.
3. Each portion in this material is assessed in a manner similar to that discussed in Stage C. A "running" tally of the elements of the clue structure covered by these materials is kept (such as the one in Table 6). A comparison of the tally for the mandated materials (e.g., Table 5) and for the new ones identified (e.g.,

Table 6) gives an indication of which elements are being satisfactorily provided for and which ones still need further attention.

4. This process continues until the useful print and non-print materials are exhausted, or a decision is made that all elements of the clue structure are adequately covered.

It is well to end this section on a cautionary note. Most of the effort with print and non-print materials will be on information for enhancing the teaching of science in a Canadian context. There is also "print material" (research literature) which speaks to the implementation of the proposed enhancement. Since it is recommended in Stage A that implementation be considered as part of Canadian context, attention should be given to this literature (perhaps with the assistance of science educators at universities and research centres).

1.5 Stage E - Procedures for Enhancing Canadian Context in Science Instruction

As was indicated in the above discussion of Stage V of this study, the researcher was not able to empirically develop the last stage of the methodology on assessment and enhancement of Canadian context in science instruction. However, there are not similar constraints on school systems, publishers or departments of education, each of which can set up projects for achieving such enhancement. A number of aspects of these projects should be common to all of them:

1. Obviously, enhancement projects need to be guided by the information from Stages A and B. It seems senseless to have each system or department of education develop a theoretical perspective on enhancing Canadian context in science and have it validated in the manner suggested in Stage A. The first two stages of the methodology need to be redone periodically so that new trends in science education and feedback from enhancement projects can be incorporated. But

each time Stages A and B are redone by one institution or agency, then the results can be used on a nation-wide basis. This would mean that any new enhancement project undertaken by a department of education, a publisher, a single large school system, or a consortium of school systems, only Stages C and D would have to be attended to before going on to Stage E.

2. Each project should involve an adequate number of teachers of the science course being enhanced for Canadian context.
3. Each product from these projects should go through a process of initial development and then a number of trials in science classrooms and revision based on feedback.
4. An adequate implementation program (preferably with a built-in research component) should be put in place when the final product comes out for general use.

The following specific possibilities for enhancing Canadian context in science are indicated by the study:

1. A department of education may decide to establish a bank of coded information on instructional methods and resources for enhancing Canadian context in a given science course and appoints a committee (consisting mainly of teachers) to perform this task. This committee must have access to information from Stages A and B. If there is a mandated curriculum and associated instructional materials for the course, then the group developing the bank would have to go through Stage C followed by Stage D. These two stages would yield a bank of information on a wide range of instructional methods and resources. A suitable computer-based storage and accessing system would have to be developed (Merrill, 1982), and the actual instructional materials

mentioned in the bank would have to be made available to teachers for whom the bank is developed. In the conceptual framework developed for CRIB by Nay et al, the use of the curriculum bank is predicated on teacher responsibility in accessing the information, assessing its value for his/her instruction and, if it is deemed useful, using it either in the original or modified form. Ideally, the teacher then will provide evaluative and supplementary feedback to the bank operation on the material for use in its revision. Alternately, a monitoring system could easily be established to identify which teachers are using the materials and thereby, through a periodic check with these teachers, identify suggested modifications or additions. Such monitoring would also assist in devising in-service programs on the use of the bank.

2. A group of teachers may be charged with the responsibility of compiling supplementary resource packages of the type prepared by the researcher in this study. This group would have access to information from Stages A and B whence it could proceed to Stage C (assessment of the current program). In lieu of doing Stage D, the author group may have access to a bank such as the one described above. It would select the activities and materials from it that are deemed most appropriate for the package.
3. A department of education or a publisher may decide to adapt a textbook (Canadian or foreign) to reflect more Canadian context. A group of writers are contracted to do the adaptation. Again, this group must have access to the information from Stages A and B. It will have to do an analysis of the textbook for Canadian context (Stage C). Finally, the group will have to enhance this Canadian

context, either on the basis of access to a bank such as the one described above, or by doing its own search for instructional materials that reflect Canadian context.

4. Instead of just supplementing a science course with a package or doing a "patch job" on a foreign textbook, the methodology described can be used to develop a new science program for use throughout the province (e.g., the new junior high science courses being developed in Alberta for implementation in 1989-1992). Presumably a curriculum committee would be constituted to produce the course. It must have access to the information from Stages A and B to help define the major objectives of the courses, as well as the concepts, skills, and attitudes to be focussed on in them. Specifically, this information from Stages A and B would help to ascertain that due emphasis is given to Canadian context. At this point one of two paths may be followed:

   (a) If the decision is to select one or more textbooks and some supplementary instructional materials for the course (a practice very common in Canada), then a modified Stage C is followed whereby each potential resource item is analyzed for Canadian context. Those finally chosen would have the most emphasis on Canadian context. If no textbook was found suitable, then an enhancement process might be followed as described in #3 above.

   (b) If the decision is to develop an entirely new textbook (as well as other teaching materials), then an author group will be set up for the purpose, or the project can be contracted out. Access to a bank of the type described above will facilitate the writing task for either group of authors. In either case, the authors will have to monitor constantly the adequacy of attention given to Canadian context (in addition to other contexts or emphases). This will entail a continual Stage C type of assessment by the authors. The department of education can also conduct its own Stage C assessment of the textbook (and other instructional products) developed by either its own author group or the contracted authors.

2. Generalizing the Application of the Method

Two kinds of generalizations of the method are self evident: within the total science area covering all grades and science specializations, and, to other subjects in the school program. With regard to the first kind, it is likely that a single theoretical perspective (Stage A) and clue structure (Stage B) would be applicable in the assessment and enhancement of Canadian context in any science subject at any grade level without difficulty. Indeed, one could use the perspective and clue structure reported in the previous study (Mrazek, 1982) until an improved combination is obtained following Stages A and B described above. It should be noted that the production of a single bank of information on the ways of enhancing Canadian context in science can be expanded over a period of time to cover all science courses at every grade level.

In terms of application of the method developed in this study to other subject areas, some overlap and some uniqueness is evident. The content components of the clue structure for Canadian context will vary from subject to subject (just as the programs of studies vary). There may be substantial overlap of the methods component between school disciplines. For example, the use of scientific process skills (e.g., hypothesizing, gathering evidence, classifying, interpreting data) in science are mirrored in social studies, language arts and even music. Another example is the use of the local environment as a teaching/learning resource in several school subjects, although the aspects studied may vary. One would also find considerable overlap between subject areas of the implementation component of a clue structure (an extension suggested in

Stage A). One begins to sense that if an appropriate theoretical perspective and associated clue structure for Canadian context were developed for the various subject areas, that some insight might come as to how an interdisciplinary approach to education can be promoted.

CHAPTER VIII

CONCLUSIONS

This chapter presents a brief account of the methodology developed for assessment and enhancement of Canadian context in science education. This will be followed by reflections on the potential impact of the study, and some suggestions for further development and research.

1. Summary of the Study

The study was designed to develop a methodology for assessment and enhancement of Canadian context in science education instructional materials. This was accomplished in five stages. In Stage I the clue structure derived from the theoretical perspective for a Canadian context for science education developed by Mrazek (1982) was expanded and refined. This revised clue structure was then validated by means of a questionnaire sent to a national sample of 441 people who had a direct or indirect interest in science education. Attempts were made to have a representative sample with regard to geographical distribution. The 142 validators who responded provided information which assisted greatly in the preparation of the final version of the clue structure.

In Stage II a procedure was developed for application of the clue structure to the assessment of instructional materials. The final clue structure from Stage I was translated into an assessment instrument. This instrument was used by the researcher to analyze the prescribed and supplementary instructional materials of the geology component in Alberta Grade 8 science for a Canadian context. The results of this analysis pointed to a number of deficiencies in terms of Canadian context for science education within the primary instructional materials used in teaching the geology component.

In Stage III procedures and sources were identified and explored for collecting information for enhancing the Canadian context in instructional materials for Grade 8 geology. These sources are science teachers, scientists, science educators at universities and regional offices of Alberta Education, and available print and non-print reference materials. A province-wide survey was directed to all 475 teachers assigned to teach Grade 8 science in the province using an instrument based on the clue structure to indicate in what manner they actually enhanced the Canadian context for each of the geology concepts as well as in what way they thought it might be done. One hundred and twenty teachers submitted ideas which were collated, summarized and categorized in terms of the elements in the clue structure. On the basis of response to the survey instrument, six teachers were identified as giving some attention to Canadian context, and were interviewed for in-depth information on this aspect. Based on knowledge of the science subject area being investigated, publication within the areas, and general interest expressed in assisting science educators in this area, three practicing Alberta geologists were identified and interviewed to obtain information on supplementary materials for teaching the geology component in Grade 8 science. The wealth of information provided by these scientists was again collated, summarized and classified in terms of the elements of the clue structure for a Canadian context. Five science educators were also interviewed for the same purpose. Finally, examination of the relevant print and non-print materials related to the geology component was undertaken. Over 85 different print resources and 125 non-print resources including slides, films, videofilms and investigation kits were looked at of which a detailed analysis of 25 print resources and 13 non-print resources is included in the study.

In Stage IV a procedure for enhancing Canadian context in science instruction was developed. Using the Stage II and III results to identify weaknesses in the coverage of elements in the clue structure, a package of suggestions for enhancing a Canadian context in instructional materials was developed for the geology component of the Grade 8 program which consisted of 66 suggestions for implementation with appropriate references and designation of Canadian context elements. A teacher resource supplemental package and exemplar field trip guide were developed. This package of suggestions for enhancing Canadian context was validated by the six earth science teachers who were earlier interviewed in Stage III. The validation showed overwhelming support for the suggestions for enhancing Canadian context in science instruction in the geology program.

In Stage V the methodology for analyzing and enhancing the Canadian context in science instruction was reformulated, using the information from Stages I, II, III and IV. This general strategy begins with the development of the theoretical perspective as developed in Mrazek's study (1982) and continues through the design procedure identified in Stages I to IV of the current study.

This study shows that a workable methodology for the assessment and enhancement of instructional materials for Canadian context in science education can be formulated and applied.

2. Reflections on the Potential Impact of the Study

A question that immediately comes to mind is related to ownership and understanding of a clue structure for a Canadian context in science education. If it takes eight years to feel comfortable with interpretation and application of a context, as it did for the researcher, how many practicing teachers can we really expect to understand this concept in terms of instruction in science? It would appear that the best method available for implementation of Canadian context in science education would be to use the methodology for assessment and enhancement of instructional materials for a Canadian context at the curriculum development level, beginning with curriculum evaluation, redesigning of the curriculum and subsequent adaptations of instructional materials. Then, through pre-service and in-service work with teachers, train the teachers to use the already modified materials.

This is in effect what has taken place. The Province of Alberta has mandated inclusion of a Canadian context for science education within the new curriculum development taking place from Grades 1-12 in six different strands of science education. The new science - technology - society focus, in combination with defining scientific literacy in terms of course objectives, includes many of the elements taken from the clue structure used in this study on the methodology for assessment and improvement of instructional materials for a Canadian context. Using a more holistic approach to teaching science which includes a Canadian context, science education opportunities may be provided for students to experience concepts which are presently shared by several disciplines. The science curriculum can be enhanced and expanded to give proper representation to the social, economic, moral, ethical and political values embraced in the goals and aims of Canadian science education.

The selection of the earth science component of the Grade 8 program has proven to be a very appropriate choice in that it is reflected at each level of the new Grade 7-12 sciences with differing levels of sophistication. This facilitates transfer of the findings of this study to curriculum changes being planned for science in Alberta. Indeed, the development of this methodology for assessment and enhancement of science instructional materials for a Canadian context has already begun to have its impact. A number of the new curriculum development committees in the general sciences are using the assessment instrument used in Stage II and information from Stage IV to evaluate what will potentially be included in prescribed and supplementary materials for the new courses. As well, one Manitoba university has used the clue structure for a Canadian context developed in this study as a basis for a new science methods course. It focuses on the history of Canadian science and technology, philosophy of Canadian science, and Canadian science — society relationships in order to allow science teachers the opportunity to perceive science in a more holistic manner.

Having looked in depth at each of the science areas being taught in Alberta, at both elementary and secondary levels, it appears that opportunities for use of this methodology are numerous. It is the researcher's hope that the development of this methodology may assist teachers in the Province of Alberta and elsewhere in Canada to enhance their courses for Canadian context and re-establish the science — society interrelationships which make these courses relevant in terms of the students' lived world.

3. Suggestions for Further Research and Development

In conducting this study, it has become apparent to the investigator that a number of other areas related to the study need further investigation:

- A primary extension of this study would be to use the methodology in other areas and grades in science to test its generalizability.
- Another possible extension of the study would be to apply the methodology to other subject areas in order to test its generalizability.
- It should be possible to do an exhaustive curriculum development study (e.g. in developing new junior high science curricula in Alberta) where consideration is given to incorporation of Canadian context in order to ascertain if the methodology has merit in guiding curriculum development.

- An extension could be the development of a set of school curriculum materials using the HyperCard Authoring system on the Macintosh computer. This system is designed to produce a Hypertext environment where the user (i.e. student or teacher) can select any piece of information (text or graphic) by simply pointing to it and clicking the mouse. Screen display immediately changes to provide more detailed information for that item. This could be done for Canadian scientists. For example, a brief description of Alexander Graham Bell may include mention of Baddeck. Selecting this word might give a map of Nova Scotia with a few locations relevant to scientific discoveries. Selecting one of these locations would give further information, and so on. There is virtually no experience with developing a practical Hypertext environment for school use. The technique begs the opportunity to be applied to a relatively well-structured domain of knowledge such as Canadian scientists and their discoveries. This could serve as the starting point for establishing a computer-based Curriculum Resources Information Bank for science.
- Further research could be done on the opportunities for inclusion of students in critical reflection and assessment of their learning resources in terms of Canadian context.
- A logical extension would be to apply the methodology to university geology courses used in preservice education of teachers. A further extension would be to implement a geology course enhanced for Canadian context. One could then identify any changes in student teachers' attitudes, perceptions, and conceptual development related to the enhancement for Canadian context.
- The methodology could be applied to science curricula being used in a third world environment, i.e., a non-industrialized nation. Comparison of the

application of the methodology in two differing socio-economic settings would perhaps lead to its further refinement in terms of generalizability.

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APPENDIX I

Elements of a Clue Structure for a Canadian Context For Science Education (Mrazek, 1982)

Elements of a Clue Structure for a Canadian Context For Science Education

The elements for teaching science education in a Canadian context include the following:

1. An interdisciplinary approach to science facilitating study of man's interrelatedness with his natural and social environment.
2. Promotion of an understanding and appreciation of the relationship between science and Canadian society including the impact that science and technology have on Canadian society and culture today.
3. A depiction of how science and technology can be used to alter the economic and political situation in Canada.
4. History of Canadian science which includes the impact that science and technology had historically upon Canadian life.
5. Promotion of an awareness of the role of Canadian scientists and technologists in Canada's growth and development.
6. Recognition of contributions made by Canadian scientists to international science.
7. A knowledge of the tradition in which science is done in Canada including present emphasis and philosophy underlying Canadian science.
8. Acknowledgment of the interrelationship of pure and applied science allowing a description of the world as it is while also showing the means by which the environment is adapted to suit man's needs.
9. Attention to methods of inquiry which can be used in dealing with pressing Canadian problems which require a scientific or technological solution.
10. A treatment of Canadian science policy promoting an understanding and awareness of the differential emphasis on certain areas of research in pure and applied science in Canada.

11. Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives.
12. Inclusion of topics and problems of current local scientific significance which could include taking feasible action on suggested solutions.
13. Inclusion of Canadian produced science instructional materials which students may easily relate to their own life and environment.
14. Provision for teacher's guides to show how foreign instructional materials can be used or supplemented to be considered more in line with Canadian educational circumstances and needs.
15. A method for bringing the unique problems of each of the major regional areas in Canada together into one context interrelated through common concerns.

APPENDIX II

Regional Emphasis of a Canadian Context in Curriculum Guides

A Regional Emphasis of Canadian Context for Science Education

It is assumed by many that the needs and problems in education vary from region to region within Canada because of its very large size. In a 1975 review of education policies in Canada, evidence was presented which indicated that despite the seeming anomalies of development of the Canadian West in a regional context, the common elements of the educational enterprise at all levels far outweigh the differences. Commonality in the four western provinces' educational system was identified as resting on 'philosophical foundations concerned with basic knowledge and fundamental skills, character development, personal attributes related to attitudes, standards, and moral values, individual-social rights and responsibilities, problem solving, physical, mental and emotional development, aesthetic appreciation and promotion of creativity'. The review, in summing up its analysis of education purposes, aims, objectives, and goal-setting for the western provinces refers to the two over-riding motivations in Western Canadian education as being first, 'an insistent personal-social emphasis' and second, 'an orientation to the future'. Educational planning at the provincial level within regions seems to be focused on continuing definitions of over-all educational objectives, on basic legislation necessary for establishment and maintenance of provincial standards, on development of fiscal arrangements to permit local governments to maintain acceptable levels of educational services, and on research activities designed to improve existing services and to point the way to future changes in direction which education may take. The Science Council study to this point has not revealed significant differences between the approaches to a Canadian context in science education by provinces across Canada. This may be so because there was so little to compare. In order to obtain a better impression of the view toward a Canadian context held within a region concerning the curriculum-as-planned, an in-depth word by word analysis of the junior and senior high school science curriculum guides used in the 'western provinces' region was conducted. Though this analysis was limited to the four western provinces, namely British Columbia, Alberta, Saskatchewan, and Manitoba; it is quite possible that the results may indicate general trends exhibited by secondary science curriculum guides used in other provinces forming regions across Canada. This section attempts to determine what focus, if any, was placed on the use of Canadian content in outlining the concepts and objectives included in curriculum guides used by teachers.

Curriculum guides for each of the junior and senior high school science programs in each of the four provinces mentioned were analysed by identifying key words or phrases which either gave direct reference to something uniquely Canadian or implied this in the context of the statement. Therefore, in order to identify the key phrases which would direct a teacher to use Canadian content, it was necessary to look for both implicit and explicit direction. A key word or phrase was considered to be implicit if it was tacitly comprised or to be understood though not expressed. Examples of this included the terms society, personal, local, community, the students' own environment and many more. In some cases, the context in which the word was found seemed extremely important, such as "visit a microbiologist". This direction would more often than not infer a local microbiologist. On the other hand, a term was considered to be explicit if it distinctly stated a reference to Canadian, the name of the provinces, or a specific place name within Canada or an identifiable body within Canada.

Table 8 shows the results of an in-depth word by word analysis of the curriculum guides. It becomes readily apparent that other than the British Columbia (8-10) General Science and the British Columbia Earth Science/Geology courses in senior high schools, most course guides make very little mention or offer little direction to teachers to use Canadian examples or include Canadian content.

The British Columbia Earth Science 11 and Geology 12 guides encourage teachers to include Canadian content by giving many different activities and investigations specific to British Columbia for each of the learning outcomes included in the scope and sequence.

Though Manitoba's guides were extremely voluminous, for example Biology with 274 pages and Physics with 174 pages, there was comparatively less effort to include Canadian content in the many activities suggested. In most cases, the guides provided little direction toward Canadian content in the concept/sub-concept development on the suggested activities. Generally, any reference to Canadian content or local references were included in the introduction to the guide under the general goals or objectives of the program. Even then, most of the references were implied, with the reference to society left to the teacher to interpret.

Table 9 gives some indication of the range of words/phrases used and the number of occasions each was used as the key phrase. In cases where more than one was used in the excerpt indicated, only the one was selected which seemed to have the greater emphasis in the context of the statement. This table clearly indicates that the terms local and society are used the most in implicit references and Canadian/Canada and the provincial name were the most common explicit references.

All in all, with the exception of the British Columbia General Science guide and the Earth Science 11/Geology 12 guides, there certainly is much room for improvement in the direction given teachers by the Education Ministries if students are to relate science to the environment in which they live. In the British Columbia Chemistry guide, the closest references even to society were the use of the terms air pollution and the internal combustion engine.

It appears that within a region the greatest emphasis concerning a Canadian context in science education concerns the national resources found within that area and relevance to the student's immediate environment. Consideration of local and provincial aspects included in this study may shed further light on these relationships.

TABLE 8

Analysis of Curriculum Guides for Indication of Canadian Context

Subject Area Guide	References Found Under: Core	References Found Under: Other Science Sections	References Found Under: Other Sections in Guide	Number of References Categorized: Explicit	Number of References Categorized: Implicit	Number of References Categorized: Total
British Columbia						
Junior High General	9	80	4	8	85	93
Sr. Biology	5	0	0	4	1	5
Sr. Physics	4	2	0	1	5	6
Sr. Chemistry	2	0	0	0	2	2
Sr. Earth Science/Geology	90	24	6	96	24	120
Provincial Total	110	106	10	109	117	226
Alberta						
Junior High General	2	4	10	1	15	16
Sr. Biology	3	3	8	4	10	14
Sr. Physics	10	16	5	7	24	31
Sr. Chemistry	5	8	8	1	20	21
Provincial Total	20	31	31	13	69	82
Saskatchewan						
Junior High General	10	28	1	18	21	39
Sr. Biology	4	0	0	1	3	4
Sr. Physics	0	4	2	1	5	6
Sr. Chemistry	0	0	4	0	4	4
Provincial Total	14	32	7	20	33	53
Manitoba						
Junior High General	16	15	12	6	37	43
Sr. Biology	13	33	0	19	27	46
Sr. Physics	4	13	12	8	21	29
Sr. Chemistry	0	5	7	1	11	12
Provincial Total	33	66	31	34	96	130
Regional Total	177	235	79	176	315	491
% of Total	36	48	16	36	64	100

TABLE 9

Language Used to Indicate a Canadian Context

Subject Area Guide	Indicators	Number
British Columbia		
Jr. High General	Local	36
	Society	14
	Students' locale	2
	In their area	4
	Community	3
	Canada	2
	Land Use	1
	Petrochemical industry	1
	Fossil fuels	1
	Specific resources	1
	Social	1
	Their lives	2
	Sun energy sources	1
	Our energy sources	1
	In their home	3
	Their daily	1
	Okanagan	2
	B.C.	4
	In their environment	3
	Personal	2
	Media	1
	Take a trip	1
	Your Area	3
	Their town	1
	Their world	1
	Our world	1
	Practical problems	1
	Where school is located	1
	Canadian	2
	B.C.	2
Sr. Biology	Canada	2
	Social	2
	Cultural	2
	Everyday life	1
British Columbia (cont'd)		
Sr. Physics	Personal	1
	National	1
	Internal combustion engine	1
	Air pollution	1
	(Both in context)	1
Sr. Chemistry	Local	19
	Canada	46
	School grounds	2
	Named area in Canada	21
Sr. Earth Science/Geology	British Columbia	30
	Society	1
	Our	1
Alberta		
Jr. High General	Local	3
	The environment	4
	Alberta	1
	Society	2
	Humanistic	1
	Social	3
	Everyday life	1
	National	1
	Man's impact	1
Sr. Biology	Canadian	2
	Alberta	1
	Society	4
	Humanistic	1
	Social	4
	Provincial/Federal	1
	We observe	1
Sr. Physics	Homes	1
	Our culture	1
	Society	9
	Visit	1
	Social	5

TABLE 9 (cont'd)

Subject Area Guide	Indicators	Number
Alberta (cont'd)		
	Society in which we live	1
	Canada	3
	Alberta	5
	Federal government	1
	Everyday life	2
	Local	1
	Humanistic	1
	At home	2
	Roles played by people	1
	Alberta	1
Sr. Chemistry	Our environment	2
	Our life styles	1
	His personal life	1
	Our North American life	2
	Our	1
	Our economy	1
	Everyday life	1
	Society	3
	Humanistic	1
	Social	2
	Local	2
Saskatchewan		
Jr. High General	Local	2
	North America	2
	The prairies	1
	Saskatchewan	13
	Canada	4
	National	1
	Citizen	1
	Community	2
	Our society	1
Saskatchewan (cont'd)		
	Social	2
	Crown corporations	1
	The home	2
	The school	2
	Selected adults	1
	The class	1
	Residential	1
	Habitation	1
	School environment	1
Sr. Biology	Social	2
	Canadian	1
	Societal	3
	Social	2
Sr. Physics	Canada	1
	Society	2
	Culture	2
Sr. Chemistry		
Manitoba		
Jr. High General	Observe the position	1
	Arrange with	2
	Local	5
	Lifestyles	1
	Department of Agriculture	1
	Agriculture representatives	1
	Canada	1
	Individuals and society	1
	Candu	1
	Canadian	3
	Manitoba	2
	Student's own	1
	Their own	1

TABLE 9 (cont'd)

Subject Area Guide	Indicators	Number
Manitoba (cont'd)		
	Their personal	2
	Student's environment	1
	Public	1
	Individual's	1
	Investigate	1
	Record	1
	Forecast	1
	Use them	1
	Take a trip	2
	Collect	3
	Examine	1
	Contributions	1
	Visit	1
	Toronto	1
	Excavate	1
	Your school	2
	Community	2
Sr. Biology	Visit	1
	Collect	3
	Manitoba	10
	Canadian	5
	Toronto	1
	Our environment	1
	Excavate	1
	Social	2
	Name of place	3
	Personal	1
	Local	4
	Society	9
	Your school	1
	Our society	1
	Community	1

Subject Area Guide	Indicators	Number
Manitoba (cont'd)		
	Citizens	1
	Individual and society	1
	Everyday life	1
Sr. Physics	Individual and society	1
	Everyday life	4
	Candu	1
	Canadian	6
	Society	9
	Manitoba	1
	Student's own	1
	Their own	1
	Their personal	2
Sr. Chemistry	Student's environment	2
	public	1
	Student's families	1
	Canada	1
	The class	1
	To give a table	1
	Local	1
	Society	6
	Everyday life	1

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APPENDIX III

Revised and Elaborated Draft of the Clue Structure

Revised and Elaborated Draft of the Clue Structure

On the basis of in-depth analysis of the responses to the validation of the Mrazek (1982) clue structure and the literature search, a number of questions began to take shape which might serve to get at the essence of each of the clue structure components identified Table 1 in Chapter III. In terms of the Roberts and Russell (1975) model, these should be the best possible questions which will allow interpretation of the clue structure in a manner consistent with the aspects of a Canadian context for science education identified in the Mrazek (1982) theoretical perspective. These clue structure components, a way of organizing information, are manifested by the following questions:

1. Content Components of Science Education in a Canadian Context

1.1 Interdisciplinary Nature of Education

Is an attempt made to show that all living things interact with and are interdependent upon each other and their environment and therefore lend themselves to study in an interdisciplinary manner?

Is provision given for studying functional relationships in phenomena which go beyond the individual characteristics of the parts?

Is promotion made of the interrelationships of science to other facets of Canadian life in an interdisciplinary manner?

Is an attempt made to use science, combined with aspects of social studies and Canadian studies to assist students in developing their perspectives of national identity and the role of science in defining that identity?

Is there inclusion of an understanding and appreciation of the effect of science and technology on modern Canadian society?

Is an attempt made through the study of science in its social context, to examine the historical interaction of intellectual and social activities?

Is an attempt made to bring about an understanding and appreciation of man's inter-relatedness with his natural and social environment?

Is assistance provided to develop intellectual tools the student may use to be productive in our rapidly changing environment such as critical-mindedness and decision-making skills?

Is an attempt made to promote Canadian science education as a relevant and functional experience?

1.2 Canadian Science - Canadian Society Interaction

Is provision made for development of an understanding and appreciation of the relationship between science and Canadian society?

Is attention given to the impact that science and technology have on Canadian society and culture?

Are there ample examples and illustrations of this impact from contemporary Canadian life?

Is an attempt made to portray science education as part of our total Canadian culture?

Is science presented in a way which promotes getting to know ourselves and our universe?

Is science and technology depicted as a consideration in the economic and political situation in Canada?

Is attention given to the scientific, technological and social problems facing Canada and the world, and ways of resolving these issues?

Is attention given to processes of decision-making for resolving science-related social problems?

Is attention given to the variety of roles that high school students as adults will play in Canadian society in the future and how science can prepare them for those roles?

1.3 History of Canadian Science

Is attention given to the many important Canadian achievements in science?

Is attention given to the impact that science and technology have had historically upon Canadian life?

Is there promotion of an appreciation of the part played by scientific breakthroughs, both at home and abroad, in shaping and making possible the development of this country?

Is an attempt made to develop in students an awareness and appreciation of the significant role of Canadian scientists and technologists in Canada's growth and development?

Is there acknowledgement of early Canadian achievements in science, which includes the mapping of resources, identifying and classifying species, and exploring the natural history of the land as a prelude to settlement?

Is attention given to the significant contributions made by Canadian scientists to international science?

1.4 Philosophy Underlying Canadian Science

Is an attempt made to show how historical and social influences helped to determine how science was launched, developed and utilized in Canada?

Are examples of our scientific legacy from other countries such as Britain provided?

Is attention given to factors which contributed to give science its special place in Canadian society and culture such as the confrontation with the land and entrepreneurial ideology?

Is attention given to how the science that emerged was in turn significant in shaping Canadian society and culture?

Is attention given to the adoption and adaptation of laboratory technology and science to the solution of Canadian problems?

Is attention given to the generation of a first approximation to Canadian science - a Canadian adaptation of European science as related to production and its grounding in the material realities of Canadian life?

Is an attempt made to show how scientific societies and associations of scientific professionals provided the early organizational framework for Canadian science?

Is an attempt made to develop an awareness of the tradition in which science is done in Canada?

1.5 Pure Science, Canadian Applied Science and Their Interrelationship

Are students encouraged to understand the nature of both pure science and of applied science (technology) and the manner in which they serve as a bridge between science and society and act as a unifying force between the various disciplines?

Is an attempt made to show the relationship of pure and applied science in terms of science attempting to describe the world while technology is the means by which humans adapt the environment to suit their needs?

Is an attempt made to include issues of pressing national concern relating to science and technology in the classroom experience of students?

Is an attempt made to use applied science to put science concepts in everyday affairs where the student may confront them?

Is an attempt made to make students aware of how "applied science" can be used to interpret critically what is taking place around them?

1.6 Science as Inquiry

Is the nature of scientific inquiry promoted as a major element in scientific literacy?

Is the learning of science as inquiry promoted?

Is learning science by inquiry (often designated as process) promoted?

When dealing with specific achievements of Canadian scientists, is attention being paid to the specific methods of inquiry used and to the social, economic and political circumstances making the achievements possible?

Are Canadian discoveries related to the total discipline as being developed internationally?

Are students given opportunities to apply inquiry strategies when dealing with pressing Canadian problems which require a scientific/technological solution (e.g. in environmental degradation, resource depletion)?

1.7 Canadian Science Policy, Current Research Emphasis in Canada and Their Interaction

Are students encouraged to become aware of the effects science and technology have on them and on Canada's position in the world community?

Are students encouraged to understand and appreciate why there is emphasis on certain areas of research in pure and applied science?

Is a simplified treatment of Canadian science policy included in the science curriculum?

Is there inclusion of the science policy debate which has existed in Canada since the early 1960's with the original objective being to devise mechanisms by which we could more effectively use science in the service of the nation and include mobilization of scientific effort to solve perceived national problems?

Are students informed of the milestones in this science policy debate and the dynamics of science policy formulation?

Are the determinants of Canadian science policy addressed: concern with the survival and maintenance of the nation, strengthening of indigenous technology in order to eventually make our 'branch plants' independent, a concern for our environment, maintaining the status of academic science, etc.?

Are changes in science policy in Canada over the past decade addressed: "mission" or "task-oriented" research, increased involvement of provinces in pure and applied research, development of special institutes or centers for applied research, tax write-offs for research done by industry, etc.?

Are areas identified as being of specific interest and benefit to Canada: communication, management of the oceans (especially the Arctic), transportation, oil and gas technology for severe climatic and geography conditions, resource development, etc.?

Is assessment of the adequacy of Canada's science policy considered: why research and development support for pure science is so low, why Canada has the lowest science budget as a percent of the GNP of all the OECD countries, why governments are increasingly dictating the kind of pure and applied research being done, etc.?

2. Methodological Components of Science Education in a Canadian Context

2.1 Maximum Use of the Local Environment

Are students encouraged to relate abstract knowledge to concrete situations which they have encountered?

Are opportunities for experiences and examples provided which will serve as concrete illustration and reinforcement of the science concept being learned?

Are students encouraged to develop a deep understanding and appreciation of the natural and social world in which they live?

Are students required to apply basic scientific laws and concepts to the study and understanding of their immediate environment?

Are students required to deal with topics and problems of current local scientific significance and to take feasible action on suggested solutions?

Are students encouraged to develop a commitment to the careful use of natural resources in Canada and to the preservation and improvement of their environment?

2.2 Canadian Science Instructional Materials

Are provisions made for inclusion of locally produced instructional materials for teaching science in a Canadian context which meet the following criteria:

They contain Canadian content that students can relate to their own life and environment; i.e., it must be highly relevant to students.

They include wherever relevant, information on Canadian science and scientists, the Canadian science-society inter-relationship, etc.

They are of high quality in terms of content selection, organization and presentation.

They contain implicit messages that are congruent with teaching science in a Canadian context.

2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context

If materials are produced outside Canada, are revisions of them possible for inclusion of Canadian emphasis, examples, activities, etc.?

In the case of use of good foreign instructional materials that have not been revised, are teachers' guides available to show how the materials can be used (e.g., by appropriate supplementation) more in line with Canadian educational circumstances and needs?

2.4 Problems of Regionalism

Is opportunity provided for development of a national conception of this country's scientific and technological needs?

Is an attempt made to bring the unique problems of each of the major areas in Canada together into one context - a Canadian context?

Are students encouraged to understand and appreciate the regional differences that exist in Canada?

Is an attempt made to show that all of the regions of Canada are interrelated through such concerns as climate, energy production and use, protection of the environment, and development and use of resources?

APPENDIX IV

STAGE I: Validation of the Clue Structure by a National Sample

Included in this Appendix are:

1. Covering letter to Stage I Validators
2. Follow-up letter to non-respondents in Stage I
3. Validation Instrument for the Clue Structure

1. Covering letter to Stage I Validators

Fellow Science Educators

A clue structure for 'A Canadian Context for Science Education' is the basis of a methodology which I am devising as part of my Ph.D. thesis. The clue structure questions will serve as a foundation for examining instructional materials to determine the type and extent of Canadian context that has been and can be included. This is based on the theoretical perspective for 'A Canadian Context for Science Education' developed in my unpublished masters thesis available through the University of Alberta. A special thanks is extended to all who had shareed their views in this stage of my work.

In order for my clue structure to reflect a realistic view of a Canadian context for science education, I am soliciting reactions to it from science educators across Canada. You were suggested to me as a person who might be willing to spend the time and effort necessary for such a reaction. I would appreciate your contentions, support, note of errors or omissions, need for additions, etc.. In reacting to this perspective, please use the margins and spaces provided to make comments at appropriate points or write them on the back of the paper.

To enable me to pursue my Ph.D. study with all possible haste, please return the clue structure to me with your comments by March 15, 1985. A mailing label has been included to facilitate this. All contributions will be held in confidence, and will be acknowledged in the thesis.

If you have a colleague who would be interested in reacting to this document, feel free to duplicate and pass it on.

Thank you for your valuable input.

Gratefully yours,

Rick Mrazek

2. Follow-up letter to non-respondents in Stage I

March 19, 1985

Dear Colleague:

Towards the beginning of February you received a copy of a validation instrument for a clue structure of 'A Canadian Context for Science Education.' I realize that for most participants the requested deadline of March 15 was simply too pressing.

I would like to clarify the instructions for the validation. As a validators, it is requested that you react to the <u>relevance</u> of the questions in defining a Canadian context, rather than specifically answering the questions. It would be appreciated if you would comment on your choice or use examples if you prefer.

I will be pursuing this investigation following my Ph.D. study, therefore I would still appreciate your reactions to the questions I pose at your earliest convenience.

Based on those reactions received to date, contributors have a wealth of ideas regarding a Canadian context for science education. These reactions can play a vital role in the direction of my research.

I look forward to hearing from you and sincerely hope you have the opportunity to react to the document which you received and may use the enclosed mailing label to assist in its return.

Gratefully yours,

Rick Mrazek

Rick Mrazek

3. Validation Instrument for the Clue Structure

The clue structure of a Canadian context for science education consists of a set of questions which may assist in the identification of the presence of elements which form one perspective of a Canadian context for science education. The clue structure questions included should meet the following criteria:

(a) As a set, the clue structure questions need to be broad enough to capture the important, generally accepted elements of a Canadian context for science education.

(b) In both terminology and content, clue structure elements need to have meaning for many audiences, including those unsophisticated in science and in education.

(c) The clue structure questions have to be limited in number.

(d) Each clue structure question needs to have some important unifying feature and to be distinct from other clusters in some meaningful way. (This does not imply mutual exclusivity, which is probably impossible.)

(e) Clue structure questions have to lend themselves to operational definitions in terms of student outcomes and elements of practice in science education.

(f) Clue structure questions have to differ from one another in ways which translate into some differences with respect to the operational definitions mentioned in (e) above.

Instructions

1. Using the Likert scale following each question indicate the relevance of each question to the element identified in defining Canadian context. Please blacken one response for each item.

ER = Extremely Relevant
QR = Quite Relevant
SR = Slightly Relevant, but may need revision
NR = Not Really Relevant
TI = Totally Irrelevant

2. For each item that you would like to elaborate on, please give a brief reason for choice in the space provided.
3. Where possible, please give a specific example from the science area in which you are most familiar.
4. Using the enclosed mailing label, forward you response by March 15, 1985 if at all possible.

To achieve the aims and goals of science education stated in documents issued by ministries of education in Canada, it is necessary to use a balanced variety of contexts. The Science Council of Canada has recommended a stronger emphasis be placed on the inclusion of a Canadian context for science education, which has been neglected in the past. Mrazek (1982) identified elements of a clue structure for such a Canadian context. These clue structure elements are manifested by the following questions.

1. Content Components of Science Education in a Canadian Context

1.1 Interdisciplinary Nature of Science Education

1.1.1 Is opportunity provided for richer treatment of the science, technology and society interrelationship through interdisciplinary treatment of the subject matter?

ER QR SR NR TI

1.1.2 Is there an attempt to show that all living things interact with and are interdependent upon each other and their environment and therefore lend themselves to study in an interdisciplinary manner?

ER QR SR NR TI

1.1.3 Is there provision for studying functional relationships in phenomena which go beyond the individual characteristics of the parts?

ER QR SR NR TI

1.1.4 Is there promotion of the interrelationships of science to other facets of Canadian life in an interdisciplinary manner?

ER QR SR NR TI

1.1.5 Is there an attempt to use science, combined with aspects of social studies and Canadian studies to assist students in developing their perspectives of national identity and the role of science in defining that identity?

ER QR SR NR TI

1.1.6 Is there promotion of an understanding and appreciation of the effect of science and technology on modern Canadian society?

ER QR SR NR TI

1.1.7 Is there an attempt through the study of science in its social context, to examine the historical interaction of intellectual and social activities?

ER QR SR NR TI

1.1.8 Is there an attempt to bring about an understanding and appreciation of man's interrelatedness with his natural and social environment?

ER QR SR NR TI

1.1.9 Is there assistance provided to develop intellectual tools the student may use to be productive in our rapidly changing environment such as critical-mindedness and decision-making skills?

ER QR SR NR TI

1.1.10 Is there an attempt to promote Canadian science education as a relevant and functional experience?

ER QR SR NR TI

1.2 Canadian Science - Canadian Society Interaction

1.2.1 Is there provision for demonstrating to students why they should take science?

ER QR SR NR TI

1.2.2 Is attention given to the effects that science and technology have had on the workplace?

ER QR SR NR TI

1.2.3 Are students encouraged to discuss social issues from a scientific and technological perspective?

ER QR SR NR TI

1.2.4 Are students encouraged to approach social problem-solving which includes considering the impacts of science and technology on the quality of human existence and the biosphere?

ER QR SR NR TI

1.2.5 Is there provision for development of an understanding and appreciation of the relationship between science and Canadian society?

ER QR SR NR TI

1.2.6 Is there attention given to the impact that science and technology have on Canadian society and culture?

ER QR SR NR TI

1.2.7 Are there ample examples and illustrations of this impact from contemporary Canadian life?

ER QR SR NR TI

1.2.8 Is there an attempt to portray science education as part of our total Canadian culture?

ER QR SR NR TI

1.2.9 Is science presented in a way which promotes getting to know ourselves and our universe?

ER QR SR NR TI

1.2.10 Is science and technology depicted as a consideration in the economic and political situation in Canada?

ER QR SR NR TI

1.2.11 In a science class -- is attention given to the scientific, technological and social problems facing Canada and the world, and ways of resolving these issues?

ER QR SR NR TI

1.2.12 Is attention given to process of decision-making for resolving science-related social problems?

ER QR SR NR TI

1.2.13 Is there attention given to the variety of roles that high school students as adults will play in Canadian society in the future and how science can prepare them for those roles?

ER QR SR NR TI

1.3 History of Canadian Science

1.3.1 Is there attention given to the many important Canadian achievements in science?

ER QR SR NR TI

1.3.2 Is there attention given to the impact that science/technology have had historically upon Canadian life?

ER QR SR NR TI

1.3.3 Is there promotion of an appreciation of the part played by scientific breakthroughs, both at home and abroad, in shaping and making possible the development of this country?

ER QR SR NR TI

1.3.4 Is there an attempt to develop in students an awareness and appreciation of the significant role of Canadian scientists and technologists in Canada's growth and development?

ER QR SR NR TI

1.3.5 Is there acknowledgement of early Canadian achievements in science, which included the mapping of resources, identifying and classifying species, and exploring the natural history of the land as a prelude to settlement?

ER QR SR NR TI

1.3.6 Is there attention given to the significant contributions made by Canadian scientists to international science?

ER QR SR NR TI

1.3.7 Are advances in science presented as being due to the community which surrounds the scientists as well?

ER QR SR NR TI

1.4 Philosophy Underlying Canadian Science

1.4.1 Is there an attempt to make science relevant in personal terms and also develop social conscience?

ER QR SR NR TI

1.4.2 Is opportunity provided for discussion of the nature of science providing a cautious view of knowledge which makes us mindful of the limitations of human knowledge?

ER QR SR NR TI

1.4.3 Is an attempt made to allow students to approach questions of values and ethics without feeling threatened?

ER QR SR NR TI

1.4.4 Is there an attempt to show how historical and social influences helped to determine how science was launched, developed and utilized in Canada?

ER QR SR NR TI

1.4.5 Are examples of our scientific legacy from other countries such as Britain provided; i.e., the ideology and educational practice of the Scots who believed that science was not only a tool for the understanding of nature, but also as a tool for the enrichment of mankind through development and exploitation of nature?

ER QR SR NR TI

1.4.6 Is attention given to factors which contributed to give science its special place in Canadian society and culture such as the confrontation with the land and entrepreneurial ideology?

ER QR SR NR TI

1.4.7 Is there attention given to how the science that emerged was in turn significant in shaping Canadian society and culture?

ER QR SR NR TI

1.4.8 Is there attention given to the adoption and adaptation of laboratory technology and science to the solution of Canadian problems?

ER QR SR NR TI

1.4.9 Is there attention given to the generation of a first approximation to Canadian science -- a Canadian adaptation of European science as related to production and its grounding in the material realities of Canadian life?

ER QR SR NR TI

1.4.10 Is there an attempt to show how scientific societies and associations of scientific professionals provided the early organizational framework for Canadian science?

ER QR SR NR TI

1.4.11 Is there an attempt to develop an awareness of the tradition in which science is done in Canada?

ER QR SR NR TI

1.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.5.1 Are students encouraged to understand the nature of both pure science and of applied science (technology) and the manner in which they serve as a bridge between science and society and ac. as a unifying force between the various disciplines?

ER QR SR NR TI

1.5.2 Is there an attempt to show the relationship of pure and applied science in terms of science attempting to describe the world while technology is the means by which humans adapt the environment to suit their needs?

ER QR SR NR TI

1.5.3 Is there an attempt to include issues of pressing national concern relating to science and technology in the classroom experience of students?

ER QR SR NR TI

1.5.4 Is there an attempt to use applied science to put science concepts in everyday affairs where the student may confront them?

ER QR SR NR TI

1.5.5 Is there an attempt to make students aware of how "applied science" can be used to interpret critically what is taking place around them?

ER QR SR NR TI

1.6 Science as Inquiry

1.6.1 Is inquiry promoted as a major element in scientific literacy?

ER QR SR NR TI

1.6.2 Is the learning of science as inquiry promoted?

ER QR SR NR TI

1.6.3 Is learning science by inquiry (often designateed as process) promoted?

ER QR SR NR TI

1.6.4 When dealing with specific achievements of Canadian scientists, is attention being paid to the methods of inquiry used (for example, in the form of case studies) and to the social, economic and political circumstances making the achievements possible?

ER QR SR NR TI

1.6.5 Are Canadian discoveries related to the total discipline as being developed internationally?

ER QR SR NR TI

1.6.6 Are students given opportunities to apply inquiry strategies when dealing with pressing Canadian problems which require a scientific/technological solution (e.g., in environmental degradation, resource depletion)?

ER QR SR NR TI

1.7 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

1.7.1 Are students encouraged to become aware of the effects science and technology have on them and on Canada's position in the world community?

ER QR SR NR TI

1.7.2 Are students encouraged to understand and appreciate why there is emphasis on certain areas of research in pure and applied science?

ER QR SR NR TI

1.7.3 Is a simplified treatment of Canadian science policy included in the science curriculum?

ER QR SR NR TI

1.7.4 Is there inclusion of the science policy debate which has existed in Canada since the early 1960's with the original objective being to devise mechanisms by which we could more effectively use science in the service of the nation and include mobilization of scientific effort to solve perceived national problems?

ER QR SR NR TI

1.7.5 Are students informed of the milestones in this science policy debate and the dynamics of science policy formulation?

ER QR SR NR TI

1.7.6 Are the determinants of Canadian science policy addressed: concern with the survival and maintenance of the nation, strengthening of indigenous technology in order to eventually make our 'branch plants' independent, a concern for our environment, maintaining the status of academic science, etc.?

ER QR SR NR TI

1.7.7 Are changes in science policy in Canada over the past decade addressed: "mission" or "task-oriented" research, increased involvement of provinces in pure and applied research, development of special institutes or centers for applied research, tax write-offs for research done by industry, etc.?

ER QR SR NR TI

1.7.8 Are areas identified as being of specific interest and benefit to Canada included: communication, management of the oceans (especially the Arctic), transportation, oil and gas technology for severe climatic and geographic conditions, resource development, etc.?

ER QR SR NR TI

1.7.9 Is assessment of the adequacy of Canada's science policy considered: why research and development support for pure science is so low, why Canada has the lowest science budget as a percent of the GNP of all the OECD countries, why governments are increasingly dictating the kind of pure and applied research being done, etc.?

ER QR SR NR TI

2. Methodological Components of Science Education in a Canadian Context

2.1 Maximum Use of the Local Environment

2.1.1 Are students encouraged to relate abstract knowledge to concrete situations which they have encountered?

ER QR SR NR TI

2.1.2 Are opportunities for experiences and examples provided which will serve as concrete illustration and reinforcement of the science concept being learned?

ER QR SR NR TI

2.1.3 Are students encouraged to develop a deep understanding and appreciation of the natural and social world in which they live?

ER QR SR NR TI

2.1.4 Are students required to apply basic scientific laws and concepts to the study and understanding of their immediate environment?

ER QR SR NR TI

2.1.5 Are students required to deal with topics and problems of current local scientific significance and to take feasible action on suggested solutions?

ER QR SR NR TI

2.1.6 Are students encouraged to develop a commitment to the careful use of natural resources in Canada and to the preservation and improvement of their environment?

ER QR SR NR TI

2.2 Canadian Science Instructional Material

Are provisions made for inclusion of locally produced instructional materials for teaching science in a Canadian context which meet the following criteria?

2.2.1 It contains Canadian content that students can relate to their own life and environment; i.e., it must be highly relevant to students.

ER QR SR NR TI

2.2.2 It includes, wherever relevant, information on Canadian science and scientists, the Canadian science - society interrelationships, etc..

ER QR SR NR TI

2.2.3 It is of high quality in terms of content selection, organization and presentation.

ER QR SR NR TI

2.2.4 It contains explicit messages that are congruent with teaching science in a Canadian context.

ER QR SR NR TI

2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context

2.3.1 If produced outside Canada, are revisions possible for inclusion of Canadian emphasis, examples, activities, etc.?

ER QR SR NR TI

2.3.2 In the case of good foreign instructional materials that have not been revised, are teachers' guides available to show how the materials can be used (e.g., by appropriate supplementation) more in line with Canadian educational circumstances and needs.

ER QR SR NR TI

2.4 Problems of Regionalism

2.4.1 Is there opportunity provided for development of a national conception of this country's scientific and technological needs?

ER QR SR NR TI

2.4.2 Is there an attempt to bring the unique problems of each of the major areas in Canada together into one context -- a Canadian context?

ER QR SR NR TI

2.4.3 Are students encouraged to understand and appreciate the regional differences that exist in Canada?

ER QR SR NR TI

2.4.4 Is there an attempt to show that all of the regions of Canada are interrelated through such concerns as climate, energy production and use, protection of the environment, and development and use of resources?

ER QR SR NR TI

APPENDIX V

Summary of Responses of Validators to Validation Questionnaire

Included in this Appendix are:

1. Summary of Likert responses.
2. Summary of Free Comments on the Validation Questionnaires.

1. Summary of Likert Response

The Likert scale following each clue structure question indicating the relevance of each question to the element identified in defining Canadian context was interpreted in terms of mean score support and variance for each of the three major validation groups.

Scores were assigned on the basis of the following:

5 = ER = Extremely Relevant

4 = QR = Quite Relevant

3 = SR = Slightly Relevant but may need revision

2 = NR = Not Really Relevant

1 = TI = Totally Irrelevant

Table 10 summarizes the Likert responses for each of the content and methodological components of science education in a Canadian context.

TABLE 10

Perceived Relevance of Clue Structure Components in the Stage I Validation

1.1 Interdisciplinary Nature of Science Education in a Canadian Context for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
1.1.1	3.88	1.51	3.94	0.75	4.42	0.53	4.05
1.1.2	3.82	1.73	3.79	1.02	4.07	0.92	3.86
1.1.3	3.67	1.68	3.54	0.89	3.89	0.88	3.63
1.1.4	4.17	0.85	4.01	0.50	4.32	0.43	4.09
1.1.5	3.76	1.12	3.56	0.92	4.25	0.47	3.74
1.1.6	4.35	0.81	4.16	0.67	4.50	0.60	4.26
1.1.7	3.47	1.13	3.51	0.98	4.07	0.35	3.61
1.1.8	4.23	0.88	4.06	0.68	4.25	0.40	4.12
1.1.9	4.17	1.20	4.10	0.79	4.17	1.07	4.11
1.1.10	3.85	0.89	3.66	1.14	4.07	1.13	3.71

TABLE 10 (cont'd)

1.2 Canadian Science - Canadian Society Interaction for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
1.2.1	3.73	1.19	4.13	0.87	4.39	1.02	4.06
1.2.2	3.88	0.69	4.04	0.55	4.21	0.59	4.05
1.2.3	4.20	0.45	4.14	0.55	4.42	0.53	4.20
1.2.4	4.14	0.77	4.08	0.61	4.46	0.74	4.13
1.2.5	3.88	0.92	3.62	0.88	4.25	0.83	3.81
1.2.6	4.00	0.88	3.89	0.85	4.50	0.39	4.01
1.2.7	4.05	0.70	3.68	0.83	4.50	0.39	3.86
1.2.8	3.67	1.04	3.51	0.81	4.17	0.50	3.68
1.2.9	3.67	1.21	3.67	1.00	4.35	0.80	3.89
1.2.10	3.73	0.72	3.48	1.25	4.17	0.64	3.69
1.2.11	4.23	0.59	4.13	0.64	4.57	0.53	4.27
1.2.12	3.79	0.98	3.85	0.82	4.32	0.64	3.90
1.2.13	3.97	0.79	3.98	0.74	4.10	0.66	3.97

TABLE 10 (cont'd)

1.3 History of Canadian Science for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
1.3.1	3.73	0.90	3.86	0.92	4.39	0.45	3.90
1.3.2	3.85	0.83	3.63	0.69	4.25	0.61	3.76
1.3.3	3.76	0.53	3.62	0.66	4.07	0.56	3.71
1.3.4	3.79	0.51	3.79	0.89	4.35	0.51	3.90
1.3.5	3.61	0.94	3.40	0.80	4.10	0.81	3.56
1.3.6	3.67	0.86	3.79	0.86	4.25	0.47	3.83
1.3.7	3.17	1.02	3.14	0.93	3.85	0.98	3.29

TABLE 10 (cont'd)

1.4 Philosophy Underlying Canadian Science for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
1.4.1	3.97	1.32	3.81	0.72	4.10	0.59	3.91
1.4.2	4.02	1.14	3.90	0.92	4.25	0.68	4.02
1.4.3	3.91	1.13	3.60	0.91	4.03	0.60	3.71
1.4.4	3.44	0.77	3.35	0.82	3.82	0.57	3.44
1.4.5	3.11	0.69	3.06	0.90	3.64	1.08	3.11
1.4.6	3.17	0.85	3.08	0.75	3.42	0.74	3.13
1.4.7	3.35	0.99	3.21	0.84	3.75	0.61	3.30
1.4.8	3.61	1.17	3.47	0.70	3.85	0.69	3.53
1.4.9	2.70	0.85	2.68	0.59	3.25	0.90	2.75
1.4.10	2.76	1.12	2.77	0.96	3.28	1.06	2.81
1.4.11	3.11	0.81	3.06	0.92	3.82	0.50	3.19

TABLE 10 (cont'd)

1.5 Pure Science, Canadian Applied Science and Their Interrelationship in a Canadian Context for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
1.5.1	3.58	0.77	3.79	0.72	4.14	0.76	3.55
1.5.2	3.52	1.36	3.71	0.63	4.10	1.02	3.73
1.5.3	3.85	0.89	[illegible]	0.72	4.21	0.52	3.90
1.5.4	4.00	0.94	3.91	0.77	4.32	0.50	4.01
1.5.5	3.73	0.90	3.86	0.65	4.03	1.24	3.95

1.6 Science as Inquiry in a Canadian Context for Science Education

1.6.1	4.05	1.40	4.16	0.70	4.35	1.15	4.19
1.6.2	3.85	1.47	4.17	0.65	4.35	1.37	4.18
1.6.3	4.02	1.44	4.08	0.64	4.14	1.05	4.11
1.6.4	3.73	1.01	3.52	0.73	3.85	1.05	3.58
1.6.5	3.35	0.93	3.29	0.91	3.71	0.84	3.35
1.6.6	4.11	0.81	3.81	0.74	4.28	0.56	3.97

TABLE 10 (cont'd)

1.7 Canadian Science Policy, Current Research Emphasis in Canada and Their Interaction in a Canadian Context for Science Education

Questionnaire item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
1.7.1	3.85	0.71	3.74	0.86	4.00	0.42	3.79
1.7.2	3.38	1.06	3.64	0.63	4.00	0.57	3.65
1.7.3	3.00	1.17	3.10	1.23	3.64	0.87	3.21
1.7.4	2.94	1.05	3.09	1.14	3.57	0.67	3.16
1.7.5	2.70	1.09	2.75	0.91	3.28	0.77	2.87
1.7.6	3.23	1.18	3.14	1.18	3.57	0.45	3.27
1.7.7	2.88	0.86	2.95	1.01	3.28	0.56	2.97
1.7.8	3.82	0.91	3.83	0.81	4.00	0.35	3.83
1.7.9	3.05	0.93	3.21	1.25	3.64	0.87	3.28

TABLE 10 (cont'd)

2.1 Local Environment in a Canadian Context for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
2.1.1	4.52	0.66	4.20	0.72	4.50	0.75	4.31
2.1.2	4.47	0.83	4.27	0.68	4.60	0.73	4.74
2.1.3	4.35	0.99	4.10	0.74	4.60	0.52	4.31
2.1.4	4.44	0.95	4.33	0.44	4.60	0.52	4.42
2.1.5	3.88	0.69	3.74	0.73	4.21	0.95	3.86
2.1.6	4.52	0.36	4.08	0.66	4.53	0.39	4.25

2.2 Canadian Science Instructional Materials for Science Education

2.2.1	4.61	0.41	4.21	0.68	4.53	0.53	4.31
2.2.2	4.26	0.84	4.02	0.72	4.28	0.56	4.09
2.2.3	4.20	1.22	4.17	0.84	4.53	0.96	4.19
2.2.4	3.76	0.94	3.82	0.76	4.10	0.59	3.87

TABLE 10 (cont'd)

2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context for Science Education

Questionnaire Item Number (element)	Science Educators		Science Teachers		Others		Total Group
	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$	Variance S	Mean Score $\bar{x}$
2.3.1	3.85	0.53	4.05	0.88	4.32	0.36	4.08
2.3.2	3.91	0.61	4.01	0.79	4.25	0.61	4.01

2.4 Problems of Regionalism in a Canadian Context for Science Education

2.4.1	3.55	0.95	3.68	0.83	4.03	0.53	3.72
2.4.2	3.50	0.89	3.58	0.94	4.14	0.69	3.69
2.4.3	3.73	0.84	3.62	1.15	4.07	0.92	3.91
2.4.4	3.94	0.93	4.00	0.64	4.35	0.58	4.04

2. Summary of Free Comments on the Validation Questionnaire

In order for one to deal with over 800 comments regarding specific components of the clue structure and identify the most important points and concerns, it was necessary to employ a common strategy throughout. For each component or statement concerning the clue structure comments were summarized under the following categories:

(a) Concurrence

(b) Disagreement

(c) Suggested Clarification

(d) How to Handle the Element in a Canadian Context.

A blank under one of the above subheadings indicates that there was no comment made by the validators, or that it was difficult to derive meaning from the comments that were relevant for that element.

The code used for the clue structure components and the elements specified under them is identical with that used in the questionnaire (Appendix IV). The mean value indicated following the element and prior to the summary is the <u>total</u> group mean score from Table 10.

Most of the responses fall under the classification of Concurrence or Suggested Clarification. Under Concurrence are examples which show agreement with the question asked. These in many cases are answers to the question, rather than stating the relevance of the question. It can be assumed that because they have shown that some aspect of science education is being carried out now, and the fact that they mention it, it is considered relevant.

A number of the responses in the Suggested Clarification category imply that the question is not limited to Canadian context or that the question has little to do with Canadian context. The latter type of response was often made although the question being asked made no mention of Canadian context.

Clarification must be made for those types of questions where Canadian context is not being questioned. In this category as well are those responses which indicated that the question would have greater relevance if placed in a different category. There were also those who felt that certain ideas would be best taught in a different subject area, e.g. Social Studies. Many of the responses in this category were very useful for the final clue structure. If they do not give any specific clarifying statement they do ask thought provoking questions. These are questions that others may also ask.

There are a number of responses in the "How to Handle the Element in a Canadian Context" category, which simply mention a course name, e.g., Biology 20. A concern when trying to categorize these statements was "Does this mean it is being handled now in Biology 20, or the concept should be taught in Biology 20?" These responses have been taken to mean that the concept is now being taught in the given subject area.

It should also be recognized that the educator responding to the question is either teaching the mentioned concept or knows of it being taught. It does not mean it forms a uniform part of the curriculum throughout Canada. In spite of this it is felt these responses are best placed in this category, because it is one area being taught now. Perhaps others may also find it appropriate to teach these concepts in similar courses.

Overall, many responses are answering the question rather than stating if the question is relevant or not. A judgment had to be made on these answers based on the type of punctuation used, the question, and responses made by others. Many assumptions have to be made! For example, "No! Does this mean the concept is not being done now but is relevant, or it is not important?" Because a number of assumptions have to be made it was considered correct to place these responses in the confusion category. Confusion also resulted because the question was answered, rather than the relevance of the statement clarified.

The following summary identifies the main thrust of comments pertaining to each element under each component of the clue structure. Specific attention has been given to include those points which were significant in the consideration of the final clue structure.

1. Content Components of Science Education in a Canadian Context

1.1 Interdisciplinary Nature of Science Education

1.1.1 Is opportunity provided for richer treatment of the science, technology and society interrelationship through interdisciplinary treatment of the subject matter? (mean = 4.50)

Concurrence: Science is integral to our culture, and threads through every aspect of life. Therefore, this aspect is relevant to include in science by interrelating Canadian sciences, technology and society, certainly more than is being done now. This is important to do with or without Canadian context.

Disagreement: It is suggested this will not necessarily be achieved through interdisciplinary treatment.

Suggested Clarification: "Richer that what?" The statement does not indicate Canadian context. It is not clear whether the opportunity would be provided through interdisciplinary subject matter or an interdisciplinary treatment would provide more opportunity. Furthermore, is the interdisciplinary approach to include only the sciences, or should it include technology as well as most if not all the other subjects in the school program?

How to Handle the Element in a Canadian Context: It is being handled now in biology, general science and health in optional areas. The STS focus on national, provincial, and municipal problem areas develops a more complete awareness of the complex nature of problems and their possible or probable resolutions.

1.1.2 Is there an attempt to show that all living things interact and are interdependent upon each other and their environment and therefore lend themselves to study in an interdisciplinary manner? (mean = 3.86)

Concurrence: Interdependence is a necessary life-skill required for survival. For example, survival of the community, an ecological niche, or a species. This awareness is required to understand the complexity of society and its interactions. If this implies an "eco" type system, then the level of concept in terms of student reasoning skills is relevant. And though it is relevant within its confines, it does appear to narrow the interdisciplinary nature somewhat. It is interesting that the science described here could become one way of determining the nature of Canada.

Disagreement: There seemed to be some problems with the 'therefore...' part of this question. It would appear that biology could handle the first part of this question, however. The second part may be slightly relevant as an analogy, but otherwise it seems to have nothing to do with interdisciplinary nature of science.

Suggested Clarification: It would appear that these are not unique nor limited to a Canadian context. The interaction of living things is not unique to a Canadian setting. The portion of this question "and therefore lend themselves to study in an interdisciplinary manner" does not add anything to this statement and therefore should be removed. This would get rid of the ambiguity where the added statement seems to create two questions instead of the one. One would not be faced with the dilemma of what to do if they agree with the first part but don't agree with the second part.

How to Handle the Element in a Canadian Context:

1.1.3 Is there provision for studying functional relationships in phenomena which go beyond the individual characteristics of the parts? (mean = 3.63)

Concurrence: It is important to understand the role of individuals or parts in relation to operation of a functional unit. There is no meaning in terms of individual organisms unless each part is seen in relation to the whole.

Disagreement:

Suggested Clarification: This may or may not be specific or limited to Canadian context. There seems to be some question as to the intent of this statement. If it means going beyond the limits of one area of discipline, such as Chemistry and extending into Physics, Art, etc., then agreement would follow naturally, however this should be defined.

How to Handle the Element in a Canadian Context:

1.1.4 Is there promotion of the interrelationships of science to other facets of Canadian life in an interdisciplinary manner? (mean = 4.09)

Concurrence: This seems like a natural and there should be more. Separating science from its impact on our lives is not realistic, therefore it is necessary to include the interrelationship of science to other facets of life that is unique to the Canadian setting. It should be automatic in the sense that textbook examples would be translated to a Canadian context if they are not Canadian books.

Disagreement: The ability of scientists and those in the arts to speak together is low. There would be great difficulty encountered in expecting one to believe that this can actually be accomplished.

Suggested Clarification: The term 'facet' seems to need clarification, or definition. In this context it is simply too global. It may be beneficial to replace "...to other facets of Canadian life" with "areas of studies".

How to Handle the Element in a Canadian Context: One could look to the format followed by the Alchem materials.

1.1.5 Is there an attempt to use science, combined with aspects of social studies and Canadian studies to assist students in developing their perspectives of national identity and the role of science in defining that identity? (mean = 3.74)

Concurrence: The interdisciplinary awareness and realization that much of our national identity stems from the impact of science and technology on our lives and community, and the impact upon economic and political development are an absolute necessity. These are certainly areas that are not being attended to now. If there were no constraints from curriculum design or time, the impact of science on society could certainly be emphasized more. This may become increasingly important and relevant if the identity sees itself in a role sympathetic to minimizing the destruction of the environment.

Disagreement: This area seems to be more applicable to social studies than to science. It would seem that the phrase "combined with aspects of social studies and Canadian studies" would indicate that this is already being attended to. Also, students may not have the skills and/or the necessary background knowledge to engage effectively in such a widely focused goal.

Suggested Clarification: There seems to be more than one question involved here. This may tend to confuse the issue as to whether it relates more to technology (parochial) than science (International).

How to Handle the Element in a Canadian Context:

1.1.6 Is there promotion of an understanding and appreciation of the effect of science and technology on modern Canadian society? (mean = 4.26)

Concurrence: This is an absolutely necessary focus. People are often unaware of the necessary development of science (research) required in order for a particular technological development to occur. This may stem from the fact that teachers teach science without too much application on Canadian society. We must recognize science as an integrated part of everyone's life.

Disagreement:

Suggested Clarification:

How to Handle the Element in a Canadian Context:

1.1.7 Is there an attempt through the study of science in its social context, to examine the historical interaction of intellectual and social activities? (mean = 3.61)

Concurrence: This is certainly an excellent goal, but the question arises as to where one is supposed to get the time during the school week to be able to incorporate aspects such as this. In order to assist us in understanding ourselves in and through our science, we have to include the history of our scientific development and its affiliated groups, such as the Geological Survey of Canada.

Disagreement: Science is a human endeavour, however, upon reflection one would be more tempted to say it's applicable to other countries.

Suggested Clarification: This component may best be used in another section referring to science and society. If one was to remove "in a social context" then it might fit best under the history of Canadian science. Another alternative would be to remove the item completely because of its overlap.

How to Handle the Element in a Canadian Context:

1.1.8 Is there an attempt to bring about an understanding and appreciation of man's interrelatedness with his natural and social environment? (mean = 4.12)

Concurrence: The amount included would depend on the course itself, but it is absolutely imperative that we learn to live in harmony with nature and others. If it is in a scientific context, this would be particularly important to students.

Disagreement:

Suggested Clarification: The Canadian natural and social environment has many unique features which would serve as an excellent basis for teaching ecological interrelationships. Though respect for the environment should be of highest priority and it is absolutely necessary to understand things such as pollution and its consequences, it would seem that this could happen in other parts of the school curriculum rather than in science.

How to Handle the Element in a Canadian Context:

1.1.9 Is there assistance provided to develop intellectual tools the student may use to be productive in our rapidly changing environment such as critical-mindedness and decision-making skills? (mean = 4.11)

Concurrence: This is extremely relevant and indeed one of the necessary skills for survival of man. Not only is this area absolutely essential, but probably the most important one identified so far. Canadian science education cannot settle for simply memory work, we must teach our students how to think as well.

Disagreement:

Suggested Clarification: Although extremely important to science education, this area may not be relevant in terms of a specificity to a Canadian context. It seems it would be relevant to all science education. Are critical-mindednesses and decision-making skills specific to Canada? This question may be more appropriately placed in the methodology section of the survey or under the Inquiry cluster.

How to Handle the Element in a Canadian Context:

1.1.10 Is there an attempt to promote Canadian science education as a relevant and functional experience? (mean = 3.71)

Concurrence: This is extremely relevant assuming there is emphasis on the word "experience." Since much of science is universal, the selection of science topics and the development of these ideas relative to a Canadian focus may be an important feature.

Disagreement: In the "grand scheme of things" relevance on Canadian science education has little to do with the interdisciplinary nature of science.

Suggested Clarification: "Relevant and functional" seems to be quite open to interpretation. It has not been shown that people really know what Canadian science education is! Concepts are world-wide — context examples may be Canadian. We may be better off dealing with high priority items, which will lead to the "useful, constructive, or positive" items usually following or occurring as a by-product.

How to Handle the Element in a Canadian Context:

1.2 <u>Canadian Science - Canadian Society Interaction</u>

1.2.1 Is there provision for demonstrating to students why they should take science? (mean = 4.06)

Concurrence: This is extremely relevant for any science course. Members of society must understand the relationship between science and society. The relevance of science in one's life for young people should be developed through their innate curiosity. The audience is captive, and the challenge is to keep their attention! Through inquiry, as with the introduction of any concept, teachers can take advantage of the situation.

Disagreement:

Suggested Clarification: The question 'Why should I?' can only be answered appropriately by the students. We cannot answer that for them. By simply showing them that it is important — the objective will informally be realized. There may be no need to make it formal as it can be shown through the methodology employed. It may be clearer if "Why they should take" is replaced with "The benefit derived from taking".

How to Handle the Element in a Canadian Context:

1.2.2 Is attention given to the effects that science and technology have had on the workplace? (mean = 4.05)

Concurrence: Science and technology are often separated in people's thinking. In order to develop competitiveness in a world trade market, it is important to understand this idea. This reflects a need for curricula to start presenting relevant applications.

Disagreement:

Suggested Clarification: If the effects of science and technology within the workplace are to be studied, then we might ensure that the ills as well as the benefits are included. If we ensure that the emphasis is on Canadian problems, within the context of specific examples attention will be directed to the relationship between the nature of science and one's life.

How to Handle the Element in a Canadian Context:

1.2.3 Are students encouraged to discuss social issues from a scientific and technological perspective? (mean = 4.20)

Concurrence: All issues are complex and in order to understand the issue, all variables must be considered in order to establish a resolution that is most appropriate. As new courses are revised and developed, this emphasis should be implemented.

Disagreement:

Suggested Clarification: This may come only as a result of emphasis placed on the technological nature of our culture. It will occur only as a result, not necessarily as an objective.

How to Handle the Element in a Canadian Context:

1.2.4 Are students encouraged to approach social problem-solving which includes considering the impacts of science and technology on the quality of human existence and the biosphere? (mean = 4.13)

Concurrence: We already experience a great quality of life, it is now important to learn to share the collective benefits to improve quality of life for all on this earth.

Disagreement: Most students will not be in a position that requires this skill. It could certainly be considered a long-range priority but for now it might be best to table it.

Suggested Clarification: This element seems to need a little more definition. One is left to wonder exactly what "approach" means.

How to Handle the Element in a Canadian Context:

1.2.5 Is there provision for development of an understanding and appreciation of the relationship between science and Canadian society? (mean = 3.81).

Concurrence: This is extremely relevant but an element that certainly begs definition in terms of understanding what this relationship actually is. It may be manifested in a relationship with science and Canadian society within the Western Hemisphere and world society.

Disagreement:

Suggested Clarification: There does not seem to be much distinction between this element and the element identified in 1.2.6. It may be best to combine the two.

How to Handle the Element in a Canadian Context:

1.2.6 Is there attention given to the impact that science and technology have on Canadian society and culture? (mean = 4.01)

Concurrence: Students cannot study science for the sake of science. They must realize the impact of things like genetic engineering.

Disagreement:

Suggested Clarification: There seems to be some overlap between this element and 1.2.5. In 1.2.5 "provision for development of an understanding and appreciation of a relationship" makes the statement more relevant where in 1.2.6 the importance considered is less.

How to Handle the Element in a Canadian Context:

1.2.7 Are there ample examples and illustrations of this impact from contemporary Canadian life? (mean = 3.86)

Concurrence: Unless the student has first-hand experience, examples from the present are nearly as distant or foreign as those in the past. This is extremely relevant, however, much of the problem of non-implementation of this element is because examples are difficult to find and are not included in textbooks.

Disagreement:

Suggested Clarification: It is unclear whether the impact refers to the previous elements, this should be stated specifically. One might include "of this science and technology impact."

How to Handle the Element in a Canadian Context:

1.2.8 Is there an attempt to portray science education as part of our total Canadian culture? (mean = 3.68)

Concurrence:

Disagreement:

Suggested Clarification: The question seems to arise as to whether science education is a part of culture or a way of creating and sustaining it. We may not need to portray science education as important, rather as educators we can show how dramatically science affects students' lives.

How to Handle the Element in a Canadian Context:

1.2.9 Is science presented in a way which promotes getting to know ourselves and our universe? (mean = 3.89)

Concurrence: This is not only quite relevant for any science program but it is also important to human existence.

Disagreement:

Suggested Clarification: "To know ourselves" really needs more definition. Does this mean it is specific to Canada or possibly more universal and not limited to Canadian context.

How to Handle the Element in a Canadian Context: The media treatment of science should be upgraded in terms of resources for classrooms. This would assist in promoting this element.

1.2.10 Is science and technology depicted as a consideration in the economic and political situation in Canada? (mean = 3.69)

Concurrence: We should attempt to show how research and development is integral to our development as a culture and therefore must be backed politically and economically (financially).

Disagreement:

Suggested Clarification:

How to Handle the Element in a Canadian Context:

1.2.11 In a science class — is attention given to the scientific, technological and social problems facing Canada and the world, and ways of resolving these issues? (mean = 4.27)

Concurrence: Our future politicians, scientists, problem solvers and leaders are in the classroom today. It is imperative that we provide the basis for focussing attention to the scientific, technological and social problems facing Canada and the world.

Disagreement: This is an advanced notion and requires much knowledge and skill in a variety of areas on the part of the student. It may be much too complex for junior high school students.

Suggested Clarification: "Coping with" may be better than "resolving." It should be clarified as to whether this really means science and/or the technology-related social issues.

How to Handle the Element in a Canadian Context:

1.2.12 Is attention given to process of decision-making for resolving science-related social problems? (mean = 3.90)

Concurrence: These processes are very important and extremely relevant for any science course. Decision making is a necessary skill in the information laden society. It not only applies to science education in Canada but also to all science education no matter what country you are from.

Disagreement:

Suggested Clarification: How does a class discuss the methods by which science can help to solve Canadian or world problems when the students know little or no science? It seems that this is almost "motherhood and apple pie" in that one cannot speak against it but seems very impractical when teachers/professors are not interdisciplinary in their background or often interests. This may be more relevant for the social studies program.

How to Handle the Element in a Canadian Context:

1.2.13 Is there attention given to the variety of roles that high school students as adults will play in Canadian society in the future and how science can prepare them for those roles? (mean = 3.97)

Concurrence: There needs to be a clear understanding of diversity of opportunity and responsibility and the role of science on quality of life experienced. This can bring new life to the classroom and hopefully leadership in the future, however at the present time high school sciences leave the students quite inadequately prepared.

Disagreement: It is not the school's job to train people for adult jobs and roles. Let trade schools and universities do this. Besides, by the time texts are printed they are outdated and any thought of including this element is an extremely idealistic expectation.

Suggested Clarification: We may not be able to safely predict what students' needs will be in terms of science in the future. General skills, rather than specific training is certainly safe. Society is being reshaped — training quickly — it's difficult to predict what will be relevant 10 years from now. We also need more emphasis on the roles for women in science and technology.

How to Handle the Element in a Canadian Context: An interdisciplinary course (e.g., a general science course) should have a component that shows how many occupations are science and/or technology related.

1.3 History of Canadian Science

1.3.1 Is there attention given to the many important Canadian achievements in science? (mean = 3.90)

Concurrence:

Disagreement: Presumably this is of little value in making such judgements. One must ask the question "Are Canadian achievements important?".

Suggested Clarification: The emphasis could better be placed on present situations. Historical perspectives might best be left on the back burner. Since major developments publicized are American, how does one determine what important achievements really are?

How to Handle the Element in a Canadian Context:

1.3.2 Is there attention given to the impact that science/technology have had historically upon Canadian life? (mean = 3.76)

Concurrence: It is certainly important to understand the growth of a nation and how that has determined our present situation.

Disagreement:

Suggested Clarification: It may be difficult to separate impacts on Canadian life as being distinct from that in other countries, but impact on the lives of students in a class would be readily dealt with. The element might better reflect this.

How to Handle the Element in a Canadian Context:

1.3.3 Is there promotion of an appreciation of the part played by scientific breakthroughs, both at home and abroad, in shaping and making possible the development of this country? (mean = 3.71)

Concurrence: Students should be shown just how much they owe to science and technology.

Disagreement: Scientific breakthroughs are often illusory, or virtually fictional. They are frequently overemphasized as scientific knowledge usually evolves. Science is a world community endeavour upon which no one has a monopoly and therefore these scientific breakthroughs are difficult to define in terms of roles in a more localized setting.

Suggested Clarification: "Appreciation" is not operationally stated and "of this country" is too narrow. There is a great deal of ambiguity which seems to arise here since we must point out that we cannot deal with Canadian science in isolation and since all the Canadian scene deals with other countries — must we study everything? Remove it.

How to Handle the Element in a Canadian Context:

1.3.4 Is there an attempt to develop in students an awareness and appreciation of the significant role of Canadian scientists and technologists in Canada's growth and development? (mean = 3.90)

Concurrence: We really don't discuss the Canadian scientists. There is too little development of a national identity and pride in our nation. The opportunity to learn more about Canadian scientists would certainly change this.

Disagreement:

Suggested Clarification: "In Canada's growth and development" is only one area, are there others? " Awareness and appreciation" should be redefined in measurable terms.

How to Handle the Element in a Canadian Context:

1.3.5 Is there acknowledgement of early Canadian achievements in science, which included the :apping of resources, identifying and classifying species, and exploring the natural history of the land as a prelude to settlement? (mean = 3.56)

Concurrence:

Disagreement: This aspect certainly wouldn't impress students. it would require a redefinition of what science is — at least for most students. The way this element is stated it is certainly inclusive, but to the point of being so ambiguous that one doesn't know whether it applies to present day science.

Suggested Clarification: This area should be integrated with Social Studies. In fact it is done in most junior high school Social Studies courses.

How to Handle the Element in a Canadian Context:

1.3.6 Is there attention given to the significant contributions made by Canadian scientists to international science? (mean = 3.83)

Concurrence: Science operating in a world community is not only an importa.t understanding but an essential one. One may be strapped to find examples within this area though.

Disagreement:

Suggested Clarification: International science needs a definition.

How to Handle the Element in a Canadian Context:

1.3.7 Are advances in science presented as being due to the community which surrounds the scientists as well? (mean = 3.29)

Concurrence: Science progress does result from cooperative study and effort. If this refers to the community of other scientists, technicians and public support then it is applicable.

Disagreement: One is hard-pressed to try to understand this question. There is a great amount of ambiguity in determining what exactly we mean by "the community which surrounds the scientists."

Suggested Clarification: This refers specifically to the degree of awareness the society has towards the value of research and development of scientific and technological things. It would seem that <u>this is not a suitable element</u> to be included under the history of Canadian science.

How to Handle the Element in a Canadian Context:

1.4 <u>Philosophy Underlying Canadian Science</u>

1.4.1 Is there an attempt to make science relevant in personal terms and also develop social conscience? (mean = 3.91)

Concurrence: This is certainly an important area but one which must also be done in terms of using the global perspective because we are very dependent on the world scene.

Disagreement: High school and junior high school kids often aren't <u>aware</u> of the part they play in society — they don't <u>have</u> a broad picture. Therefore it may be impossible to make science relevant in personal terms and develop a social conscience.

Suggested Clarification: Delete "and also develop social conscience" since this is a separate question. One is begged to ask what "relevant in personal terms" and "social conscience" really mean. They seem to be exclusive ideas and therefore better dealt with in two questions.

How to Handle the Element in a Canadian Context: An interdisciplinary course would seem to facilitate making science relevant in personal terms and developing social conscience.

1.4.2 Is opportunity provided for discussion of the nature of science providing a cautious view of knowledge which makes us mindful of the limitations of human knowledge? (mean = 4.02)

Concurrence: This is extremely relevant to science in general and more specifically to a Canadian context. This is one area which is not dealt with enough. Students a led to believe that science explains most things. This is probably due to the fact that the study of most science in schools is still a preview of much of what of <u>is</u> known.

Disagreement:

Suggested Clarification: What are the limitations of human knowledge? One must take a look at the language used and ask whether it is consistent with the nature of science, i.e., "within the limits of" and "it is generally accepted that."

How to Handle the Element in a Canadian Context:

1.4.3 Is an attempt made to allow students to approach questions of values and ethics without feeling threatened? (mean = 3.71)

Concurrence: This is very relevant but could, and should, be dealt with primarily by the family. In terms of scientifically related values and ethics — e.g., values on ecology and the protection of the environment — we must definitely treat these aspects as necessary components of science education.

Disagreement: The opening views of various values orientations and ethics are the cause of much misunderstanding and argumentation. We must ask whether values ought to become a <u>major</u> aspect of science. We may not want to make education do more than it should. In junior high school in particular some topics are beyond the level of actual involvement — i.e., abortion, test-tube babies, etc..

Suggested Clarification: We must consider whose "ethics and values." Does one mean — are such issues treated from several points of view? It is necessary to make it clear that more than one approach may be valid.

How to Handle the Element in a Canadian Context:

1.4.4 Is there an attempt to show how historical and social influences helped to determine how science was launched, developed and utilized in Canada? (mean = 3.44)

Concurrence: This focus is necessary to be scientifically literate.

Disagreement: This seems not to be that relevant for Canada. Many historians are not fond of science and could actually be considered to detest it. To state they must now cover this aspect of history would cause great fireworks.

Suggested Clarification: In its present form, this element is too specific and related to others. In Canada may be too narrow — why not include all of the world but do include Canada. It could also be extended or developed toward present-day factors. No matter how it is treated, it would probably be better in Section 1.3.

How to Handle the Element in a Canadian Context:

1.4.5 Are examples of our scientific legacy from other countries such as Britain provided; i.e., the ideology and educational practice of the Scots who believed that science was not only a tool for the understanding of nature, but also as a tool for the enrichment of mankind through development and exploitation of nature? (mean = 3.11)

Concurrence: An example of this would be the series "A Planet for the Taking" by David Suzuki, a super show.

Disagreement: So far, technology has all but ruined the environment. Students should be given an attitude of rejuvenation. The emphasis may be best spent on the present and future rather than on the past. As well, this emphasis on exploitation smacks of Judeao-Christian values where nature is for our use and exploitation.

Suggested Clarification: The word exploitation seems inappropriate. It has some very negative selfish meanings in modern language. With the example provided, this element seems specific to something totally different than to what it being dealt with here and begs responses that have little to do with science education in Canada. There is a strong overlap with thrusts of Section 1.3 and therefore should be removed.

How to Handle the Element in a Canadian Context:

1.4.6 Is attention given to factors which contributed to give science its special place in Canadian society and culture such as the confrontation with the land and entrepreneurial ideology? (mean = 3.13)

Concurrence: If one is to ask if science has a special place in Canadian society they may indeed respond positively but 0.75% of Gross National Product does not reflect a "special place."

Disagreement: This element is worded in ivory-tower language. Not only is the meaning of the question very unclear but use of terms such as "special" gives strong impressions of elitism.

Suggested Clarification: It would seem that aspects of this element are included in Section 1.3. It should be clarified whether entrepreneurial ideology is actually related to science.

How to Handle the Element in a Canadian Context:

1.4.7 Is there attention given to how the science that emerged was in turn significant in shaping Canadian society and culture? (mean = 3.30)

Concurrence: This is important if we are speaking of the transition from agricultural science to industrial technological processes.

Disagreement: A number of American ideals have been taken on and should not necessarily be reinforced in science education.

Suggested Clarification: The way this is worded it appears to be much too narrow — it may be better served including all of society of which Canadian is a part. There seem to be delimitations to "significant." As well, is science shaped by society and culture or is it society and culture that is shaped by science? Is this element asking if the science is the same as the science out — and account for any differences? No matter what the answer, these aspects would be better dealt with in Section 1.3 or removed.

How to Handle the Element in a Canadian Context:

1.4.8 Is there attention given to the adoption and adaptation of laboratory technology and science to the solution of Canadian problems? (mean = 3.53)

Concurrence: If we are speaking to the solution of problems, then this is extremely relevant and if we are speaking to Canadian problems, then it is relevant, within that framework.

Disagreement: Who is to define "solution of Canadian problems"? Whose belief is to be reflected in this and can one actually state that there is a "solution."

Suggested Clarification: "Laboratory science and technology" should be defined. Does it mean all non-applied science? In terms of being relevant for junior or senior high school science, too few students are capable of utilizing these skills, and therefore the universities should be left to do this.

How to Handle the Element in a Canadian Context:

1.4.9 Is there attention given to the generation of a first approximation to Canadian science — a Canadian adaptation of European science as related to production and its grounding in the material realities of Canadian life? (mean = 2.75)

Concurrence:

Disagreement: This element as worded is simply meaningless jargon.

Suggested Clarification: There seems to be great confusion surrounding this element. If aspects are to be incorporated at all, they should be placed in Section 1.3 but certainly <u>would be better off disposed of</u> since it seems to be redundant and too ambiguous for use here.

How to Handle the Element in a Canadian Context:

1.4.10 Is there an attempt to show how scientific societies and associations of scientific professionals provided the early organizational framework for Canadian science? (mean = 2.81)

Concurrence: If we use the Geological Survey of Canada, which succeeded, then there is certainly a place for this. However, if we use the Royal Society of Canada, which failed, then one must asked if it had the same impact.

Disagreement: Who cares?

Suggested Clarification: This element as worded would be better off incorporated in Section 1.3. However, not only does this seem relevant only at a university level, but it is also very misleading. If one were to check, they may find the scientific societies and associations did not provide an early organizational framework but instead of leading, they often reacted to situations. It may be best deleted.

How to Handle the Element in a Canadian Context:

1.4.11 Is there an attempt to develop an awareness of the tradition in which science is done in Canada? (mean = 3.19)

Concurrence:

Disagreement:

Suggested Clarification: Usually students are not interested in these types of history questions in science. Students want to know — "How can this information be used and will I need to know this in the future?" so it would not be very effective. This element also seems to have been dealt with in Section 1.3 and therefore is redundant. This elements begs too many questions to be effective in this form or in this section.

How to Handle the Element in a Canadian Context:

1.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.5.1 Are students encouraged to understand the nature of both pure science and of applied science (technology) and the manner in which they serve as a bridge between science and society and act as a unifying force between the various disciplines? (mean = 3.55)

Concurrence: This is certainly relevant to a Canadian context, however teachers do not often deal with this difference.

Disagreement: This is simply a low priority in the actual way we teach.

Suggested Clarification: Too much ground may be covered in this question. It may be better off breaking this into two parts by removing "and act as a unifying force between the various disciplines." A better idea still is to simply remove this part from the question since there are serious questions as to whether it actually works.

How to Handle the Element in a Canadian Context: This is a theme which is carried out in many elementary school primary grades and should probably be incorporated in this junior and senior high school level. It could be considered to be the crux of the science-technology-society focus.

1.5.2 Is there an attempt to show the relationship of pure and applied science in terms of science attempting to describe the world while technology is the means by which humans adapt the environment to suit their needs? (Mean = 3.73)

Concurrence: This is extremely important but some question is raised as to whether it is limited to Canadian context. If it is a Canadian context within a global context then it is certainly one which requires even more support.

Disagreement:

Suggested Clarification: Not everyone will agree with the definition of technology presented here. If the statement implies the definition of the purposes or outcomes of science and technology then many will certainly not be in agreement with that definition. There may be an artificial distinction at work here and should be clarified.

How to Handle the Element in a Canadian Context:

1.5.3 Is there an attempt to include issues of pressing national concern relating to science and technology in the classroom experience of students? (Mean = 3.09)

Concurrence: Major ecological problems (e.g., acid rain) must be emphasized — the sooner the better. Technological advancements are probably the most exciting and most important at this point in time. One would have to ensure that these are strongly related to science and technology, since a social studies overlap probably wouldn't be acceptable.

Disagreement:

Suggested Clarification: "Pressing" should be removed since there appears to be no need to qualify it. Students should also include issues which may not be necessarily perceived as pressing. A check should be made to see whether this would better fit under Science and Society Section 1.2.

How to Handle the Element in a Canadian Context:

1.5.4 Is there an attempt to use applied science to put science concepts in everyday affairs where the student may confront them? (Mean = 4.01)

Concurrence: This will probably be a by-product of a well designed science program. The types of science concepts which should be included should focus on ecologically-related aspects such as acid rain and pollution.

Disagreement:

Suggested Clarification: There is also a need to experience the impact of technology. This is better stated in Section 1.5.5. Would it be better if there is an attempt to place students in situations where they may use applied science to study relevant science concepts?

How to Handle the Element in a Canadian Context:

1.5.5 Is there an attempt to make students aware of how "applied science" can be used to interpret critically what is taking place around them? (mean = 3.95)

Concurrence:

Disagreement:

Suggested Clarification: Is it not pure science that interprets? This applies more for pure science than the black boxes of applied science.

How to Handle the Element in a Canadian Context:

1.6 Science as Inquiry

1.6.1 Is inquiry promoted as a major element in scientific literacy? (mean = 4.19)

Concurrence: It would appear that this is our *raison d'etre*. It would appear that this not only reflects Canadian context but the nature of science itself no matter where it is being taught. This is extremely relevant and important for all science courses.

Disagreement:

Suggested Clarification: Will all science teachers really know what 'Science as Inquiry' means, as well as "scientific literacy"? These may need defining.

How to Handle the Element in a Canadian Context:

1.6.2 Is the learning of science as inquiry promoted? (mean = 4.18)

Concurrence: This again is extremely relevant for all sciences. There seems to be some movement in this direction with more emphasis placed on inquiry and lab work at all levels.

Disagreement:

Suggested Clarification: It is necessary to define what the difference is here between this and the prior question 1.6.1.

How to Handle the Element in a Canadian Context:

1.6.3 Is learning science by inquiry (often designateed as process) promoted? (mean = 4.11)

Concurrence: It could not be argued that it is not important.

Disagreement: At the junior and senior high school level, the inquiry approach can be handled by only a few select students.

Suggested Clarification: "Inquiry" and "Process" are not identical and therefore require definition. This element seems to be redundant and basically the same as the one preceding 1.6.2 and also 1.6.1: these should be combined.

How to Handle the Element in a Canadian Context:

1.6.4 When dealing with specific achievements of Canadian scientists, is attention being paid to the methods of inquiry used (for example, in the form of case studies) and to the social, economic and political circumstances making the achievements possible? (mean = 3.58)

Concurrence:

Disagreement:

Suggested Clarification: This may be extremely relevant however results are noted more so than the inquiry technique used. In retrospect, the process often exists only in the mind of the author anyway. It may be of dubious value. Do we really know the methods of inquiry used?

How to Handle the Element in a Canadian Context:

1.6.5 Are Canadian discoveries related to the total discipline as being developed internationally? (mean = 3.35)

Concurrence: Understanding the discipline is of most significance when all its relationship are included.

Disagreement: As it stands, this would involve total knowledge of all human existence!

Suggested Clarification: This question seems totally out of context with inquiry. This question may have some aspects related to Section 1.3 but should be removed from this area.

How to Handle the Element in a Canadian Context:

1.6.6 Are students given opportunities to apply inquiry strategies when dealing with pressing Canadian problems which require a scientific/technological solution (e.g., in environmental degradation, resource depletion)? (mean = 3.97)

Concurrence: These are extremely relevant for all problems including those we label as Canadian. Problem solving strategies should be employed without risk and included as a major priority in a school science program.

Disagreement: Average adults do not have the faculties to apply "inquiry strategies" on their own, so how does the average student?

Suggested Clarification: Though these are more than just Canadian problems and their importance cannot be questioned, they may not be applicable at high school age or for development for most students below this level.

How to Handle the Element in a Canadian Context:

1.7 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

1.7.1 Are students encouraged to become aware of the effects science and technology have on them and on Canada's position in the world community? (mean = 3.79)

Concurrence: This should be a major priority.

Disagreement:

Suggested Clarification: "on Canada's position in the world community" could be removed as it seems to be a subsidiary question.

How to Handle the Element in a Canadian Context:

1.7.2 Are students encouraged to understand and appreciate why there is emphasis on certain areas of research in pure and applied science? (mean = 3.65)

Concurrence: This is excellent, in particular in the high school grades, since most will soon be a voting public. Unfortunately, it is mainly left to teachers to determine the extent to which this will happen and all we can do is hope that it is being done through physics, chemistry and biology. We must focus on careers and possible research focus.

Disagreement:

Suggested Clarification: This could also be extended to include whether it reflects trends or how long these emphases would last.

How to Handle the Element in a Canadian Context:

1.7.3 Is a simplified treatment of Canadian science policy included in the science curriculum? (mean = 3.21)

Concurrence:

Disagreement: Is there such a thing Canadian science policy? We don't seem to have one and therefore this element doesn't make any sense whatsoever.

Suggested Clarification: Since one cannot readily define what we mean by this policy, whether it is Canadian science policy, political policy or academic policy, it might be best to integrate into other aspects of questions or <u>leave out altogether</u>. If one were to attempt to look at the definition of 'simplified' we must define then what degree/extent or emphasis we would include, and at these levels of learning for students in science education it may be totally irrelevant.

How to Handle the Element in a Canadian Context:

1.7.4 Is there inclusion of the science policy debate which has existed in Canada since the early 1960's with the original objective being to devise mechanisms by which we could more effectively "use science in the service of the nation

and include mobilization of scientific effort to solve perceived national problems"? (mean = 3.16)

Concurrence:

Disagreement:

Suggested Clarification: If this question were to be used, it must be broken into smaller bite-sized pieces, since right now it is too long. Since there doesn't seem to be a real debate and the emphasis has changed to more of the social effects of science, this seems to open the door for science to be used politically. Stop after "the early 1960's." In this way, 1.7.5 to 1.7.7 all fit into this category. These should all be combined in some way.

How to Handle the Element in a Canadian Context:

1.7.5 **Are students informed of the milestones in this science policy debate and the dynamics of science policy formulation?** (mean = 2.87)

Concurrence:

Disagreement: No. This is totally irrelevant.

Suggested Clarification: One question would be sufficient in 1.7.5 to 1.7.7. Too many definitions would be required within this statement to make it readily applicable to science education. If it can't be combined, delete it.

How to Handle the Element in a Canadian Context:

1.7.6 **Are the determinants of Canadian science policy addressed: concern with the survival and maintenance of the nation, strengthening of indigenous technology in order to eventually make our 'branch plants' independent, a concern for our environment, maintaining the status of academic science, etc.?** (mean = 3.27)

Concurrence:

Disagreement:

Suggested Clarification: This element would better be included in a social studies program and not necessarily within this context.

How to Handle the Element in a Canadian Context:

1.7.7 Are changes in science policy in Canada over the past decade addressed: "mission" or "task-oriented" research, increased involvement of provinces in pure and applied research, development of special institutes or centers for applied research, tax write-offs for research done by industry, etc.? (mean = 2.97)

Concurrence:

Disagreement: Since most are not aware of any of these, this is totally irrelevant.

Suggested Clarification: This sounds more like a social studies topic, and even if it was science, where would one find out about these?

How to Handle the Element in a Canadian Context:

1.7.8 Are areas identified as being of specific interest and benefit to Canada included: communication, management of the oceans (especially the Arctic), transportation, oil and gas technology for severe climatic and geographic conditions, resource development, etc.? (mean = 3.83)

Concurrence: Though it may not be relevant for all courses, there is a definite need for more information regarding career development and research focus in science.

Disagreement:

Suggested Clarification: These topics may better be associated with social sciences unless it is clarified that we are dealing with the science component of them.

How to Handle the Element in a Canadian Context:

1.7.9 Is assessment of the adequacy of Canada's science policy considered: why research and development support for pure science is so low, why Canada has the lowest science budget as a percent of the GNP of all the OECD countries, why governments are increasingly dictating the kind of pure and applied research being done, etc.? (mean = 3.28)

Concurrence:

Disagreement: It is questionable that it is a teacher's place to openly question the appropriateness of current policy or that such a political science focus should be included in science education.

Suggested Clarification: This might turn kids away from science or it might spin them on to pressure governments. This question and element would be better left to the university level and therefore may not be appropriate for inclusion here. Consider removing it.

How to Handle the Element in a Canadian Context:

2. Methodological Components of Science Education in a Canadian Context

2.1 Maximum Use of the Local Environment

2.1.1 Are students encouraged to relate abstract knowledge to concrete situations which they have encountered? (mean = 4.31)

Concurrence: This is very important in science instruction but must also be considered within a Canadian context if we are to make science interesting for students and thereby entice them to enhance their ability to think.

Disagreement:

Suggested Clarification:

How to Handle the Element in a Canadian Context: In-service is essential!

2.1.2 Are opportunities for experiences and examples provided which will serve as concrete illustration and reinforcement of the science concept being learned? (mean = 4.74)

Concurrence: This is extremely relevant for any science where it is necessary to include experiences and examples.

Disagreement:

Suggested Clarification: One could include Canadian experiences and Canadian examples as well as an emphasis at a local level.

How to Handle the Element in a Canadian Context: In-service is essential!

2.1.3 Are students encouraged to develop a deep understanding and appreciation of the natural and social world in which they live? (mean = 4.31)

Concurrence:

Disagreement:

Suggested Clarification: It is difficult to understand what "deep understanding and appreciation" means, therefore remove the word 'deep'.

How to Handle the Element in a Canadian Context: In-service is essential!

2.1.4 Are students required to apply basic scientific laws and concepts to the study and understanding of their immediate environment? (mean = 4.42)

Concurrence: This should be a part of <u>any</u> curriculum.

Disagreement: Your average student cannot handle the scientific laws and concepts, let alone apply them in a creative study of their immediate environment.

Suggested Clarification: The focus of this element may be changed to an ability to observe practical applications.

How to Handle the Element in a Canadian Context:

2.1.5 Are students required to deal with topics and problems of current local scientific significance and to take feasible action on suggested solutions? (mean = 3.86)

Concurrence:

Disagreement: This would cost millions of dollars — or simply is not feasible without resources.

Suggested Clarification: "Feasible action on suggested solutions" should be defined.

How to Handle the Element in a Canadian Context:

2.1.6 Are students encouraged to develop a commitment to the careful use of natural resources in Canada and to the preservation and improvement of their environment? (mean = 4.25)

Concurrence: Effective and efficient use of resources and the development of responsibility to future generations is an absolute necessity.

Disagreement:

Suggested Clarification: Is it possible to state this in some other way where it would not be such a motherhood statement?

How to Handle the Element in a Canadian Context:

2.2 <u>Canadian Science Instructional Materials</u>

2.2.1 Are provisions made for inclusion of locally produced instructional materials for teaching science in a Canadian context which meet the following criteria? It contains Canadian content that students can relate to their own life and environment; i.e., it must be highly relevant to students. (mean = 4.31)

Concurrence: These are motherhood statements but absolutely necessary.

Disagreement: Not all science can be highly relevant to students.

Suggested Clarification: What is wrong with studying science for its own sake?

How to Handle the Element in a Canadian Context:

2.2.2 It includes, wherever relevant, information on Canadian science and scientists, the Canadian science - society interrelationships, etc.. (mean = 4.09)

Concurrence:

Disagreement: This is not necessary for all science courses.

Suggested Clarification: It should be noted that this can only be to the extent that local advances have an affect on the larger aspects.

How to Handle the Element in a Canadian Context:

2.2.3 It is of high quality in terms of content selection, organization and presentation. (mean = 4.19)

Concurrence: This is absolutely essential. How could anyone consider anything else?

Disagreement:

Suggested Clarification: Does this necessarily have to be specific to Canadian context?

How to Handle the Element in a Canadian Context:

2.2.4 It contains explicit messages that are congruent with teaching science in a Canadian context. (mean = 3.87)

Concurrence:

Disagreement: No. Explicit messages must not be confused with dogma.

Suggested Clarification: What does explicit mean? This question does not properly reflect the kinds of messages that have been contained within this clue structure. It would be better to leave it out.

How to Handle the Element in a Canadian Context:

2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context

2.3.1 If produced outside Canada, are revisions possible for inclusion of Canadian emphasis, examples, activities, etc.? (mean = 4.05)

Concurrence: This is quite relevant but must be considered with hesitation. Revisions made just to please the need for Canadian context can reach the point of absurdity. There is no need to eliminate good foreign examples and replace them with poor Canadian ones.

Disagreement: We should not have to produce the materials outside of Canada and adapt them to have some Canadian emphases. We should be producing our own.

Suggested Clarification: We must define what we mean by foreign. Is this material relating to flora, fauna, environment, or general ecology, because if they are, then they would be more useful in B.C. if they are from Washington State or even Alaska than "Canadian stuff" from Ontario.

How to Handle the Element in a Canadian Context: Include it directly in departmental policy in dealing with curriculum materials.

2.3.2 In the case of good foreign instructional materials that have not been revised, are teachers' guides available to show how the materials can be used (e.g., by appropriate supplementation) more in line with Canadian educational circumstances and needs. (mean = 4.01)

Concurrence: This is an absolute necessity.

Disagreement: It has to be in the student materials as teachers don't read teachers' guides. We should be using Canadian materials anyway.

Suggested Clarification: Criteria must be established for what we mean by 'good'.

How to Handle the Element in a Canadian Context:

2.4 Problems of Regionalism

2.4.1 Is there opportunity provided for development of a national conception of this country's scientific and technological needs? (mean = 3.72)

Concurrence:

Disagreement:

Suggested Clarification: It may be best to consider national <u>and</u> local needs.

How to Handle the Element in a Canadian Context:

2.4.2 Is there an attempt to bring the unique problems of each of the major areas in Canada together into one context — a Canadian context? (mean = 3.69)

Concurrence: It is important to understand the great diversity of the nation and the need for interdependence to ensure survival.

Disagreement: Some regional problems may be regional problems.

Suggested Clarification: It's necessary to identify these unique problems as science-based problems.

How to Handle the Element in a Canadian Context: This may best be served in courses such as Ecology 20 where one looks at the terrestrial region's pollution problems in terms of the science involved.

2.4.3 Are students encouraged to understand and appreciate the regional differences that exist in Canada? (mean = 3.91)

Concurrence: This must be done, but carefully.

Disagreement:

Suggested Clarification: The regional differences that are being alluded to must be described in terms of science or technology. Otherwise, if it doesn't involve anything scientific it should be put into social studies.

How to Handle the Element in a Canadian Context: Cultural exchanges, including scientific applications, are needed.

2.4.4 Is there an attempt to show that all of the regions of Canada are interrelated through such concerns as climate, energy production and use, protection of the environment, and development and use of resources? (mean = 4.04)

Concurrence: These factors contribute greatly to regional disparity and therefore are essential to include in any discussion about the application of science in Canada.

Disagreement:

Suggested Clarification: This element seems to be focussing on exactly the same thing encountered in 2.4.2. The two elements should be combined into one.

How to Handle the Element in a Canadian Context:

APPENDIX VI

Final Draft of the Clue Structure

Clue Structure for 'A Canadian Context for Science Education'

The elements for teaching science education in a Canadian context include the following:

1. Content Components of Science Education in a Canadian Context

1.1 Interdisciplinary Nature of Science Education

1.1.1 Treatment of the science, technology and society interrelationship through interdisciplinary treatment of the subject matter.

1.1.2 Through an interdisciplinary treatment, show that all living things interact with and are interdependent upon each other and their environment.

1.1.3 Study of the functional relationships in phenomena which go beyond the individual characteristics of the parts usually studied within the limits of one discipline.

1.1.4 Interdisciplinary descriptions of the interrelationships of science to other facets of Canadian life.

1.1.5 Use of science to assist students in developing their perspectives of national identity and the role of science in defining that identity.

1.1.6 An understanding and appreciation of the effect of science and technology on modern Canadian society.

1.1.7 An understanding and appreciation of humankind's interrelatedness with the natural and social environment.

1.1.8 Development of intellectual tools the student may use in our rapidly changing environment such as critical-mindedness and decision-making.

1.1.9 Make Canadian science education a relevant and functional experience.

1.2 Canadian Science - Canadian Society Interaction

1.2.1 Demonstration to students of the benefits derived from taking science.

1.2.2 Study the effects (ills and benefits) that science and technology have on the Canadian workplace.

1.2.3 Discussion of Canadian social issues from a scientific and technological perspective.

1.2.4 Introduction to social problem-solving which includes considering the impacts of science and technology on the quality of human existence in the biosphere.

1.2.5 Study of the relationship between science and technology and Canadian society and culture.

1.2.6 Use of examples and illustrations of the impact of science and technology from contemporary Canadian life.

1.2.7 Portrayal of science as part of the total Canadian culture.

1.2.8 Presentation of science in a way which promotes getting to know ourselves and our universe.

1.2.9 Offering science and technology as a consideration in the study of the economic and political situation in Canada.

1.2.10 Attention to the scientific, technological and social problems facing Canada and the world, and ways of resolving these issues.

1.2.11 Attention to the various points of view concerning processes of decision-making for resolving science- related social problems.

1.2.12 Attention to the variety of roles that high school students as adults will play in the future Canadian society and how science can prepare them for those roles.

1.3 History of Canadian Science

1.3.1 Attention to the many important Canadian achievements in science.

1.3.2 Attention to the impact that science/technology had historically upon Canadian life.

1.3.3 Study of the significant role of Canadian scientists and technologists in Canada's growth and development.

1.3.4 Attention to the significant contributions made by Canadian scientists to science internationally.

1.4 Philosophy Underlying Canadian Science

1.4.1 Make science relevant in personal terms.

1.4.2 Portray the nature of science as a cautious view of knowledge, making us mindful of the limitations of human knowledge.

1.4.3 Investigation of questions of values and ethics related to science without feeling threatened.

1.4.4 Develop social conscience related to science and technology.

1.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.5.1 Study the nature of both pure science and of applied science (technology) and the manner in which they serve as a bridge between science and society.

1.5.2 Study of various views of the relationship of pure and applied science in terms of science attempting to describe the world while technology is seen by some as the means by which humans adapt the environment to suit their needs.

1.5.3 Inclusion of issues of Canadian concern relating to science and technology in the classroom experience of students.

1.5.4 Use of applied science to put science concepts in everyday affairs where the students may confront them.

1.5.5 Make students aware of how pure and applied science can be used to interpret critically what is taking place around them.

1.6 Science as Inquiry

1.6.1 Promotion of inquiry as a major element in what many refer to as scientific literacy.

1.6.2 Promotion of learning of science as inquiry.

1.6.3 Dealing with specific achievements of Canadian scientists, paying attention to the methods of inquiry used.

1.6.4 Application of inquiry strategies when students are dealing with Canadian problems which require a scientific or technological solution (e.g. in environmental degradation, resource depletion).

1.7 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

1.7.1 Study of the effects science and technology have on Canada's position in the world community.

1.7.2 Study of why there is emphasis on certain areas of research in pure and applied science.

1.7.3 Addressing some of the determinants of Canadian science policy: concern with the survival and maintenance of the nation, strengthening of indigenous technology in order to eventually make our 'branch plants' independent, a concern for our environment, maintaining the status of academic science.

1.7.4 Inclusion of areas identified as being of specific interest and benefit to Canada: communication, management of the oceans (including the Arctic), transportation, oil and gas technology for severe climatic and geographic conditions, resource development, etc.

2. Methodological Components of Science Education in a Canadian Context

2.1 Maximum Use of the Local Environment

2.1.1 Encouragement of students to relate abstract knowledge to concrete situations which they have encountered.

2.1.2 Provision of opportunities for experience and examples which will serve as concrete illustrations and reinforcement of the science concept being learned.

2.1.3 Development of an understanding and appreciation of the natural and social world in which the students live.

2.1.4 Application of basic scientific laws and concepts to the study and understanding of the students' immediate environment.

2.1.5 Study of topics and problems of current local scientific significance with discussion of feasible action and suggested solutions.

2.1.6 Development of a commitment to the careful use of natural resources in their locality and to the preservation and improvement of their environment.

2.2 Canadian Science Instructional Materials

2.2.1 Inclusion of locally or nationally produced instructional materials which contain Canadian content that students can relate to their own life and environment; i.e. it must be highly relevant to students.

2.2.2 Inclusion of locally or nationally produced instructional materials which include, wherever relevant, information on Canadian science and scientists, the Canadian science-society interrelationship, etc.

2.2.3 Inclusion of locally or nationally produced instructional materials which are of high quality in terms of content selection, organization and presentation.

2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context

2.3.1 Where materials are produced outside Canada, revisions are possible for inclusion of Canadian emphasis, examples, activities, etc.

2.3.2 In the case of good instructional materials produced outside Canada that have not been revised, provision of teachers' guides to show how the materials can be used (e.g., by appropriate supplementation) more in line with Canadian educational circumstances and needs.

2.4 Problems of Regionalism

2.4.1 Provision of opportunity for development of a conception of regional scientific and technological needs in relation to national needs.

2.4.2 Study of how science may be related to the regional differences that exist in Canada.

2.4.3 Study of how the regions of Canada may be interrelated through such concerns as climate, energy production and use, protection of the environment, and development and use of resources.

APPENDIX VII

Instrument for Assessing Canadian Context in Instructional Materials

Presence of Elements of a Canadian Context for Science Education

This instrument was developed to assist the classroom teacher to assess science curriculum materials for Canadian context.

Name of materials being reviewed:

Author/Producer:

Section or Unit being reviewed:

Reviewed by:

PART I

Indicate the degree of presence, in the instructional materials being reviewed, of the elements for teaching science education in a Canadian context listed below. Using a pen, circle one response for each item. Respond to all items.

EE = extremely evident

QE = quite evident

SE = slightly evident

NE = not evident but could be incorporated

NA = not evident and not applicable

Page numbers and specific examples should be identified where relevant.

To what extent is the inclusion of each of the following elements for a Canadian context evident in the materials being reviewed:

1. Content Components of Science Education in a Canadian Context

1.1 Interdisciplinary Nature of Science Education

1.1.1 Treatment of the science, technology and society interrelationship through interdisciplinary treatment of the subject matter.

EE QE SE NE NA

1.1.2 Through an interdisciplinary treatment, show that all living things interact with and are interdependent upon each other and their environment.

EE QE SE NE NA

1.1.3 Study of the functional relationships in phenomena which go beyond the individual characteristics of the parts usually studied within the limits of one discipline.

EE QE SE NE NA

1.1.4 Interdisciplinary descriptions of the interrelationships of science to other facets of Canadian life.

EE QE SE NE NA

1.1.5 Use of science to assist students in developing their perspectives of national identity and the role of science in defining that identity.

EE QE SE NE NA

1.1.6 An understanding and appreciation of the effect of science and technology on modern Canadian society.

EE QE SE NE NA

1.1.7 An understanding and appreciation of humankind's interrelatedness with the natural and social environment.

EE QE SE NE NA

1.1.8 Development of intellectual tools the student may use in our rapidly changing environment such as critical- mindedness and decision-making.

EE QE SE NE NA

1.1.9 Make Canadian science education a relevant and functional experience.

EE QE SE NE NA

1.2 <u>Canadian Science - Canadian Society Interaction</u>

1.2.1 Demonstration to students of the benefits derived from taking science.

EE QE SE NE NA

1.2.2 Study the effects (ills and benefits) that science and technology have on the Canadian workplace.

EE QE SE NE NA

1.2.3 Discussion of Canadian social issues from a scientific and technological perspective.

EE QE SE NE NA

1.2.4 Introduction to social problem-solving which includes considering the impacts of science and technology on the quality of human existence in the biosphere.

EE QE SE NE NA

1.2.5 Study of the relationship between science and technology and Canadian society and culture.

EE QE SE NE NA

1.2.6 Use of examples and illustrations of the impact of science and technology from contemporary Canadian life.

EE QE SE NE NA

1.2.7 Portrayal of science as part of the total Canadian culture.

EE QE SE NE NA

1.2.8 Presentation of science in a way which promotes getting to know ourselves and our universe.

EE QE SE NE NA

1.2.9 Offering science and technology as a consideration in the study of the economic and political situation in Canada.

EE QE SE NE NA

1.2.10 Attention to the scientific, technological and social problems facing Canada and the world, and ways of resolving these issues.

EE QE SE NE NA

1.2.11 Attention to the various points of view concerning processes of decision-making for resolving science- related social problems.

EE QE SE NE NA

1.2.12 Attention to the variety of roles that high school students as adults will play in the future Canadian society and how science can prepare them for those roles.

EE QE SE NE NA

1.3 History of Canadian Science

1.3.1 Attention to the many important Canadian achievements in science.

EE QE SE NE NA

1.3.2 Attention to the impact that science/technology had historically upon Canadian life.

EE QE SE NE NA

1.3.3 Study of the significant role of Canadian scientists and technologists in Canada's growth and development.

EE QE SE NE NA

1.3.4 Attention to the significant contributions made by Canadian scientists to science internationally.

EE QE SE NE NA

1.4 Philosophy Underlying Canadian Science

1.4.1 Make science relevant in personal terms.

EE QE SE NE NA

1.4.2 Portray the nature of science as a cautious view of knowledge, making us mindful of the limitations of human knowledge.

EE QE SE NE NA

1.4.3 Investigation of questions of values and ethics related to science without feeling threatened.

EE QE SE NE NA

1.4.4 Develop social conscience related to science and technology.

EE QE SE NE NA

1.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.5.1 Study the nature of both pure science and of applied science (technology) and the manner in which they serve as a bridge between science and society.

EE QE SE NE NA

1.5.2 Study of various views of the relationship of pure and applied science in terms of science attempting to describe the world while technology is seen by some as the means by which humans adapt the environment to suit their needs.

EE QE SE NE NA

1.5.3 Inclusion of issues of Canadian concern relating to science and technology in the classroom experience of students.

EE QE SE NE NA

1.5.4 Use of applied science to put science concepts in everyday affairs where the students may confront them.

EE QE SE NE NA

1.5.5 Make students aware of how pure and applied science can be used to interpret critically what is taking place around them.

EE QE SE NE NA

1.6 Science as Inquiry

1.6.1 Promotion of inquiry as a major element in what many refer to as scientific literacy.

EE QE SE NE NA

1.6.2 Promotion of learning as science as inquiry.

EE QE SE NE NA

1.6.3 Dealing with specific achievements of Canadian scientists, paying attention to the methods of inquiry used.

EE QE SE NE NA

1.6.4 Application of inquiry strategies when students are dealing with Canadian problems which require a scientific or technological solution (e.g. in environmental degradation, resource depletion).

EE QE SE NE NA

1.7 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

1.7.1 Study of the effects science and technology have on Canada's position in the world community.

EE QE SE NE NA

1.7.2 Study of why there is emphasis on certain areas of research in pure and applied science.

EE QE SE NE NA

1.7.3 Addressing some of the determinants of Canadian science policy: concern with the survival and maintenance of the nation, strengthening of indigenous technology in order to eventually make our 'branch plants' independent, a concern for our environment, maintaining the status of academic science.

EE QE SE NE NA

1.7.4 Inclusion of areas identified as being of specific interest and benefit to Canada: communication, management of the oceans (including the Arctic), transportation, oil and gas technology for severe climatic and geographic conditions, resource development, etc.

EE QE SE NE NA

2. Methodological Components of Science Education in a Canadian Context

2.1 Maximum Use of the Local Environment

2.1.1 Encouragement of students to relate abstract knowledge to concrete situations which they have encountered.

EE QE SE NE NA

2.1.2 Provision of opportunities for experience and examples which will serve as concrete illustrations and reinforcement of the science concept being learned.

EE QE SE NE NA

2.1.3 Development of an understanding and appreciation of the natural and social world in which the students live.

EE QE SE NE NA

2.1.4 Application of basic scientific laws and concepts to the study and understanding of the students' immediate environment.

EE QE SE NE NA

2.1.5 Study of topics and problems of current local scientific significance with discussion of feasible action and suggested solutions.

EE QE SE NE NA

2.1.6 Development of a commitment to the careful use of natural resources in Canada and to the preservation and improvement of their environment.

EE QE SE NE NA

2.2 <u>Canadian Science Instructional Materials</u>

2.2.1 Inclusion of locally or nationally produced instructional materials which contain Canadian content that students can relate to their own life and environment; i.e. it must be highly relevant to students.

EE QE SE NE NA

2.2.2 Inclusion of locally or nationally produced instructional materials which include, wherever relevant, information on Canadian science and scientists, the Canadian science society interrelationship, etc.

EE QE SE NE NA

2.2.3 Inclusion of locally or nationally produced instructional materials which are of high quality in terms of content selection, organization and presentation.

EE QE SE NE NA

2.3 <u>Adaptation of Foreign Science Instructional Materials to a Canadian Context</u>

2.3.1 Where materials are produced outside Canada, revisions are possible for inclusion of Canadian emphasis, examples, activities, etc.

EE QE SE NE NA

2.3.2 In the case of good instructional materials produced outside Canada that have not been revised, provision for teachers' guided to show how the materials can be used (e.g., by appropriate supplementation) more in line with Canadian educational circumstances and needs.

EE QE SE NE NA

2.4 Problems of Regionalism

2.4.1 Provision of opportunity for development of a conception of Canada's scientific and technological needs, in relation to national needs.

EE QE SE NE NA

2.4.2 Study of how science may be related to the regional differences that exist in Canada.

EE QE SE NE NA

2.4.3 Study of how the regions of Canada may be interrelated through such concerns as climate, energy production and use, protection of the environment, and development and use of resources.

EE QE SE NE NA

APPENDIX VIII

Major Geology Concepts in the Geology Component of the Grade 8 Science Program (Alberta Education, 1978)

Geology Concepts in the Grade 8 Earth Science Program

Concept C8.7

The crust of the Earth is formed of rocks.

1. Common minerals found within the Earth's crust.

   Most minerals are made up of elements from a group of only nine naturally occurring elements.

2. Rocks are formed from a mineral or a mixture of minerals.

3. Rocks can be categorized into three main groups.

   (a) Initially all rocks were formed by the cooling magma of the earth.

   Texture and mineral content of igneous rocks can be used for identification.

   (b) Erosion and/or deposition form sedimentary rocks.

   Grain size and/or mineral content of sedimentary rocks can be used for identification.

   (c) Sedimentary and igneous rocks can be reconstituted to form metamorphic rocks.

   Metamorphic rocks are classified on the basis of their mineral content and structure.

Concept C8.8

The crust of the Earth is constantly being changed.

1. Landforms are being built up by movements within the crust.

   (a) Earthquakes are the result of movements of masses of rock.

   (b) Faulting and folding are the result of large forces in the crust.

   (c) Volcanism is associated with faulting in the crust.

2. Weathering weakens rock formations.

   (a) Mechanical weathering makes small pieces out of large ones.

   (b) Chemical weathering changes the rock itself.

3. Erosion changes the landforms.
   - (a) Erosion is caused by running water.
   - (b) Erosion is caused by wind.
   - (c) Erosion is caused by glaciation.
   - (d) Erosion is caused by ground water.
   - (e) Agents of erosion help lay down sediments.
4. Dynamic processes are at work within the Earth.
   - (a) Forces acting on the crust are due to the structure of the Earth.
   - (b) Theories have been advanced to explain how forces have acted on the crust to produce the present landforms.

     Continental drift, plate tectonics and sea floor spreading are theories advanced to explain crustal deformation.

<u>Concept E8.1</u>

Materials from the crust have had an important influence on mankind's daily living.

1. Fossil fuels and their products are important in the economy of Alberta.
2. Since crustal materials are limited, exploitation must be managed for maximum benefit.

<u>Concept E8.2</u>

Evidence for determining the past history of the Earth comes from a study of the crust.

1. Age determinations can be estimated on the basis of rates of changes of crustal materials.
   - (a) Sediments have been laid down throughout the life of the earth.
   - (b) Radioactive elements decay at measurable rates.
2. Fossil evidence can be used to relate past events in the history of the earth from one place to another.
   - (a) There are different kinds of fossil evidence: remains, casts, molds, and replacement fossils.

(b) Earth's history can be divided into periods of geologic time on the basis of the type of fossil evidence.

(c) Fossil evidence is used in oil and gas exploration.

APPENDIX IX

Analysis of Prescribed Instructional Materials Used in Teaching Geology Concepts in the Grade 8 Earth Science Program

Included in this Appendix are:

1. A description of instructional materials analyzed in Stage II.
2. Analysis of the prescribed instructional materials used in teaching geology concepts in the Grade 8 Earth Science Program.

1. Description of Instruction Materials Analysed in Stage II

Prescribed References

1. Heller, R. L. et al. (1976). Challenges to Science: Earth Science. Scarborough: McGraw-Hill. Coding used in Analysis - CSS.

   This text was written in the U.S.A., in a style which presents a good deal of physics and chemistry. Student activities such as use of silly putty to demonstrate folding (p. 133), though rather limited, do relate directly to content. The selection of color photos and diagrams appears adequate but have to be supplemented to relate more specifically to Alberta since nearly all relate to the U.S.. This text has been screened by the Canadian Metric Commission staff and uses SI units throughout. The only difference between U.S. and Canadian versions of this text are the SI units.

2. Jackson, J.H. and Evans, E.D. (1976). Spaceship Earth: Earth Science. Markham: Houghton-Mifflin. Coding use in Analysis - SE.

   This book was written in the U.S.A. and presents a blend of "discovery approach" along with concept development. The discovery approach provides activities for students which attempts to introduce some aspects of a problem solving approach. It also offers a balanced approach to the theory of evolution and creationism. Considerable emphasis is placed on the topic of space with little emphasis on glaciation. It does not use SI units consistently, and some Imperial units appear in the descriptions.

Support Materials

1. Films and Videos included in the analysis are those suggested and documented in the Learning Resource 1978 Junior High School Science Guide produced by Alberta Education. Coding used in Analysis - LR.

2. Analysis of the Prescribed Instructional Materials

The data from the analysis of the prescribed instructional materials are listed under each of the concept areas to which it relates. The coded name of the resources and specifics of the section referred to are given first. This is then followed by the related element from the clue structure for a Canadian context and the extent of evidence in brackets following it.

CONCEPT C8.7

The crust of the Earth is formed of rocks.

- LR - Planet of Man: Challenge of the Deep (201008) This film highlights the search for mineral resources in the oceans with a focus on the process of sediment accumulation.

1.5.2 - Pure Science, Canadian Applied Science and Their Interrelationship (SE)

1. **Common Minerals are found within the Earth's crust.**

- CSS - pp. 27-30. Discussion goes into all types of minerals that are found on the earth's crust. There is potential to talk about minerals that are found in Canada/Alberta itself, though South Dakota and Maine are examples, p. 25 activities.

1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

Most minerals are made up of elements from a group of only nine naturally occurring elements.

- CSS - p. 27; pp. 429-434 - Lists all the elements and their percentages of the total with discussion.
- LR - Planet of Man: Animal, Vegetable or Mineral (201006) - This film applies chemical and physical properties of minerals to fashioning tools and discussion of the impact this had on early civilizations.
- LR - Metal in Harmony (PB25) - This film places production of aluminum and its applications in a context of everyday life.

1.1.3, 1.1.4 Interdisciplinary Nature of Science Education (QE)

1.2.6, 1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.5.1, 1.5.2, 1.5.4 Pure Science, Canadian Applied Science and Their Interrelationship (SE)

2.1.3 Maximum Use of the Local Environment (SE)

2. Rocks are formed from a mineral or a mixture of minerals.

- CSS - pp. 30-33 rock forms; p. 34; pp. 30-41; pp. 435-436. Names 10 common minerals. Gives a number of examples such as Black Hills, Arkansas, Wyoming. Refers to Hutton.
- SE - p. T38 - 9.1 - Rocks and Minerals are identified and compared.

1.1.3, 1.1.8 Interdisciplinary Nature of Science Education (SE)

1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

2.1.3, 2.1.4 Maximum Use of the Local Environment (SE)

3. Rocks can be categorized into three main groups.

- LR - Rocks that originate underground (C2417) - This video film explores the formation of igneous and metamorphic rocks.
- CSS - p. 34 - Identifies three main groups of rocks; p. 43-55 - Igneous Rock of the Canadian Shield; p. 51 - Discussion of Sudbury, Ontario; pp. 57-89 - Activities pp. 60, 70, 81, 82; Activities 4-2, 4-3, 4-4, 4-5 on production of rust, settling of sediments and relative densities of minerals. All activities apply features which could be found in Canada but not Canadian context outside of activities.
- SE - p. 272 - Game about rocks, called Skullduggery where students answer questions about rocks while competing on teams.

1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.4.1 Philosophy Underlying Canadian Science (SE)

1.5.1, 1.5.2, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship (SE)

(a) Initially all rocks were formed by the cooling magma of the earth.

- CSS - p. 45-46; Activity 31 - Growing Crystals; p. 51 - Sudbury, Ontario and Minnesota mentioned as areas where nickel-rich coarse grained igneous rocks are found; p. 45-50.
- SE - pp. 247-252. Figure 917 Check Yourself sections encourage some interdisciplinary thinking where students apply concepts to economic conditions. Text tries to relate geology to the student though Canadian examples are scarce.

1.1.6, 1.1.9 Interdisciplinary Nature of Science Education (QE)

1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.4.1 Philosophy Underlying Canadian Science (QE)

1.6.1, 1.6.2 Science as Inquiry (QE)

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (QE)

Texture and mineral content of igneous rocks can be used for identification.

- CSS - p. 45-46.; Activity 3.1, applies to all environments; mentions only one U.S. lab in the discussion and lab for growing crystals using thymol.
- LR - The Fractured Look (120166) - This NASA video tape looks at the way Landsat imagery can contribute to exploration for mineral resources and monitoring geological hazards.

1.1.6 Interdisciplinary Nature of Science Education (QE)

1.2.8 Canadian Science - Canadian Society Interaction (QE)

1.4.1 Philosophy Underlying Canadian Science (QE)

1.5.1, 1.5.4 Pure Science, Canadian Applied Science and their Interrelationship (QE)

1.6.1, 1.6.2 Science as Inquiry (QE)

(b) Erosion and/or deposition form sedimentary rocks.

- LR - Rocks that Form the Earth's Surface (B2422) - This film explores the formation and transportation of sedimentary rocks.

- CSS - Activity 4.1 and 4.2; producing rust; soil and soil conservation; p. 68 - thunderstorms and dry area activities. Examples from Bronx, New England, Texas, Louisiana, Kansas, Grand Canyon and Southern California.
- SE - pp. 252-263. Check Yourself. Collecting and examining rocks students are encouraged to check their own backyard.

1.1.9 Interdisciplinary Nature of Science Education (SE)

1.2.6, 1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

2.1.1, 2.1.2, 2.1.3, 2.1.4, Maximum use of the Local Environment (QE)

Grain size and/or mineral content of sedimentary rocks can be used for identification.

- CSS - pp. 73-77, extensive discussion of the Grand Canyon. No reference to Canadian examples.

1.1.9 Interdisciplinary Nature of Science Education (SE)

(c) Sedimentary and igneous rocks can be reconstituted to form metamorphic rocks.

- CSS - pp. 90-91 - metamorphic processes; pp. 89-96. Identification procedures for metamorphic rocks.
- SE - pp. 265-270. Students are encouraged to check their local area.

1.1.4, 1.1.9 Interdisciplinary Nature of Science Education (SE)

1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (QE)

Metamorphic rocks are classified on the basis of their mineral content and Structure.

- CSS - p. 89-99 - Metamorphic Rock processes are described with identification procedures. Fairly international presentation. P. 97 Canada is mentioned.

1.2.6, 1.2.8 Canadian Science - Canadian Society Interaction (SE)

CONCEPT C8.8

The crust of the Earth is constantly being changed.

- LR - The Hidden Earth. (C2143) This video film demonstrates the structure of the earth through analysis of earthquakes and volcanoes with application to seismology and the study of other planets.
- LR - Riches of the Earth. (B2646) This video film focuses on formation of the earth's crust through fire, water, and ice.

1.2.8 Canadian Science - Canadian Society Interaction (QE).

1.5.5 Pure Science, Canadian Applied Science and their Interrelationship (SE)

1. Landforms are being built up by movements within the crust.

- LR - Lay of the Land: Entering the Gateway. (120501) In this video film, attention is given to the shield parkland, northern sea, lakes, forests and eskers. Produced by Alberta School Broadcasts.
- LR - Lay of the Land: Solid Land. (120502) A look at the highlands is the purpose of this video film produced by Alberta School Broadcasts.
- LR - Planet of Man: Mountain Heritage, The Appalachians. (201005) Mountain Building in the Appalachians is highlighted in this video film.
- CSS - pp. 220-224; pp. 140-145 - Reference to crust formation in the Rockies. Activities encourage use of local environment.

1.2.8 Canadian Science - Canadian Society Interaction (EE)

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (QE)

2.4.2, 2.4.3 Problems of Regionalism (SE)

(a) Earthquakes are the results of movements of masses of rock.

- LR - Earthquake Below.(160311) This NASA produced film focuses on earthquakes, faults, and San Francisco.

- CSS - p. 118 - Activity focuses on building a seismograph; p. 119. Ottawa is mentioned as a centre of seismology.
- SE - pp. 301-326; p. 27 - Skullduggery Game. Activities pp. 317-318 use materials such as green sticks to demonstrate energy transmission. Students are encouraged to check their local area.

1.2.8, 1.2.11, 1.2.12 Canadian Science - Canadian Society Interaction (SE)
1.4.1, 1.4.2 Philosophy Underlying Canadian Science (SE)
1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship (SE)
1.6.1, 1.6.2 Science as Inquiry (QE)
2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (QE)

(b) Faulting and folding are the result of large forces in the crust.

- CSS - pp. 131-139 - Activities including use of silly putty to demonstrate deformation, flow and fracture; pp. 141, 144. Rockies are discussed.
- SE - pp. 311-312. Seismographic techniques. Importance of earthquakes is considered internationally.

1.4.1 Philosophy Underlying Canadian Science (SE)
1.6.1, 1.6.2 Science as Inquiry (EE)

(c) Volcanism is associated with faulting in the crust.

- LR - Earth the Restless Planet. (133702) This video film studies volcanism through active volcanoes in Hawaii, Sicily, and Zaire.
- LR - Planet of Man: The Fire Within. (201003) Volcanic activity is the central focus of this film.
- CSS - pp. 102 - 113 - Lake Superior is mentioned as an area where remains of a billion year old volcanic pile may be found.
- SE - pp. 275-289 discusses volcanoes, their cause and measurement.

1.2.8 Canadian Science - Canadian Society Interaction (QE)
1.4.2 Philosophy Underlying Canadian Science (QE)

1.6.1, 1.6.2 Science as Inquiry (QE)

1.7.2, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction (QE)

2.1.3, 2.1.4 Maximum Use of the Local Environment (QE)

2. **Weathering weakens rock formations.**

- LR - Environmental Science: Climate and Soils. (132306) This Ontario produced film shows how wind and weather form soils.
- LR - Planet of Man: The Uneventful Day. (201011) Process of weathering is identified in this video film.
- CSS - pp. 57-64; p. 60 - Rust activity identifies iron content in sediments. Colorado and Amazon rivers are used as examples of colour attributed to sediments of clay and specific ions.
- SE - p. 334: pp. 347-354 - Soil formation; p. 355. Lab using bottle breaking because of water freezing. Check Yourself Activities.

1.2.8 Canadian Science - Canadian Society Interaction (QE)

1.4.1 Philosophy Underlying Canadian Science (QE)

1.6.1, 1.6.2 Science as Inquiry (EE)

(a) Mechanical weathering makes small pieces out of large ones.

- LR - Our Soil Resources (A 546). Formation of soils and their relationship to the four soil zones of the U.S. is this films main thrust.
- CSS - pp. 148-151.
- SE - pp. 336-343. Check Yourself Activities focus on materials around the house and a campsite which appear to be weathering mechanically. Canadian examples are scarce but text tries to relate geology to the immediate environment of the student p. 349. Description of mechanical weathering in Northern Canada.

1.1.9 Interdisciplinary Nature of Science Education (QE)

1.2.1 Canadian Science - Canadian Society Interaction (SE)

1.4.1 Philosophy Underlying Canadian Science (SE)

1.6.1, 1.6.2 Science as Inquiry (SE)

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (SE)

(b) Chemical weathering changes the rock itself.

- SE - pp. 343-347. Check Yourself Activities focus on weathering and relationships to tools of industry. Attempt made throughout to give students active participation in activities on weathering.

1.2.8 Canadian Science - Canadian Society Interaction (QE)

1.4.1, 1.4.2 Philosophy Underlying Canadian Science (QE)

1.6.1, 1.6.2 Science as Inquiry (EE)

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (SE)

3. Erosion changes the landforms.

- CSS - pp. 147-169 speak to levelling the land through different forms of erosion.
- LR - Erosion: Leveling the Land. (B2368) This film includes discussion of processes of weathering, erosion and deposition.
- LR - Outdoors Unlimited: Badlands (123504) Animals and their relationship to the topography of the land to present is the film's main interest. Produced by Alberta School Broadcasts.

1.1.9 Interdisciplinary Nature of Science Education (QE)

1.2.8 Canadian Science - Canadian Society Interaction (QE)

1.4.2 Philosophy Underlying Canadian Science (SE)

1.5.2 Pure Science, Canadian Applied Science and their Interrelationship (QE)

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction (QE)

2.1.3, 2.1.5 Maximum Use of the Local Environment (QE)

2.2.1 Canadian Science Instructional Materials (EE)

(a) Erosion is caused by running water.

- SE - pp. 361-362. North American examples are provided of rivers and glaciers. Pp. 368, 371, 374-392, p. 385. Figure 1319 is of the Kicking Horse River in British Columbia. Check Yourself Activities, some examples related well to getting to know our environment.
- CSS - pp. 155-160; 151-152. Mississippi is used as an example of a drainage basin but others could be included.
- LR - Waves on Water (B2426). The relationship between waves and seismology is included in this film.
- LR - The Beach: A River of Sand (C2419). The relationship of sand, existing between land and waves is of central concern in this video film.

1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.4.1 Philosophy Underlying Canadian Science (QE)

1.6.1, 1.6.2 Science as Inquiry (QE)

2.1.1, 2.1.2 Maximum Use of the Local Environment (EE)

(b) Erosion is caused by wind

- CSS - pp. 166-167. Discussion of erosion and deposition by wind. Reference to U.S. but could include Canada.
- LR - Why do we still have mountains? (C2367) Weathering, erosion and deformation of the earth's crust are of primary importance in the film.

1.4.1 Philosophy Underlying Canadian Science (EE)

(c) Erosion is caused by glaciation.

- LR - Glaciers. (B2722) Mount Rainier to Alaska and Antarctica - glaciers are revealed in this film.
- LR - Planet of Man: Trail of Ice Age Blues. (201004) Glaciation of North America and man's adaptation to the subsequent landforms is central to this film.

- LR - Glaciation. (B2301) The Great Ice Age, glaciers and their effects on terrain and climate are central to this film.
- LR - Glacier on the Move. (A3410) This film identifies the processes of a glacier using Athabasca Glacier.
- LR - Secrets of the Ice. (C2309) The role of snow and ice in man's physical environment including mountain glaciers, ice fields of Greenland and Antarctica are elaborated in this film.
- CSS - pp. 161-165, Activities. Canada, Lake Superior, Manitoba, Ontario, Great Lakes and Hudson Bay are mentioned.
- SE - p. 360-364 Canadian Glaciation is discussed.

1.1.9 Interdisciplinary Nature of Science Education (QE)

1.2.6, 1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.3.4 History of Canadian Science (EE)

1.4.1 Philosophy Underlying Canadian Science (EE)

1.6.1, 1.6.2 Science as Inquiry (QE)

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction (SE)

2.1.1, 2.1.2, 2.1.5 Maximum Use of the Local Environment (QE)

2.2.1 Canadian Science Instructional Materials (EE)

(d) Erosion is caused by ground water.

- CSS - pp. 158-160, p. 160 activity on porosity has students relating size of various materials and pore space.

1.6.1, 1.6.2 Science as Inquiry (QE)

(e) Agents of erosion help lay down sediments.

- CSS - pp. 159-160 - activity 8.3 on porosity can be done anywhere; pp. 148-149 discusses avalanches and landslides; pp. 152-158 activities relate to stream velocity, erosion and deposition.

• SE - p. 410 - examples of current distribution of sediment.

1.2.1, 1.2.2 Canadian Science - Canadian Society Interaction (SE)

1.4.2, 1.4.4 Philosophy Underlying Canadian Science (SE)

1.5.1, 1.5.3 Pure Science, Canadian Applied Science and their Interrelationship (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

4. Dynamic processes are at work within the Earth.

• LR - How solid is rock? (C2594) Field evidence and lab experiments in this film demonstrate that underground rock can break and flows.

(a) Forces acting on the crust are due to the structure of the Earth.

• CSS - pp. 123-127 - activity 6.2 on Isostasy.

1.4.1, 1.4.2 Philosophy Underlying Canadian Science (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

(b) Theories have been advanced to explain how forces have acted on the crust to produce the present landforms.

• LR - Planet of Man: The Inner Limit. (201009) Journey to the center of the earth is conducted in this film.

• CSS - Chapter 7 on mountain building and lead up to sea-floor spreading; Chapter 8 on levelling the land have aspects of this; pp. 224-230.

1.2.5, 1.2.6 Canadian Science - Canadian Society Interaction (SE)

1.3.2 History of Canadian Science (SE)

1.4.1 Philosophy Underlying Canadian Science (QE)

1.6.1, 1.6.2 Science as Inquiry (QE)

Continental drift, plate tectonics and sea floor spreading are theories advanced to explain crustal deformation.

• LR - Planet of Man: Beyond a Doubt - Revolution. (201012) Continental Drift is discussed in this film.

• LR - Planet of Man: Jigsaw Fit. (201002) This film describes the theory of plate tectonics.

- LR - Plate Tectonics. This film outlines the theories of plate tectonics.
- SE - Many activities allow for discovery such as one relating melted minerals to sodium acetate; investigation format, p. 249.
- CSS - pp. 224-225 - Continental Drift; p. 230 - Pangea.

1.2.8 Canadian Science - Canadian Society Interaction (EE)

1.4.2 Philosophy Underlying Canadian Science (EE)

1.6.1, 1.6.2 Science as Inquiry (EE)

CONCEPT E8.1

Materials from the crust have had an important influence on mankind's daily living.

- LR - Energy: The Consumption Assumption. (125101) The flow of energy is followed through primitive societies through to the wasteful consumption in the industrial world. This video film is produced by Alberta School Broadcasts.

1.1.2, 1.1.9 Interdisciplinary Nature of Science Education (QE)

1.2.3, 1.2.5 Canadian Science - Canadian Society Interaction (SE)

1.4.2 Philosophy Underlying Canadian Science (QE)

1.5.2 Pure Science, Canadian Applied Science and their Interrelationship (SE)

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction (SE)

2.2.1 Canadian Instructional Materials (EE)

2.4.1, 2.4.2, 2.4.3 Problems of Regionalism (SE)

1. Fossil fuels and their products are important in the economy of Alberta.

- CSS - pp. 302-305 - Leduc, Alberta and Ontario are included as the oil industry in Canada is highlighted; pp. 83-84 - Prairie area is discussed in terms of coal, petroleum and gas.
- SE - p. 354 Check Yourself Activities related to perculation and leaching.

1.2.1, 1.2.3, 1.2.6, 1.2.8 Canadian Science - Canadian Society Interaction (SE)

1.6.4 Science as Inquiry (QE)

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction (EE)

2. **Since Crustal materials are limited, exploitation must be managed for maximum benefit.**

   - CSS - pp. 50-55 - Nickel sources in Sudbury, Ontario; pp. 80-82 - metal mines in Canada; p. 85 - oil and natural gas reserves; pp. 97-99 - extraction of lead from lead ore, Lake Superior; pp. 300-301 - the future of our natural resources; p. 304 - discussion of nuclear fission and uranium. Hands on activities include extracting lead from its ore, settling sediments and minerals, and comparing relative densities of minerals for purposes of extraction.

   1.6.4 Science as Inquiry (SE)

   2.1.6 Maximum Use of the Local Environment (QE)

CONCEPT E8.2

Evidence for determining the past history of the Earth comes from a study of the crust.

- LR - Planet of Man: Voices of Time and Earth. (201001) the Grand Canyon is used as a clock of earth's history. This film is produced in Ontario.

1.1.8 Interdisciplinary Nature of Science Education (QE)

2.2.1 Canadian Science Instructional Materials (EE)

1. **Age determinations can be estimated on the basis of rates of changes of crustal materials.**

   - CSS - pp. 171-174 - discussion of principle of superposition and correlation of rocks; pp. 181-183 refers to radioactive decay and geologic time scale; p. 184. Dinosaur discussion could be related to Alberta.

1.2.5 Canadian Science - Canadian Society Interaction (SE)

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (SE)

(a) Sediments have been laid down throughout the life of the earth.

- CSS pp. 171-175 basic geologic principles; pp. 63-73 (activity: p. 68, 70, 71 on settling of sediments of different sizes, sediments in lake and river water and how fast sediments are deposited).

6.1.1, 1.6.2 Science as Inquiry (QE)

(b) Radioactive elements decay at measurable rates.

- CSS pp. 171-185 refers to radioactive decay as the Earth clock and its use in determining aspects of the geologic time scale.

1.4.2 Philosophy Underlying Canadian Science (SE)

1.6.1, 1.6.2 Science as Inquiry (QE)

2. Fossil evidence can be used to relate past events in the history of the earth from one place to another.

- CSS - pp, 171-175 - Records in Rock relates correlation of rocks with fossils; 175-181 discusses fossils with activities using fossils to relate rocks.

1.6.1, 1.6.2 Science as Inquiry (EE)

(a) There are different kinds of fossil evidence: remains, casts, molds, and replacement fossils.

- CSS - p. 175 discusses different aspects and kinds of fossil evidence.
- SE - p. T38-9-10 - Making Model Fossils.

1.4.4 Philosophy Underlying Canadian Science (SE)

1.6.1, 1.6.2 Science as Inquiry (Ee)

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment (SE)

(b) Earth's history can be divided into periods of geologic time on the basis of the type of fossil evidence.

- CSS - pp. 171-175. Discusses geologic time lines. pp. 436-437 are time line activities.

- LR - Planet of Man: Shield of Plenty. (201007) This film portrays the evolution of geologic time from Precambrian period to present.

1.4.1 Philosophy Underlying Canadian Science (SE)

(c) Fossil evidence is used in oil and gas exploration.

- LR - Energy: Sources of Resources.(125103) Discussion about the energy that is stored beneath the earth's surface is the theme of this film produced by Alberta School Broadcasts.
- LR - Decision to Drill. (C1851) Produced by Imperial Oil, this film documents the search and drilling for oil and natural gas in Western Canada.

1.1.1, 1.1.3, 1.1.6, 1.1.9 Interdisciplinary Nature of Science Education (QE)

1.2.2, 1.2.5, 1.2.6, 1.2.7 Canadian Science - Canadian Society Interaction (QE)

1.3.2 History of Canadian Science (QE)

1.4.4 Philosophy Underlying Canadian Science (SE)

1.5.2, 1.5.4 Pure Science, Canadian Applied Science and their Interrelationship (QE)

1.7.1, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction (EE)

2.1.1, 2.1.2, 2.1.3 Maximum Use of the local Environment (EE)

2.2.1 Canadian Science Instructional Materials (EE)

2.4.1, 2.4.2, 2.4.3 Problems of Regionalism. (EE)

APPENDIX X

STAGE III: Survey of Alberta Grade 8 Science Teachers

Included in this Appendix are:

1. Covering letter sent to Stage III science teachers (since the outline sent to teachers was identical to that in Appendices VII and VIII, the outline has been omitted from Appendix X).
2. Follow-up letter to non-respondents in Stage III.
3. Summary of comments made by Stage III Alberta teachers regarding teaching geology concepts in the Grade 8 Earth Science Program.

1. Covering Letter Sent to Stage III Science Teachers

October 1, 1985

Fellow Science Teacher:

Identification of the 'Presence of Elements of a Canadian Context in the Geology Component of Earth Science' is part of a methodology which I am devising as part of my Ph.D. thesis.

This questionnaire is being sent to each Alberta Grade 8 science teacher in an attempt to find out what is being done, and what could be done, to supplement or modify the prescribed Grade 8 Earth Science curriculum materials in the area of a Canadian context. If you have incorrectly been identified as a teacher who has taught, or is presently teaching this program, please present this questionnaire to the teacher in your school who is.

To enable me to pursue my Ph.D. study with all possible haste, please return the questionnaire to me by November 15, 1985. I greatly appreciate the effort necessary to provide this information which is so important to my study. A self addressed envelope has been included to facilitate mailing through your school.

All contributions will be held in confidence, and will be acknowledged in the thesis.

Thank you for your valuable input.

Gratefully yours,

Rick Mrazek

2. Follow-up Letter to Non-respondents in Stage III

November 1, 1985

Dear Colleague:

Towards the middle of October you received a copy of a survey of elements for 'A Canadian Context for Science Education' in the Grade 8 Earth Science Program. I realize that for most participants the requested deadline of November 15 is very pressing. I will be pursuing this investigation following my Ph.D. study, therefore I would still appreciate your reactions to the questions I pose at your earliest convenience.

Based on those reactions received to date, contributors have a wealth of ideas regarding a Canadian context for science education. These reactions can play a vital role in the direction of my research.

I look forward to hearing from you and sincerely hope you have the opportunity to react to the document which you received. If you have misplaced the questionnaire, I would be pleased to send another. Please feel free to contact me if you have any questions regarding this study. The enclosed mailing label may be of assistance for this purpose.

Gratefully yours,

Rick Mrazek

Rick Mrazek

3. Summary of Comments Made by Stage III Alberta Teachers Regarding Teaching Geology Concepts in the Grade 8 Earth Science Program.

In this Appendix, specific comments given by teachers regarding teaching Geology Concepts in the Grade 8 Earth Science program are summarized and the clue structure elements associated with these suggestions are then indicated.

CONCEPT C8.7

The crust of the earth is formed of rocks.

- Collection and identification of local rock samples should be encouraged. These could be prepared by students in the form of kits, along with guides/identifications and keys. Alternately, prepared kits can be used by students. Some field trips, dependent on the locality of the school, could be used to collect rock samples. Field trips to the mountains (e.g., Banff, Kananaskis) and the Badlands were specifically mentioned.
- AV materials can be used where available and applicable. No specific films were suggested by teachers.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

1. Common minerals are found within the earth's crust. Most minerals are made up of elements from a group of only nine naturally occurring elements.

- One should examine economically important minerals in Alberta and Canada with specific attention paid to the features, locations, and mining techniques used. Canada's role as a mineral producer and her involvement in the gem industry could be used as starting points for application to the use of minerals in Canada's hi-tech industry. Mineral ore locations in Canada could be correlated with presentations and kits that are offered by many companies. Maps of minerals in Canada could be used for this specific purpose with attention given to the effects on the economies in the different regions. Students could be asked to list materials related to minerals that are found in their homes and everyday lives.

If one obtains samples of minerals from Canadian companies, one could start with identification of the minerals, move to a brief description of each of the companies' processes involved, through to impacts on the environment in terms of effects of processing (example: strip mining). Wherever possible, use examples of local and regional mineral deposits, such as the salt at Lindberg, or the limestone west of Calgary.

- Filmstrips and films could supplement what students learn about minerals through mineral identification labs or cut-out models that students could make to relate crystal shapes to minerals.
- Field trips to local areas, museums and other hands-on field trip components could be used with student collection in mind as long as it is promoted with conservation and respect. An example of a museum tour that was rated as excellent for Alberta Grade 8 earth science students was the Calgary Museum.

1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.5, 1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.2 Science as Inquiry

1.7.1 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

2.4.2 Problems of Regionalism

2. Rocks are formed from a mineral or a mixture of minerals.

- In this area, laboratory work with identification of local rock and mineral samples was identified as one of the key components. The pamphlet "Mining - What Mining Means to Canada" was cited as an excellent resource in terms of Canadian content. Some of the tests recommended for minerals include the acid test of limestone and such components as streak, hardness, lustre, etc.. One could check students' understanding of this concept by having students work on samples of up to 30 rocks where 10 are igneous, 10 sedimentary and 10 metamorphic. Students could then try to identify the minerals that are related to the creation of these rocks.
- Field trips to local areas again are highlighted with an emphasis on Kananaskis, Drumheller, Calgary Zoo, Glenbow Museum, and others which seem to be close to Calgary.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

3. Rocks can be categorized into three main groups.

- The collection and laboratory identification of the three main types of rocks with specific reference to local collecting were the major focus of suggestions in this section. A major activity listed classification of rocks according to student-identified characteristics which would then have a follow-up of identification tests for hardness, streak, and other characteristics.

- Visual resources were identified in a number of cases, however, specific films were not listed.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.4.1 Philosophy Underlying Canadian Science

1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(a) Initially all rocks were formed by the cooling magma of the earth.

- Use of filmstrips and films was a popular suggestion within this area, but once again no specific titles were listed. There was reference to films which would represent the theories involved with how rocks were formed by the cooling magma of the earth and emphasis on the concepts related to the structure of present-day earth.
- Volcanoes from around the world can be studied with an emphasis on the relationship to hot spots and possible magma chambers in Canada or close to Canada. Samples and studies related to Mt. St. Helens were listed in a number of cases.
- Alberta geologic history in terms of the Canadian Shield could be used as an example to discuss igneous rock formations and their location in northeastern Alberta. Examples of band iron rock could be shown to the students.

1.4.1 Philosophy Underlying Canadian Science.

2.1.1, 2.1.2, 2.1.3 Maximum Use of the local Environment.

Texture and mineral content of igneous rocks can be used for identification.

- Lab work including identification of typical igneous rocks found in Canada should include prepared samples which demonstrate the diversity of igneous rock found in Alberta. To prepare for further use by students, many rock samples could be identified in terms of their place of origin within Canada and developed into lab kits which would include maps and all pertinent information.

- Experiments and physical demonstrations could be used to identify properties of crystals, where students actually make and cool crystals to identify cooling rates and crystal size. The experiment of cooling wax is specifically identified as being useful.

1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(b) Erosion and/or deposition form sedimentary rocks.

- In-class study could include stream table work where erosion and deposition are demonstrated. Many materials such as plaster of paris, water mixed with sand, gravel, etc. can be deposited and then the water allowed to evaporate in order to show the process of sedimentation. Topographical model-building of a local area serves as excellent reinforcement of this. Specific reference can be made to the combination of wind and water erosion evident in British Columbia, Saskatchewan, and Ontario with cross-relationships to erosion remnants produced by chinooks in Alberta.
- Local field trips to stream and river banks were highly stressed. These were listed in relationship as well to erosion by wind/glaciers and water. Common examples cited included the Bow River, the Red Deer River and Badlands, sedimentary deposits of glacial lake Edmonton, the North Saskatchewan River, Dinosaur Park, and many landforms in southern Alberta related to glaciation and erosion.
- Films were identified as a possible resource. None were specifically named. However, a number of comments noted that most films available were old and needed reprinting.

• Labs using local samples could be used to demonstrate how rocks are formed within the area. Through experiments showing how erosion and deposition take place, predominantly using stream tables, one could show how sedimentary rocks found within the glacial deposits became sorted and compressed.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry.

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

Grain size and/or mineral content of sedimentary rocks can be used for identification.

• Labs and experiments, primarily using sieves to separate by size and weight of minerals, seem to be the primary focus of contributions in this area. Using screen sieves water is used as a sorting agent, similar to filtrations. Students spend time identifying sedimentary rocks by sight, usually using a hand lens for common rocks found in Alberta such as sandstones, shales, siltstones, and conglomerates. An alternate demonstration was suggested where a mixture of gravel and sand is in a jar. Students shake this mixture and note the resulting settling.

1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(c) **Sedimentary and igneous rocks can be reconstituted to form metamorphic rocks.**

• Specific field trips for the purpose of collecting local samples for the preparation and identification of metamorphic rock kits were commonly mentioned. An area which seemed to have been identified by teachers as a good resource to observe rock types and changes between sedimentary and metamorphic conditions was Waterton Park.

- Films and filmstrips were identified as an excellent way to provide explanation for the processes involved in the rock cycle. No specific titles were mentioned by teachers.

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

Metamorphic rocks are classified on the basis of their mineral content and structure.

- The use of local samples of common metamorphic rocks found in Canada, whether through physical examination within the classroom or actual on-site field examination, were the main suggestions of teachers. Specific examples included obsidian arrowheads formed by North American Indians; discussion of bauxite, asbestos, and garnet locations in Alberta and Saskatchewan; and examples of limestone — marble foliated and unfoliated rocks found in the Kananaskis. Specific resource materials mentioned include a booklet of simple lab activities that had been assembled by Calgary science teachers which focussed on different rocks and minerals of the area.

1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

CONCEPT C8.8

The crust of the Earth is constantly being changed.

- Due to the complex nature of this conceptual area, teachers relied strongly on visual presentations including films, filmstrips, and videos to show the relationships and processes involved in crustal changes. The "Planet of Man" series from ACCESS was specifically identified by teachers.
- Teachers noted that in many cases they were limited to mainly theoretical study because the locale does not provide all forms of change required for study.
- Fields trips to local areas were noted where local rivers, mountains, and foothills were available. The Kananaskis area was specifically mentioned in a number of cases.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.2 Science as Inquiry

2.1.1, 2.1.3 Maximum Use of the Local Environment

1. Landforms are being built up by movements within the crust.

- This area provided a wealth of opportunity for experimentation and construction of models. Actual models constructed by students can be made with plaster of paris, plasticine, layers of cardboard cut in various shapes, and many other readily available materials. They are cheap enough so that all students can make their own. The processes involved identification of faults, folds, etc..
- Using pictures of geological features found within Alberta and in Canada, students can discuss the formation of the local mountains, the foothills and Rockies, the dates and aging of mountains in eastern and western Canada, and the relationship to fault lines along the Pacific Coast.

- Video tapes and films were suggested as an excellent way of introducing the concept of two opposing forces — building and breaking down of earth features. The video cassette "Jigsaw Fit" with J. Tuzo Wilson was specifically mentioned.
- Local field trips were identified by teachers as a must to reinforce conceptual development within this area. These field trips ranged from identification of geodetic markers in towns (where students can see that there are actual changes in elevation and that parts of the country are still rising), trips to Foothills sections of Alberta, or to destinations such as Kananaskis and Jasper.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.3.4 History of Science

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(a) Earthquakes are the result of movements of masses of rock.

- Audio-visual aids were identified as an absolute necessity to provide students with the visual reinforcement of concepts. Pictures and slides of movement along the San Andreas Fault to the Aleutian Islands (through the coast of B.C.) leads to discussion of earthquake-proof buildings in areas such as Vancouver. Videos and films were identified by nearly all teachers, however, the only two titles specifically mentioned were "Earthquake" and "Earthquake Below."
- Teachers expressed concern that Canada must be given special attention in a context of world-wide distribution of earthquakes through the provision of data on the location of faults in Canada. Concern was expressed that it is

absolutely necessary for students to be able to identify and discuss reasons why earthquakes occur in some areas but not in Alberta. Discussions lead to investigation of mass movement associated with the Frank Slide in southern Alberta and the town in Quebec which literally slid away.

- Experiments with earth boxes and models of plates showing longitudinal and vertical movement allow students hands-on activities related to this concept. As well, models can be constructed which will illustrate location of epicenters using seismograph readings from three different locations. One of these should involve the centre located in Ottawa.

1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as inquiry

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3 Maximum use of the Local Environment

(b) Faulting and folding are the result of large forces in the crust.

- The use of models was identified as one of the primary methodologies utilized by teachers. The models are used to simulate landforms which are constructed through folding and faulting. The mediums described by the teachers ranged from foam or sponge layers through to plasticine and modelling clays.
- A number of field trips are identified. These would be used following discussions of resulting features from folding and faulting through the use of photographs. Field trips specifically identified include: the fault near Elgarton, earthquake location near Lethbridge, Jasper Mountains, Banff, Waterton, the Crowsnest Pass area, and the Rocky Mountains in general.
- Audio-visual materials such as films and slides were suggested for use in supplementing classroom discussions. Though specific titles were not mentioned, it was noted that the slides of folding and faulting should be from locations in Alberta and Canada.

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as inquiry

2.1.1, 2.1.2, 2.1.3 Maximum use of the Local Environment

(c) Volcanism is associated with faulting in the crust.

- The use of films and videotapes of local areas were regarded as a necessary substitute for possible field trips. Though no specific titles were mentioned, there were references to materials available to discuss the Ring of Fire around the Pacific Ocean, and the Mt. St. Helen's eruption.
- The use of slides in classrooms discussions pertaining to different landforms found in Alberta resulting from volcanic action and processes related to plate boundaries was mentioned by a number of teachers. The emphasis was on remnants of volcanoes along the west coast of Canada, exposures of volcanic dust (from Mt. St. Helens and Mt. Mazama) and bomb remnants such as those found in the Crowsnest Pass.
- Demonstrations illustrating how volcanoes erupt may be used in the classroom quite safely. Substitutes are available for the older dichromate experiments. Another method of modelling volcanic action is to build a model geyser to aid in the demonstration of how heat below can cause a build-up of pressure.

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum use of the Local Environment

2. Weathering weakens rock formations.

- Field trips to locally identified areas were high on the list of the teachers' methodologies. Specific examples include the Frank Slide, Capital City Park area and Glacial Lake Edmonton, the North Saskatchewan River valley, the Badlands, Waterton, and many other readily identifiable features which could be found in any community.

- Experiments and labs included freezing water in a closed jar, application of acid on limestone rocks, and the heating and cooling of rocks.
- Films, photos and slides related to weathering and rock formations were mentioned frequently, however, no specific titles were listed.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(a) Mechanical weathering makes small pieces out of large ones.

- A number of visual aids were suggested by the teachers with the greatest emphasis on those which pertain to local areas. These would include slides, posters, and overheads with specific references to Frank Slide in the Crowsnest Pass, the Drumheller area, hoodoos in Banff, and commercial applications of sandblasting. Videos were suggested, with "The Uneventful Day" being provided as an example.
- Field trips and observations around the school yard to include the effect of ice freezing, the impact of plant roots, gravity, erosion, etc. were mentioned by most teachers. More extensive field trips included those to the Bow River, or to the mountains of Alberta to observe talus and alluvial fans.
- In order to make this concept as relevant as possible for students, they should be given illustrations from everyday life. Students should be encouraged to bring weathered materials and rocks for discussion. Lab experiments can demonstrate what freezing water will do in rock cracks, or how rocks and minerals can be broken down by placing them in a jar and shaking vigorously.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(b) Chemical weathering changes the rock itself.

- Demonstration labs were identified as a key component of methodologies. Experimentation on chemical weathering includes the effects of HCl (hydrochloric acid) on calcite, limestone, gypsum, etc.. For younger students, the use of vinegar on limestone would suffice.
- Films and videos were suggested but once again no specific examples were given.
- Outdoor observation around the school and field trips were encouraged. These excursions ranged from trips to the graveyard to observe gravestone surfaces that were many years old and the effects that acid rain and oxidation of ores have had, to trips to the "Badlands" to observe caves and piping.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

3. Erosion changes the landforms.

- The use of films and videos was recommended with the "Planet of Man" series being the most frequently noted. Other approaches including visual aids incorporating the use overhead transparencies to explain the three main forces of erosion, through to map work (topographic maps) and the use of satellite imagery as well as aerial photographs. These materials can be used with stereoviewers to study the areas and compare the different stages of erosion and their impact on specific landforms.

- In this section of geology, teachers felt that field trips and outdoor excursions were of absolute necessity. There was increasing emphasis, however, on the need for available resource people to translate the geologic features found in the local areas. A number of specific trips were identified including Writing-on-Stone Park in Milk River to see the hoodoos, the Red Deer River Canyon, the Badlands at Trochu, numerous places in the Rocky Mountains, and for those in northern Alberta, the McKenzie Delta.
- Simple labs and demonstrations were identified as being very effective means of assisting students. One example of wind and water erosion was to take two boxes of soil and debris, pour water over these to show what happens as a result of water erosion and then to use a fan to show wind erosion subsequent to their drying.

1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(a) Erosion is caused by running water.

- Visits to local streams or river sites were identified as a must by nearly all teachers contributing. The use of these areas included study of the nature of the watersheds in western Canada, local water erosion, measurement of sediment volumes in Rocky Mountain watersheds, identification of coulees and other related phenomena, impacts of spring run-off and glacial run-off as well as relationships between the rate of flow of water and the rate of erosion. Specific sites identified include meanders on the Old Man and Milk Rivers, the North Saskatchewan River valley, the Bow River, the pothole coulees in southern Alberta, the Pembina River, the Red Deer River valley, and the Battle River stream system.

- Labs and demonstrations using stream tables seem to be one of the most commonly used methodologies within the classroom. This can usually be followed by use of aerial photographs of local stream or river systems in the application of the processes to these features. Specific examples listed include the Battle River drainage system, where students can also look at the age of the features in terms of oxbow lakes and effects of glacial run-off. Visual aids including films and videos are utilized by teachers. Specific mention of "The Uneventful Day" included the teacher's view that this could be made relevant to the Canadian scene.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(b) **Erosion is caused by wind.**

- A number of field trip examples were included in teachers' responses to this section. The specific sites all provide excellent examples of local soil depletion, movement of dunes by the wind, erosion of nearby rocks, and in general, the effects of wind erosion on farmland. Sites listed include Fincastle near Taber, Alberta, the Badlands of Drumheller, the hoodoos of Banff, the McIntyre Ranch, and Writing-on-Stone.
- Teachers use slides, snapshots of southern Alberta, and filmstrips to provide supplementary information on this section. The "Work of Wind" was one filmstrip mentioned.
- Demonstrations within the classroom included using sand particles propelled by wind upon an object in order to demonstrate how sand carried by the wind can erode objects.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(c) Erosion is caused by glaciation.

- Teachers' suggestions pertaining to the examination of evidence of glaciation in local areas were abundant. These include examination of glacial till and evidence of glaciation around Kinsella, glacial till and mounds around Taber, examination and comparison of areas in the Cypress Hills and the Rockies, glaciers at the Columbia Icefields, examinations of drumlins, kettle lakes, erratics, etc. east of Red Deer, glaciation around Edmonton and vicinity, and detailed study of glaciation in Waterton Park.
- Where field trips were not possible, there were numerous suggestions for use of visual aids — slides, films, etc.. In particular, the use of slides of the Columbia Icefields (Alberta's glaciers) and photographs of other Rocky Mountain regions were identified.
- In-class laboratory and theoretical study could include classification of rock types by students with a correlation to their location. Students could then be required to make inferences as to how the rocks were moved and where they might have come from. Geologists' reports on glaciation pertaining to the local area could be used to identify the paths taken by glaciers and the evidence that the glaciers did pass over the surrounding features of the land.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(d) Erosion is caused by ground water.

- The use of field trips to further explore this concept area included local visits to areas where practical problems are faced by farmers in losing the topsoil due to ground water run-off or sinkholes at the golf course and underground springs. There were more elaborate suggestions to visit the limestone caves of Alberta to study the relationship of the underground caves and springs.
- Though films and filmstrips were identified for use by teachers, the only specific title mentioned was "Ground Water."
- In many cases, teachers had indicated that, following demonstrations using stream tables, they discuss the formation of caves, supplemented by pictures, and how the depth of ground water affects rural wells. There was a request on a number of occasions to have more Alberta information provided.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(e) **Agents of erosion help lay down sediments.**

- Students either start with the use of a stream table or doing experiments which may demonstrate sedimentary layering in a tank or a large jar, then apply their analyses to watersheds of major Canadian basins. Deltas lend themselves well to this discussion, in particular those in the McKenzie area and Manitoba. Glacial lake Agassie was referred to as one area which may be discussed using the video of one "Nature of Things" program.
- A number of field trips were suggested for hands-on examination of sediment deposits in river valleys and flood plains of Alberta rivers. In most cases, the reference was made simply to local streams. However, some actually named rivers such as the North Saskatchewan River.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

4. Dynamic processes are at work within the Earth.

- This section was identified by most teachers as a preview of plate tectonics so most attention was focused on studying the processes with the aid of illustrations. Lab demonstrations included the use of boiling tomato soup. In terms of the study of plate tectonics, teachers recognized identification of Canadian scientists such as Tuzo Wilson.
- Though teachers referred to films and filmstrips, no titles were identified.

1.1.7 Interdisciplinary Nature of Education

1.3.4 History of Canadian Education

1.4.1 Philosophy Underlying Canadian Science

(a) **Forces acting on the crust are due to the structure of the Earth.**

- In this section, most teachers identified the use of lectures aided by visual materials to discuss the structure of the Earth and how forces act to change that crust. The only specific materials identified were those in a series called "Earth — Sea — Sky", a Spokane College telecourse.

(b) **Theories have been advanced to explain how forces have acted on the crust to produce the present landforms. Continental drift, plate tectonics and sea floor spreading are theories advanced to explain crustal deformation.**

- Films and videos seem to be one of the major resources utilized by teachers, however the only specific recommendations referred to a video on Continental Drift from ACCESS.
- The most common laboratory or class activity had the students cutting out continents from a map of the world and placing them in a position that would

resemble Pangea. Following this, students were then asked to focus on the North American and Juan de Fuga plates to identify the relationships that would exist between potential forces acting on these plates and the landforms that now exist. The materials produced by Kananaskis Country for their Environmental Education Library were listed by a number of teachers as a potential resource.

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2 Maximum Use of the local Environment

CONCEPT E8.1

Materials from the crust have had an important influence on mankind's daily living.

- Teachers' suggestions focussed primarily on in-class discussions and study of the economic resources in Alberta in terms of their location, how they are formed and how they are used. For the major part, these included coal, gas, and oil. Most teachers did extend these discussions to include the impact on one's community, Canada, and the international domain.

1.1.1, 1.1.4, 1.1.5, 1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.4, 1.2.5, 1.2.9 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.7.1, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

1. Fossil fuels and their products are important in the economy of Alberta.

- In-class study of possible fuels in Alberta included their formation, deposit locations, and economic importance in Alberta. Those considered were coal, oil and natural gas. In terms of their use and the effects their use on the economy and the environment, areas such as their extraction, exploration and affiliated sciences such as seismology, gravity metering, and reservoir geology were discussed. Maps from government and oil industry sources were used to show location and deposits. The SEEDS materials were mentioned by a number of teachers.

- Field trips to local oil and gas sites, coal mines, and gas plants were suggested where possible. A number of sites were identified including the Athbasca Tar Sands, Fort McMurray, Devon, Taber, Edmonton, the Crowsnest Pass, and the Lethbridge area.
- In-class visits by local oil company personnel and geologists were encouraged. Those teachers that had made this recommendation pointed out that there are several oil exploration companies which are more than happy to make available specialized personnel for class or field experiences.

1.1.1, 1.1.4, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.4, 1.2.5, 1.2.8, 1.2.9 Canadian Science - Canadian Society Interaction

1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.7.1, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

2.4.3 Problems of Regionalism

2. Since crustal materials are limited, exploitation must be managed for maximum benefit.

- In the discussion of renewable and non-renewable resources, most teachers tried to present a balance of information regarding traditional and alternate sources of energy. In the discussion of exploitation of natural resources, the tar sands in Alberta and the oil and natural gas industry seemed to be the main focal point. Teachers continually suggested the use of SEEDS materials. Where alternate sources of energy such as solar, wind and geothermal power are discussed, teachers tended to look to a number of magazines and newspaper articles for supplementation.

- In the discussion of management, or mismanagement, of natural resources, teachers suggested guest lecturers to discuss conservation policies of companies and groups involved in exploration. These included geologists, party chiefs, owners, surveyors, and others involved in predicting life spans of various fuel sources as well as environmental impact.

1.1.1, 1.1.4, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.3, 1.2.4, 1.2.5, 1.2.9, 1.2.11 Canadian Science - Canadian Society Interaction

1.3.3 History of Canadian Science

1.4.1, 1.4.4 Philosophy Underlying Canadian Science

1.7.1, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.2, 2.1.3, 2.1.6 Maximum Use of the Local Environment

2.4.3 Problems of Regionalism

CONCEPT E8.2

Evidence for determining the past history of the Earth comes from a study of the crust.

- Theoretical study seems to be one of the most dominant approaches. Using local examples, in particular that of the study of coal in Alberta, processes of mountain-building are discussed and interpretted from several points of view including those of evolutionists and creationists.
- In terms of field trips, the Drumheller area was listed by a number of teachers. Following a field trip to the Badlands, geological dating as exposed in the Grand Canyon and Drumheller areas are compared.

- Though a number of visual aids were identified by teachers for use within this section, no specific titles were listed.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

1. Age determination can be estimated on the basis of rates of changes of crustal materials.

- The major emphasis was on discussion of radioactivity (Carbon 14 dating) of fossils and rocks. Following discussions emphasizing the relative versus absolute methods of dating, C14 dating is applied to organic components of Alberta's history.
- A number of field trips were identified including trips to the Strathcona Science Centre in Edmonton, the Provincial Museum — Geology Section, and the Space Sciences Centre. More extensive trips were identified from High Prairie to Jasper to the Icefields to the David Thompson Highway to Edmonton.
- Though teachers identified films as a means of including Canadian context in this section, no specific titles were offered.

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(a) Sediments have been laid down throughout the lift of the earth.

- Teachers identified films as a way to deal with theories of uniformitarianism and catastrophism as related to methods of sedimentation, and more specifically to sedimentary rock layers in Alberta. No specific titles again were suggested.

- Local field trips to nearby river banks were suggested, where layers can be examined, columns drawn, and samples collected. Specific suggestions included Rundle Park, the North Saskatchewan River, or "Badlands" areas.

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(b) Radioactive elements decay at measurable rates.

- Most teachers indicated that they were mainly limited to theoretical study. However, to assist them in a hands-on, lab-oriented approach, some teachers mentioned the use of rock kits from the Provincial Archives which offered excellent samples of fluorescent minerals. The rock samples are studied and a geiger counter is used to measure the radioactive elements activity.
- The only field trip suggested by teachers was to University geology or biology labs to find out how radioactive dating is actually carried out.

1.2.8 Canadian Science - Canadian Society Interaction

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

2. Fossil evidence can be used to relate past events in the history of the earth from one place to another.

- Sedimentary rock samples obtained on field trips, or from kits made up of samples from specific areas in Canada, are analyzed according to the type of fossil specimen and inferences made as to the original location and history within Alberta or Canada.
- References were made on a number of occasions to slides and audio-visual materials yet the only specific reference deals with slides of marine fossils on a mountain top, i.e., Parker's Ridge, Alberta.

- Within this section, field trips are identified including visits to museums (Provincial Museum, Tyrell Museum), Drumheller Paleontology Museum, Duchess and Drumheller National Parks, and the Edmonton Museum.

1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(a) There are different kinds of possible evidence: remains, casts, molds, and replacement fossils.

- Field trips to Drumheller, with subsequent visits to both museums there, ranked high on teachers' lists for methodologies.
- Laboratory activities related to the preparation of casts, the making of molds of fossils, and the use of plastic replicas in making plaster of paris casts seemed to be one of the major activities suggested by teachers. Once students became familiar with the processes of making their own fossils, they identified relationships between fossils found in Alberta.

1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(b) Earth's history can be divided into periods of geologic time on the basis of the type of fossil evidence.

- Field trips to mining sites, volcanic areas, erosion sites, and more elaborate trips to the Drumheller area are suggested as meaningful ways for students to become familiar with local examples of fossils related to periods of geologic time.

- Audio-visual materials and films are suggested for use within this area, however the only specific mention was that of SEEDS materials and accompanying filmstrips.

1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

(c) Fossil evidence is used in oil and gas exploration.

- Teachers placed a heavy emphasis on field trips to areas of oil and gas exploration or to museums where samples may be readily available for viewing. It was considered that there were vast amounts of materials available in the province and that kits should be made available to teachers.
- Audio-visual materials and films were suggested by teachers, but only the SEEDS materials were specifically mentioned.

1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

1.7.1, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

APPENDIX XI

STAGE III: Summary of Information Gathered From Interviews with Selected Science Teachers

Included in this Appendix are:

1. Sample Questions used to Direct Interviews with Science Teachers.
2. A Summary of Information from Interviews of Selected Earth Science Teachers in Stage III.

1. Sample Questions Used to Direct Interviews with Science Teachers

The interviews with science teachers were basically conversational in nature. Though the researcher prepared guiding questions, it was necessary to be very flexible and encourage teachers to continue to discuss those areas which seemed to be of greatest importance to both them and to the study. The focus of the interview was to obtain details regarding what the teachers were doing to modify and supplement the curriculum materials to include a Canadian context, beyond the information which was given in the original survey. In each of the cases as the interview progressed teachers were encouraged to expand upon those specific areas related to implementation of a Canadian context in the geology curriculum some of which seemed to be unique to that teacher. Therefore, as individuals engaged in the dialogue, questions were offered similar to those that follow:

1. In the survey related to the teaching of geology concepts in the Grade 8 Earth Science Program, you had indicated a number of interesting activities which you use to encourage a Canadian context in science education. Could you elaborate a little on . . . ?
2. In what way do you feel these activities encourage students to consider a Canadian context in science education?
3. Do you consciously think of identifying Canadian context? How do you go about identifying those needs that are relevant to your students? How do you capture this combination of excitement and thrill of doing science, and share that with your students?
4. Do you find that the students naturally are led to something they can relate to - within their own societal structure or context?
5. What would be the basic keys that we would have to look at and address within our geology curriculum to make it more relevant to students and inclusive of a Canadian context?

6. What aspects of a Canadian context tend to fulfill the needs of a person who is truly interested in geology?

7. What guidance is necessary from a curriculum guide such as listing different activities, providing resource materials specific to areas, and identifying resource people to bring out more of the elements related to a Canadian context in science education?

8. You mentioned the EDGEO program a number of times - could you elaborate on what that is?

9. What do you perceive to be the difference between taking a package of materials that someone shipped out to you and the kind of experience you had to where there is actually in servicing and sharing of a program to include more of the components of a Canadian context for science education?

10. What role would the inclusion of a Canadian context for science education in the pre-service education that we offer the teachers for science education play in implementing a Canadian context in geology component of the Grade 8 earth science program?

2. A Summary of Information from Interviews of Selected Earth Science Teachers in Stage III

This summary of comments reflects the major views which were presented by the earth science teachers interviewed and includes excerpts from the interviews to substantiate and elaborate. These excerpts have been coded with TC. Teachers tended to provide little on the specifics beyond what was indicated on the survey but instead wanted to dwell on the support for inclusion of these aspects of the geology program or the rationale behind their selections. Therefore the summary is presented in three parts:

(1) Specific comments related to the teaching of the concepts or sub-concepts.

(2) General comments related to desirability and relevance of a Canadian context in the geology component.

(3) General comments related to feasibility and implementation of a Canadian context in the geology component.

Within each of these three sections the comments are followed by the related elements from the Clue Structure for a Canadian Context which they support.

(1) <u>Specific Comments Related to the Teaching of the Geology Concepts in the Grade 8 Earth Science Program</u>

CONCEPT C8.7

1. Common Minerals found within the Earth's crust.

Most minerals are made up of elements from a group of only nine naturally occurring elements.

- Students should be challenged to write reports.

TC1 - "For example, I asked students to find out where a mineral is found, and in what form it is usually mined. Not just North America, or Canada. This is necessary so students have an idea that we don't just live here in Canada because a particular mineral is found here. It is found all over the world in some cases. They should know that. From that point on, it is whatever they want to put in the report."

1.7.1 Canadian Science Policy, Current Emphasis in Canada and their Interaction.

2.1.3 Maximum Use of the Local Environment

2. Rocks are formed from a mineral or a mixture of minerals.

- Students should be allowed to work independently to inquire about a mineral.

TC2 - "A different approach from most of my units is something I do for a mineral unit. I give the kids each a mineral that they don't know anything about, they don't know the name, where it's from or what it does. Their job is to go through a certain series of tests and to find out all about it. It's all on their own. For three weeks they work by themselves. For the first two or three periods, I go through and explain how to identify the qualities through different mineral tests and it is their tasks to identify their object. From there they have to do further research to find out its purpose; what it is in its rock form; where it is mined; and what its value is on the market today. I find that to be really interesting because most kids really go after it."

3. Rocks can be organized into three main groups.

- No relevant information obtained from interviews.

1.1.4 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2 Science as Inquiry

CONCEPT C8.8

The crust of the Earth is constantly being changed.

1. Landforms are being built up by movements within the crust.

- No relevant infomation obtained from interviews.

2. Weathering weakens rock formations.

- No relevant information obtained from interviews.

3. Erosion changes the landforms.

(a) Erosion is caused by running water.

- Look at river flooding and the implications it has on man-made structures and development.

TC3 - "This year we had another flood which was fairly severe. There was a perfect opportunity. The following week the kids used pictures we took of the flooding of the North Saskatchewan to discuss the things we had been talking about concerning erosion. We showed the pictures of the 1915 flood in Edmonton. There is a series of slides we show. There usually is very little buildup for this kind of thing. We have one or two days where we discuss it, come back to it, and then we get into our regular units."

1.1.2 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

1.5.2, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

2.1.4 Maximum Use of the Local Environment

(b) Erosion is Caused by Groundwater.

- Look at the relationship between geologic processes and implications for human development.

TC4 - "We look at the immediate Edmonton area, we go off on a beautiful viewpoint and survey the city. The first thing is to identify some of the geological things that you can see right from there. It's great because right within our own river system, the North Saskatchewan River, we have all kinds of geological processes that have implications for developing buildings. The Convention Center is a beautiful example of what happens when we have to deal with slumping and Keeler Road (and there are a number of other roads you can talk about) is great to demonstrate the movement of the road and the problems that exist for the construction industry."

4. Dynamic processes are at work within the Earth.

- No relevant information obtained from interviews.

1.1.2 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

2.1.4, 2.1.5 Maximum Use of the Local Environment

CONCEPT E8.1

Materials from the crust have had an important influence on mankind's daily living.

1. Fossil fuels and their products are important in the economy of Alberta.

- Deal with the issues in such a way that includes the relationship of science, economy and politics.

TC5 - "If a question comes up in class and its relevant, then I make the decision whether to carry on with it as a discussion, or whether to let it go. It just depends on where I am at in the program for time and everything else. In a lot of cases I like to take the time to deal with issues and escalate right up to an economic and even political issue. The kids need to know that sort of thing. They need to have some input into how science affects the politics, or rather how politics affects science. The example of oil is great. It affects them financially, right in the pocketbook in terms of their parents. They may have heard the other day that gas prices are up or they are down or whatever; they may have heard about gas pricing laws. If it's relevant we talk about it."

- Use resource people and the local environment to talk about resources.

  TC6 - "We use the Rundle Park area a lot. We tried to find a local area close enough so we could take a whole group of kids and see enough things to make a day's activity worthwhile. We had softrock geologists explain the applications to oil, which is a very relevant resource here. You can ask the kids in the classroom how many parents have jobs related to the oil industry and you are guaranteed to have a small percentage in every class put up their hands. Now this is something that has a lot of relevancy."

1.1.6, 1.1.7 Interdisciplinary Nature of Science Education

1.2.2, 1.2.3, 1.2.5, 1.2.6, 1.2.12 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

1.7.4 Canadian Science Policy Current Emphasis in Canada and their Interaction

2.1.5, 2.1.6 Maximum Use of the Local Environment

2. Since crustal materials are limited, exploitation must be managed for maximum benefit.

- Students must be made aware of the limitations of our resources.

  TC7 - "I also deal with kids on a political sense; I am telling these kids that right now our oil wells in Alberta can only pump out so many barrels a day of free oil, not trapped oil. Whereas in the Arabian countries they are pumping out ten times that, thus it's an oil glut on the market. They can sell the oil for a lot cheaper. At this point in my last class the questions coming out were incredible. Students were all suddenly concerned about the world energy crisis. We put a graph on the board showing whats happened to the consumption of natural fuels over the last 30 years and showed how the graph escalates exponentially. The question is, what's going to happen? The natural response is we are going to run out. So what do we do now? The funny thing is that when you tell kids 'when you are my age, this problem is going to be real. It's not a problem that we are just forecasting in the future; for you that will be the future. That will be happening when you are my age, when you have a family. So what are you going to do about it?' You can just see the kids twisting in their seats and all of a sudden this has become a real issue. Like most kids this age they want to know what we were going to do about it. I answer that I don't have the answers. 'That's going to be your job as citizens of Canada and of the world as human beings. That's what you are going to be faced with'."

CONCEPT E8.2

Evidence for determining the past history of the Earth comes from a study of the crust.

1. Age determinations can be estimated on the basis of rates of changes of crustal materials

- No relevant information obtained from interviews.

2. Fossil evidence can be used to relate past events in the history of the Earth from one place to another.

- No relevant information obtained from interviews.

1.1.6, 1.1.7 Interdisciplinary Nature of Science Education

1.2.3, 1.2.5, 1.2.6, 1.2.12 Canadian Science - Canadian Science Interaction

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.3 Maximum Use of the Local Environment

(2) <u>General comments related to desirability and relevance of a Canadian context.</u>

- Identification of Canadian scientists is important. There is a certain science that is common no matter what country you are in but we must also identify things that are uniquely Canadian wherever we can.

TC8 - "This whole idea of what is Canadian is one that has needed defining because our country does not possess the same kind of attitude that Americans have and that is where having a Canadian context defined is great."

- It is important to differentiate between Canadian content and Canadian context.

TC9 - "There is a lot of geology that is not Canadian content, but it has a Canadian context because it has a very great influence on us. There is an awful lot of science that was not designed or discovered in Canada that has a profound influence on us as Canadians, and even in our relationships within Canada, that still has a Canadian context. It's hard to pin science down to a country, so we must look at the relationship of science, society and technology."

- Promoting a Canadian context is getting down to the needs of the students rather than saying it's Canadian.

TC10 - "The aspect of Canadian basically is to cover or get closer to what our students need, because if we teach geology with Canadian content from Ontario it may still be foreign to our students - depending on the circumstances. Therefore applications must be as immediate as possible."

(3) <u>General comments related to feasibility and implementation of a Canadian context.</u>

- If one is working in a Canadian context then it is necessary to ensure that the Canadian focus in terms of subject matter, as in geology, has to be localized to one's own region, the region of the school.

TC11 - "We have to focus first on our immediate environment and then go beyond that. What happens is that teachers and students are limiting themselves to resources that are available in print and this is where the policy on Canadian focus in textbooks must be enforced."

- In curriculum guides there are prescribed and recommended textbooks. As long as supplementary materials are viewed as secondary resources, teachers are not likely to use it.

  TC12 - "If prescribed textbooks do not have a Canadian context built into them, then there isn't going to be a Canadian context. You can't expect teachers to always be looking for other materials to reinforce the core program. There are costs and time constraints involved."

  TC13 - "In this province it is curriculum development by consensus rather than expertise. Things are included in the curriculum to please major stakeholder groups or use of implementation rather than for the benefit of the students. This includes selection of resource materials."

  TC14 - "In our school district we looked at a model of science which can help us to develop a logical package of resource materials on any subject that you like. We do have a general basis if we were to go in and develop the package. This seems to be sadly lacking in the field of geology and it certainly could be a basis for supplementing any of the textbooks we presently use. We can take textbooks, force them into our mold, but again we are faced with time and human resource constraints. Group power certainly comes out way ahead as opposed to an individual's effort."

- The teacher must be given ways of finding materials and implementing these in their immediate environment without having to develop these as they would an elective unit.

  TC15 - "A modularized approach may be the way to go. The stuff that teachers really hang onto, and work a lot with is material that is very specific to our area, and therefore relevant. It's a study done by people who recognize the need to get things like this, plus the fact that it involves a field trip. The kids love to get out of the school, it makes science more relevant when they can see it. We should be able to do it for every unit that we teach."

TC16 - "As far as Canadian context on a unit goes, someone should put together some process activities and problem solving activities that the students are going to do in their own schools with their own materials and that is relevant to them - i.e. Canadian content."

TC17 - "I've never really been a textbook teacher. All my material, the stuff that I really hang onto and work with a lot, is the material that is very specific to our area and therefore relevant."

- Another aspect of developing a Canadian attitude, a Canadian focus is often denied in the structure of education of children and that is the utilization of local resource personnel to a larger degree than we are now.

TC18 - "When we are dealing with issues in geology or anything relating to environment, we would often take the opportunity to invite local scientists or geologists, specialists in the area, or any of the people that are well-studied and very familiar with the local environment. They are better able to translate and describe some of these ideas from a local perspective and its a sense of community starting from within the classroom, within the environment in which the children live which will expand to the sense of provincialism and Canadianism. It's not a practice that many teachers are able to utilize as much as they would like to due to the kind of structures within which they work."

TC19 - "A program can be very relevant to Alberta when you are working with, and have worked with, professional people whose job is very specific to this area. What they teach is based on that premise. If you are working, for instance, on a textbook that is already American oriented in general, then your teachings probably won't be specific to an area unless you can find some relevancy by taking the kids outside of the classroom."

TC20 - "When I was on this field trip with a whole series of geologists and some graduate students working in the field, we took a bus tour of the Edmonton area...the idea behind this was that they wanted to get rid of the textbook style of teaching because they said this is not specific to Alberta."

TC21 - "This geologist got up and told us that geology as a profession, as a vocation, is a lonely job. He went through a series of slides to show what it was like when you work in the field. He said that's what got him interested in geology was (in his elementary days) when a teacher took a group out, just wandered out from the school along the riverbank. He studied rocks, and his teacher excited him about finding the rocks. He said that from that point on, because his teacher got so excited about what they found, 'that changed my mind.' He said that from then on he had such an incredible interest in rocks that every rock he found he brought to the teacher. We looked at it and discussed it. He then became a rockhound and 'here I am a geologist, doing what I'm doing.' That really impressed me because I thought 'okay, I'm a teacher teaching science. Geology is not my specialty, but yet I would love to be able to, if I could, do the same thing."

- Teachers must be provided with appropriate in-service and workshops to facilitate integration of a Canadian context for science education.

TC22 - "In terms of getting Canadian content, the field trip around the area looks at geology and how it affects Alberta in the Edmonton area. The people form the university, and the geologists working the field around Alberta. Everything that they told us was very relevant, and you then get to be comfortable with that area. When I first started teaching this program there was no relevancy to Canada, or to Alberta for that matter. There were very general topics that came out of books which were printed in the States."

TC23 - "So often we as teachers teach a program, and we have no idea of the true relevancy of it. We don't know how this applies to the real world. Geology is one perfect example of that. There are some teachers out there teaching geology in Grade 8 science that have no background, and worse yet, have no idea of how it applies out there. They've never even talked to a geologist. Then unless they are outstanding teachers and can still make it exciting, I think the program dies. I do not know how a teacher, without having the opportunity to talk to geologists, would know how important this stuff is."

TC24 - "After experiencing a workshop like EDGEO it becomes apparent that you need it. The most important thing I think the EDGEO unit has done is provide me with a lot of background, more background than I ever had about geology in the immediate area. The literature they give is tremendous. I have supplemented, taken sheets out of this, adding to this program. From what we don't get out of this, we get from textbooks but not a lot of it. A lot of the material I run off and get to the kids as I see fit."

TC25 - "A lot of what one learns about a Canadian context has to come from some kind of professional workshop. If you wanted to make sure that every teacher in Alberta, teaching science to Grade 8 students, attends that kind of workshop you have to make it mandatory. That's the only way I can see. I don't know how well that would be received out there, but that's one thing I would suggest."

APPENDIX XII

STAGE III: Information Gathered From Interviews With Scientists

Included in this Appendix are:

1. Questions Used to Direct Interviews with Scientists.
2. A Summary of Information from Interviews with Selected Scientists in Stage III.

1. Questions Used to Direct Interviews with Scientists

Once again the interviews with scientists were basically conversational in nature. Prior to the interviews the researcher had distributed the guiding questions listed below to each of the scientists along with the copies of the survey sent to teachers in Stage III. In each case the interview started with fairly firm adherence to the questions as outlined. As the interviews progressed and scientists were encouraged to expand upon those areas for which they showed particular interest, more flexibility was shown in order to bring out as much relevant information as possible related to a Canadian context for geology education.

1. Are there aspects of the geology component which are particular to Canada?
2. What can we do within the area to elaborate on those concepts?
3. Have teachers called upon you to serve as a resource person in this area? What have you been doing with teachers over the past years? What do you perceive could be done, your impressions or perceptions as to availability of information to enrich a Canadian context for geology education? Do you feel teachers take advantage of the opportunity to participate when in-service programs are made available? If not, how do we go about doing this?
4. Has there been an interest expressed by the local people to learn more about the geology and geomorphology of Alberta?
5. Which aspects of the local landscape do you feel are readily accessible in this area and are integral to the study of geology and geomorphology? What kinds of things do you suggest to people as far as trying to bring this local relevance, besides the field trip component where one is going out and looking at the field of study?
6. How do you feel one could promote a better understanding of a Canadian context for major geology concepts taught at junior high level?

7. Do you feel that there is a problem in teaching geology because of the lack of emphasis on transfer of knowledge to the student's immediate physical and cultural environment?
8. Does sequencing of materials in a manner which uses the application to the local environment and familiar landscapes make a significant difference in the teaching of geology?
9. Do you feel that even if a teacher is unfamiliar with the area of geology that there are abundant physical and human resources available to compensate for this and still promote a Canadian context for science education? Do you find that teachers are looking for materials and methodology suggestions? Are they actually looking for packages? How receptive are they to the suggestions you provide?
10. Are teachers aware of the contributions made by Canadian geologists to geology internationally?
11. Are we failing to encourage students at the public school level to consider careers in the earth sciences because of our lack of emphasis on Canadians' contributions to these areas?
12. Are the problems in teaching the geology concepts inherent to this field of study?
13. Is there some reason why teachers do not use local examples of geological processes?
14. How can a teacher best handle concepts in geology that are unique to the Canadian scene?

2. A Summary of Information from Interviews of Selected Scientists in Stage III

This summary of comments reflects the major views which were presented by the geologists interviewed and includes excerpts from the interviews to substantiate and elaborate. These have been coded with an S. The summary is presented in three parts:

(1) Specific comments related to the teaching of the concepts or sub-concepts.

(2) General comments related to desirability and relevance of a Canadian context.

(3) General comments related to feasibility and implementation of a Canadian context.

The three sections of comments are each followed by the related elements from the Clue Structure for a Canadian Context to which the comments apply.

(1) Specific Comments Related to the Teaching of the Geology Concepts in the Grade 8 Earth Science Program

CONCEPT C8.7

The Crust of the Earth is Formed of Rocks.

- Try to remove the abstract presentation of geology from the classroom.

  S1 - "In a class one can take a rock specimen to a class and say the rock was formed under temperatures in excess of 1000 C° in excess of 7 kilobars pressure in a highly molten plastic state. Here it is hard and brittle and totally out of context. This rock occurs in cubics of miles. Students can't even imagine what that dimension is in three dimensions. In the classroom you have walls which are 30 to 40 feet apart, how do you actually get the physical impression of the size of this body of rock into the classroom? What you have to do in truth is to let the students see this thing in the field; or in some way bring the field in a less abstract way in a fist-size specimen, and create much more realistically the earth as it really is. As we know it as geologists. Presented to them in a less abstract way than a chalk line on a board, I think we could do a better job than recreating the geological environment from the outside, than dealing with it in a cloistered atmosphere of a classroom."

1.1.9 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

2.1.1, 2.1.2, 2.1.4 Maximum Use of the Local Environment

1. Common Minerals found within the Earth's Crust.

Most minerals are made up of elements from a group of only nine naturally occurring elements.

- Canadian context is talking about research in chemistry and metallurgy.

S2 - "Isn't it amazing that all of a sudden the waste pile at the dump, which was dumped 80 years ago in the Kootenay, is being remined. They have now found a way of getting the copper and nickel out of the complex wall which was untreatable at the turn of the Century. We must bring research and its value into the classroom, and demonstrate what science there is to learn and where we can go from there."

1.2.4 Canadian Science - Canadian Society Interaction

1.4.2 Philosophy Underlying Canadian Science

2. Rocks are formed from a mineral or a mixture of minerals.

- One should start with landscapes, and other interesting components which could fit into a Canadian context, and plug in the rocks and minerals later on.

S3 - "In Chemistry, Biology, or Physics, you can do things in labs under relatively controlled conditions. You can transfer physics and chemistry directly to some facets of the earth sciences in mineralogy and geology. But to start out with geology in an earth science class by putting students in the lab and shoving a whole bunch of rocks and minerals in front of them, is the most effective way to kill any latent interest in the earth sciences."

1.1.9 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

2.1.1, 2.1.2, 2.1.4 Maximum Use of the Local environment

3. Rocks can be categorized into three main groups.

- We must teach concepts and principles in context rather than the a, b, c's of rock identification.

S4 - "After we lose our contact time with students, what they retain will be an impression of geological thought, which is the underlying thought and foundation of science. Not 'this mineral is quartz or feldspar, or whatever.' Those are the tools. You really want to know more about workings, the mechanisms, the processes, the concepts and principles. That's what we want to accomplish in large measures so they can carry on thinking geologically when they don't have access to us resource persons."

S5 - "On paper the older your students the more mature the students and therefore the more capable the students will be in dealing with more sophisticated ideas. Now whether that works in practice or not is debatable. Based on experience you have to work pretty hard to get students interested in earth science topics. It's surprising that even after all these years that is true that if the teacher is not doing a good job in the classroom the study of geology is going to be a dull, dull thing. The study of rocks must be a well-thought out sequence of activities which can focus on these things you have identified in a Canadian context. For example, Canadian geologists and mineralogists have done a lot of pioneer work in the Canadian Shield which has supplied substantial information to the world of scientific endeavor."

S6 - "The occasional student might come along who is fascinated by crystal structures. It is a most interesting aspect of physical science, but the run of the mill Grade 8 student is completely deadened by the approach which usually initiates such a study. The alternative is so apparent. You look out of the window, if you've got a window to look out of in your classroom, and there is the real world. Now maybe in the middle of downtown Edmonton and Calgary this is not as easy to do, but certainly in much of Alberta it is - not in the literal sense, but in the figurative sense it is comparatively easy to do. Don't bog things down on day 1 by handing out a box of rocks and minerals and saying memorize this for next week. That attitude would turn off a lot of students."

1.1.1, 1.1.4, 1.1.7 Interdisciplinary Nature of Science Education

1.3.1, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.3, 2.1.4 Maximum Use of the Local Environment

CONCEPT C8.8

The Crust of the Earth is Constantly Being Changed.

- In the Earth sciences there are a number of areas within the general geological field where Canada is rightfully known. Students should be made aware of the contributions of Canadian scientists within these areas.

S7 - "Three Canadian geologists with whom we should definitely be familiar are Dawson, McConnell and Wilson who stand high on anyone's list of Earth scientists."

1.3.1, 1.3.4 History of Canadian Science

1. Landforms are built up by movements within the crust.

(a) Earthquakes are the result of movements of masses of rock.

- No relevant information obtained from interviews.

(b) Faulting and Folding are the result of large forces in the crust.

- Students should know that much of the modern knowledge of thrust faulting really got started in the Rockies and Foothills of Alberta.

S8 - "The really intriguing thing about the geology in southern Alberta is the nature of the structure in the Rockies and in the Foothills. Part of this portion of the province, the Rockies and the Foothills are surrounded by so-called thrust faulting. Basically what the world of geology knows about massive thrust faulting and the terrains that it creates is based upon pioneering work in southern Alberta Rockies and Foothills, which was done largely by oil industry exploration. So when you go back to the literature and look through the critical early papers many of them deal with structure in southern Alberta. That's a fairly sophisticated idea to throw at junior and senior high schools. Tectonic formation must be part of the Earth Science curriculum, so at least the student would have some nodding acquaintance with what a thrust fault is and how rocks can be displaced in such a way to get older rocks over younger rocks for example. Teachers are reluctant to tell you how it happens to be that way. So you might say that aspect of the structure of geology of the Foothills of Alberta is certainly unique."

S9 - "Maybe there have been 2 or 3 outstanding Canadian Earth scientists that should be mentioned dealing with landforms and crust changes. Gosif Dawson was one, his father was a geologist too. R. G. McConnell and R. W. Brock were the first two geologists that were sent out to look at the Frank Slide and subsequently authored the first report on the Frank Slide. McConnell was a pioneer in understanding thrust faulting. In fact there is a McConnell Thrust out West of Calgary. He is probably the first geologist to appreciate what he was looking at in these great overthrust faults that you find at the base of some of the ranges."

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.6.3 Science as Inquiry

1.7.4 Canadian Science Policy Current Emphasis in Canada and their Interaction

2.1.3, 2.1.4 Maximum Use of the Local Environment

2.4.1, 2.4.2, 2.4.3 Problems of Regionalism

(c) Volcanism is associated with faulting in the crust.

- Students must learn to understand earth processes within a context such as time.

S10 - "When the top of Mt. St. Helen's blows off everybody hears about it instantaneously. When the Livingston Range moves on the Livingston Thrust Fault nobody hears about it."

S11 - "The trouble with the attention that volcanism gets is that it creates a distorted impression of how things appear to have happened throughout earth's history. Volcanism can be spectacular and dramatic briefly and then quiescent for 50 million years. So it gets over-attention, particularly when it affects human lives and human activities. It gets more attention than it deserves in the long view of history, but it is an attention getter, just as an earthquake is an attention getter. There is nothing like an earthquake to wake people up. But the point that should be stressed with science at any level of education is that the short dramatic spectacular incidences don't seem to have played the same role in the longer time span of history. It is within this context that a Canadian content must be placed as well."

1.1.4 Interdisciplinary Nature of Science Education

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

2. Weathering Weakens Rock Formations.

- In order for students to understand abstract concepts and processes, they must work from familiar situations to the unfamiliar.

S11 - "We take the known and we project into the mystery of the unknown. From the familiar to the unfamiliar. We talk about the geological cycle of weathering, erosion, sedimentation, continental and marine environment in the geological cycle. Everyone's aware that mountains wear. The coastal plains that were nearby, and all the rest of it. Try to bring it into the backyard. One may say 'have you seen a geological process when you came to class today? Have you seen anything working that we could call a geological process?' They think for a little while and eventually get around to the creeks, rainfall, glaciers and the wind. They eventually realize that one drop of rain falling on the earth has a finite energy and mass and therefore transmits dimensions to the earth. They multiply one raindrop by a rainstorm, by a year, by a lifetime, by a century, and eventually it can wear away the Rocky Mountains. You've seen all those processes. You don't have to see a volcano or experience an earthquake to understand that geology is working everyday. We can look at the Saskatchewan River, or the Milk River in the springtime and we can see how muddy it is. What does that mean? It means that the mountains are moving down to the Gulf of Mexico. In the fall it is not moving down quite as quick because the water is clear. The water is not working. That's challenging?"

S12 - "You can go out to the Frank Slide. Another spectacular example of that nature. At the same time talk about urbanization, urban spread, the sterilization and freezing of valuable limited resources; sand, gravel, and clay. Now that's getting into a relevant context."

1.1.9 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

3. Erosion Changes the Landforms.

- No matter what the teacher's background there are abundant resources available to supplement for a Canadian context in the geology component of the Grade 8 Earth Science Program. This includes opportunities for field trips.

S13 - "I think there is adequate material available to any teacher who is serious about the job being done to acquire at least a minimal background on the Earth sciences. For example, Landscapes of Southern Alberta could be used as a supplementary text for the sections on landforms and erosions. Also, included at the end of that thing is a comprehensive list of basic research materials which are available in the libraries. I suppose whether or not a teacher would take the time and effort to consult that kind of available material would be dependent on personal motivation and general self interest in the topic."

S14 - "It's easier to deal with the subjects such as the impact of geology on man when we are travelling in the field. One can hire a bus and go to Drumheller. Visit at a museum or see landslide phenomena on the banks of a river. You can see the terraced development on the Red Deer; you can understand that Red Deer is carving the foot into the next terrace. The filed trips may see the foundations of a house being eroded by a stream."

S15 - "The intriguing questions about the recent geological history in this part of the province of course revolved around glaciation. We don't really know how many or how long the periods of glaciations were. People have been working on that problem for a long time. There is a wealth of information and research that has been done by Canadian scientists in this area."

S16 - "Canada has long been a major player in the post-glacial game, because so much of the terrain is post-glacial. You can pick up the literature anywhere on the topic and you will find Canadian scientists and researchers actively involved in the area and some mention of Canada."

S17 - "Every town, every village has a gravel pit because they all build roads. What if a teacher were to go to that gravel pit with a class and look at the rocks? Look at the shape, the size, the composition, proportions of one rock type versus another. By hands-on inquiry in the gravel pit we could have a super experience trying to reconstruct the story of each stone and grain that came to rest in that deposit. Not all of them will have the same mode and route of travel. The teacher has a chance to excite those students by talking about the glacial path. The glacial bulldozer carrying those rocks, backtracking the bulldozer and looking at the rocks that were passing over by backyard. Of course the glacier is not the only mode of transportation. There are other modes: stream transportation, and a combination of the two. We can see gradually how the earth is stripped by these agents very effectively, how material is reworked, recycled. We can go to the Milk River and we can see silt and clay moving foot by foot, day by day, towards the Gulf of Mexico."

1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.4, 1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.4 History of Canadian Science

1.5.2, 1.5.3, 1.5.4 Pure Science Canadian Applied Science and their Interrelationship

1.6.1, 1.6.3 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

4. Dynamic Processes are at Work Within the Earth.

(a) Forces acting on the crust are due to the structure of the Earth.

- No relevant information obtained from interviews.

(b) Theories have been advanced to explain how forces have acted on the crust to produce the present landforms.

Continental drift, plate tectonics and sea floor spreading are theories advanced to explain crustal deformation.

- In teaching geology and in particular about processes and structure, we have to teach it in a way that is useful and meaningful to those we are trying to communicate with. Though the principles are universal, we have to make them come alive, and there is no better way than to put it into the context of their own lives and integrate it with Canadian research and scientific achievements.

S18 - "J. Tuzo Wilson is one of those special guys who is a member of that handful of honest to God Geniuses. Of course he has the smarts to recognize the meaning of the kind of evidence that regularly accumulates and to put it all together. In effect he wrote the first chapter in the new plate tectonics textbook and the others around the world eventually fell in line."

S19 - "The earth sciences have a real image problem in the sense that earth scientists in general are not terribly romantic types. People in the biological sciences are dealing with animals, people or plants. People in chemistry or physics are dealing with things that can be popularized very simply. But how do you popularize plate tectonics? It's an incredible concept, it's a driving force in the world of geology today, but it's not exciting in the same sense that the discovery of a new virus, development of nuclear energy or discovery of the new tallest Redwood tree. Geologists just don't figure very prominently in the public eye unless they make a mistake, and they make mistakes. Some of the things in your Canadian context might help students to better understand just what it is that a geologist does and the profound impact we have on the contributions to the knowledge of the world around us."

1.1.1, 1.1.2, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.6, 1.2.7 Canadian Science Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.2, 1.4.3 Philosophy Underlying Canadian Science

1.5.2, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.7.1, 1.7.4 Canadian Science Policy Current Emphasis in Canada and their Interaction

CONCEPT E8.1

Materials form the crust have had an important influence on mankinds' daily living.

1. Fossil fuels and their products are important in the economy of Alberta.

- Students must be shown the interrelationships of geology with the everyday world around them.

S20 - "I think there are numerous ways of exciting teachers. I gave a lecture to try to stimulate teachers and thinking geologically in Red Deer. I gave a photographic story (about 50 photographs), and the opening shot was a finger on a light switch. I said 'what is the geological connection?' From the light switch I showed the copper wiring that is behind the light switch, and natural gas processing plant, the source of the plastic (the cover on the light switch). I then showed a photograph of an incandescent light bulb and the word tungsten, silicon for the glass, copper for the contact, and then I went back in time. We went to a photograph of sub-station, a photograph of high tension wires going out, a photograph of the thermal electric plant, a shot into the pit where they mine coal, a shot of the Craetacious environment where the trees were growing from which the coal is developed. Then I reversed it. I reversed the story to give it in its correct geological chronology. We went back to form copper. I showed a picture of a copper miner from which copper is produced, then the refinery process. The lead and all the rest of it went through a total geological connection, and every element one by one to my light switch was depicted in that geological context to show how geology impacts and influences everything that you look at and see and touch."

S21 - "There isn't a thing you can look at in a room that doesn't have a geological connection, be it organic, inorganic, or whatever. There is a connection in time and space creating awareness, understanding of a method of accessing geology, showing and bringing it into the context of the environment of the classroom. The teacher may ask the student 'did you see any geology on the way to class this morning?' The student would have to talk about the asphalt cover on the road, the concrete on the curb, or the footpath. The iron in the fence surrounding the school grounds, to what forms the glass in the window. It's absolutely endless."

1.1.3, 1.1.4, 1.1.6, 1.1.9 Interdisciplinary Nature of Science Education

1.2.2, 1.2.4, 1.2.5, 1.2.6, 1.2.7 Canadian Science Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.2, 1.5.3, 1.5.4, 1.5.5 Pure Science Canadian Applied Science and their Interrelationship

2.1.3, 2.1.4, 2.1.5 Maximum Use of the Local Environment

2. Since crustal materials are limited, exploitation must be managed for maximum benefit.

- This area is a perfect opportunity for students to see the interrelationship between geology, society, and the world around them.

S22 - "The so-called energy crisis in the last decade has directed a lot of attention to the fact that oil, gas, coal, uranium, and whatnot do come from the earth and in some way their extraction must be related to the earth sciences; whether it is a humanistic, theoretical or an academic approach. That's a beginning. Every time you go down to the gas station to buy your gas you indirectly start thinking about the earth sciences. There is a monthly magazine called Geotimes published by the American Geological Institute in the States. Education in the earth sciences is one of the themes that AGI is constantly pushing. One might suppose the problems we have here in Alberta were resolved a long time ago in the United States but this is not the case. There was an earth sciences curriculum project many years ago, which produced a wonderful textbook for the high school earth sciences courses. In almost every issue of Geotimes there is a letter to the editor pleading the cause of more earth science education, bemoaning the image that geologists had in the general public mind. He is either a shyster trying to sell stock in a phony mine or he is a seismologist who failed to predict an earthquake or something of this sort. So problems of lack of general appreciation of earth scientists are not restricted to this part of the world. The problem is universal. By really pushing the Canadian Science - Canadian Society part of your clue structure, we could go a long way to overcoming this."

S23 - "You could flash a photograph of the Sherritt-Gordon plant, at Fort Saskatchewan, which produces nickel and fertilizer. There is a very interesting equation as to what's going on at Sherritt-Gordon as a major world-class plant. It imports phosphate from Florida, we can use that as North Americans; the phosphate moves by barge through the Panama Canal up to Vancouver where it hits the rail, come up across the Rocky Mountains and the Prairies and lands in Fort Saskatchewan. Potash comes from Saskatchewan, so it comes on a rail car. So we have potash, nickel coming from distant places, and we have other raw materials. And we have rail cars taking the products out. There go the packaged fertilizers from Sherritt-Gordon, labelled and all set to go. That complex has a fascinating geological complexity an interplay of raw materials, technology, human desire, business, enterprise, the energy that drives this thing. Why isn't this plant in Florida or in Saskatchewan? It's in Alberta in Fort Saskatchewan because this is a cheap source of power that comes from natural gas that's 5,000 feet down. This is geology in a Canadian context. Just by flashing that one picture and analyzing the components, there is a fairly fascinating geological jigsaw puzzle to be assembled."

1.1.2, 1.1.4, 1.1.6, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.2.9 Canadian Science Canadian Society Interaction

1.3.3 History of Canadian Science

1.5.2, 1.5.4 Pure Science Canadian Applied Science and their Interrelationships

1.7.1, 1.7.2, 1.7.3, 1.7.4 Canadian Science Policy Current Emphasis in Canada and their Interaction

2.1.4, 2.1.5, 2.1.6 Maximum Use of the Local Environment

CONCEPT E8.2

Evidence for determining the past history of the earth comes from a study of the crust.

1. Age determinations can be estimated on the basis of rates of changes of crustal materials.

- Instead of focusing on abstract concepts, we must focus on geological context principles.

S24 - "We are far too abstract. We're not using our imagination to recreate geological conditions with which we are familiar on the outside. Dealing professionally as geologists we are misleading the uninformed mind, the people we are trying to communicate with. We have to do a lot better job in communicating geological context principles. The concept of three dimensions is extremely important. What's more important is the fourth dimension, of time, which is not unique to geology, but does concern geology more than most of our sciences to normally, and the immensity of geological time. It's a terrific challenge even for people pursuing geology on a daily basis."

2.1.1, 2.1.2 Maximum Use of the Local Environment

2. Fossil evidence can be used to relate past events in the history of Earth from one place to another.

- No relevant information obtained from interviews.

(2) **General Comments Related to Desirability and Relevance of a Canadian Context**

- There is a definite need for literature and materials which presents geology in a Canadian context.

S25 - "The Canadian context aspect is a void in terms of the literature that seems to be available to teachers in the school system. We do need more Canadian based material. We need manuals that use Canadian geography and geology to prevent presentation of geology as a hypothetical abstract subject. Geology must become a live and real. It has meaning in terms of what is experienced. In education one attempts to go from the known to the unknown. We can talk about glacial Lake Lethbridge, when we are teaching in Lethbridge, instead of Lake Winnipeg. It would be great to talk about something that is just around the corner, that you drove over last Sunday with your Mom and Dad. That brings geology from being abstract to being closer to the known, familiar. The value of that is absolutely priceless. It's less effective talking about examples in Scotland, Great Britain or the United States; than getting relevant, local familiar examples. One should tend to teach in the local context. If one is teaching in Grande Prairie, use Grande Prairie examples. If one is teaching in Red Deer, list some of the Red Deer environment."

S26 - "I've had students in geology who have not followed geology as a career, but instead have taken an Education degree and have gone out into the teachers' workforce. Of course they carry with them the geological knowledge, their biases and interest in geology. They make superb teachers in the earth science program. Most of this is due to the fact that they make the effort (I've talked to many of them) to go on field trips and bring geology alive to the students in the classroom. They really get at what you are talking about in the Canadian context."

S27 - "To some there may not be anything which they would agree to call Canadian geology. Instead they may refer to it as the geology of Canada or the geology of the Western United States. Within your science community there have been major figures who happen to be Canadian. They could have been anything else, but they happen to have been Canadians - all to the good. Some may also have the impression that there is really nothing truly unique about geology as practiced in Canada. By the luck of the earth history draw Canada happened to get certain pieces of geology which have proven to be very interesting and people who are now known as Canadians happen to come and live in this part of North America. But we must go back to the basics. A Canadian context is necessary simply because you must start with the local scene which may be pretty simple and uninspiring in the geological sense or it could be very spectacular, in order to teach about geology. How interesting it is depends on how well the teacher knows the area, how dedicated they are to passing on his or her enthusiasm for the topic, and the constraints which may be imposed upon them related to these."

(3) General comments related to the feasibility and implementation of a Canadian context.

- To effectively teach the geology component of the earth sciences we must use local, regional, national and ultimately world-wide examples.

S30 - "We ought to start at home with local examples because students work everyday of their lives in a particular environment, which in some cases is a unique environment. So point number one would be to use local, regional, national and ultimately world-wide examples of particular facets of the earth sciences in general. That of course pre-supposes that the teacher knows something about the region that he is living and working in. If they don't, they would be very handicapped."

- Geology teachers should make better use of the human resources available.

  S28 - "There is a steady low pressure flow of requests for information about this, that or the other thing. People bringing in fossils or what they think are fossils. Very few of these are teachers - just the general public. I can't in all honesty say that people are knocking at the door 24 hours a day asking questions about southern Alberta geology, geomorphology or Canadian context for geology."

- For teachers to promote a Canadian context in earth science in geology, the two major points which should be emphasized are the relevance of geology to the world that the student lives in and the background knowledge that teachers need to possess in this field to make geology exciting and interesting to students.

  S31 - "If a teacher has a genuine interest in geology, a lot can happen that isn't in the initial curriculum. If a teacher doesn't have a personal interest, the best of available materials based on a Canadian context for science education will not be used under those circumstances."

  S32 - "It is impossible to be a feeling, thinking individual without at least some interest in the environment in which we exist. Therefore teachers should be very receptive to any suggestions made for upgrading a Canadian context."

  S33 - "If a teacher gets the earth science component shoved down his or her throat, probably the results are not going to be very happy for the teacher, for the student exposed to that teacher, or for the overall educational process including a Canadian context."

- Educators and scientists should work together to develop educational packages focusing on a Canadian context for geology which can be used in workshops throughout the province to assist teachers to incorporate a Canadian context for geology in their classrooms.

  S34 - "Teachers are looking for packages. We all understand that teachers are overworked. They don't have enough preparation time for innovative new thinking to take into the classroom.

- The teacher is the important cog in translating curriculum as planned into curriculum as taught. We must prepare them for this task.

  S34a - One must be cautious about the way this is implemented. Think of the educational impact on yourself if you are given a package which is on a silver plate all set to go in the classroom tomorrow morning at nine a.m. and you receive with it the impression that you have no work in preparing the material to present to your class. What is the danger there? You are not prepared because you are personally a part of preparing that package. No matter how well prepared the material in the package is, the information will stay in the package. The information doesn't move unless it travels from the teacher to the student. The package is an instrument, it is a tool."

  S35 - "If a teacher is given too many silver platter servings, there is not going to be much of an education of the teacher. Therefore it will not be passed on. What we really want is for the teacher to become excited, stimulated, and enthusiastic about geology and to pass that enthusiasm, excitement and knowledge onto the class. If you don't get it to the teacher, it's difficult to get to the student. What we have to do is work with the teacher first in order to implement a Canadian context."

  S36 - "What we need to do is have educators and scientists develop educational packages together that would allow workshops to be given on a regional basis in

Peace River, Lethbridge, Medicine Hat, or wherever. I personally would love to have the mandate to go and teach geology to teachers. I have a lot of ideas, a lot of ideas that I am just bursting to try."

S37 - "We need to institute a series of workshops. They would bring, not only geological concepts and the tools of geological thinking, but a Canadian context for that geological thinking. As well, time sequence is critical to geological analysis. Bring concepts to the teacher, make them familiar, comfortable with them. Then show them how they apply in their own environment, in their own geographic location bringing out the Canadian content."

S38 - "To truly put the geology into a Canadian context we need to set up a supply system for the Alberta school system that supplies rocks, minerals, fossils, 35 mm slides, overhead transparencies, total packages of visual aid materials, hands-on materials, manuals, laboratory manuals, and any other materials which would reflect the unique identity of Alberta and Canadian geology. Once this is done, the in-service component could be done by Education faculties and geologists together."

- Canadian context should be an integral part of university training, in particular for teachers.

S29 - "At universities what seems to get people interested in doing more work in geology and learning more of our Canadian context in that area is the introductory physical science or geography courses. So what may or may not determine how an education student feels about doing more physical geography could well be the experience they have in the introductory section. It's a pretty important class that it is the kind of recruiting device for further enrollment in geography classes, as well as an absolute pre-requisite for more advanced work. You have to have the basic background in order to apply geology to the world we live in. This may be one of the areas in which we have to do more work."

- Teachers involved in the geology program should be given the opportunity to increase their knowledge which they may not have had the opportunity to get in their undergraduate training.

  S39 - "There should be a chance to go back and pick up whether in the summertime or through in-service during the teaching season in the school year, that background. If it's not available, they have very little chance to improve the background and get the knowledge that they (a) recognize they need, and (b) want to have because they want to share it and pass it on to their students."

  S40 - "I think it is possible for a team of geologists to formulate a very effective team that could really go to work in Alberta and lift geology up by the bootstraps and see the soles were made in Canada. The EDGEO program which came to Edmonton from Ontario, is an example that shows it can be done."

  S41 - "I realize that teachers who are going into the science programs to teach geology have, by and large, no geology. I could almost count on my hand the qualified geology graduates in the teaching profession because they probably have gone through my hands. This was certainly the case in 1970 when I went with my Chief Geologist to see the Curriculum Director for the Province of Alberta. I explained what I wanted to do for the teachers. I wanted to put out a box of 24 specimens of rocks. Each of which came from Alberta, representing igneous, sedimentary and metamorphic rocks. I wanted to write a manual explaining what these rocks were all about, how they were formed, what's in them, how they were related to the student's everyday life and a bit about their history in terms of contributions of Canadian geologists. We received the okay in a list of all the principals of junior high schools in Alberta. I got a Grant from the Research Council, hired a guy from NAIT to go and collect. We collect 3/4 of a ton of rocks from 27 localities. About 1/4 of these were collected personally in the mountains. Using a shelter workshop for a Halfway House inmates, we began to prepare 1,000 sets of 24 rocks each. I designed a hydraulic press to chip and shape large rocks and train the supervisor of the shelter workshop to identify what I wanted geologically by shape and size. We designed storage box and plastic vacuum formed shipping tray that would also be a storage tray for the teacher with 24 recesses in it (4 x 6) and a cardboard lid. In three months we had produced 1,000 sets of rocks of Alberta. Then I sent a letter out to all the teachers and principals of each junior/senior high school in Alberta. We set up a mail order system and research organization. The sets were gone in no time flat. The chips that came from splitting of the rocks were screened with larger ones being retained. And we had a second set of rocks. Little boxes of chips which could be used for destructive testing microscopic work, crushing, acid work and so forth, sold for $1.50. The big set went for $10.00. We made up 3,000 chip sets and 1,000 fist size sets that weighed 10 pounds in total. I wrote a 69 page descriptive booklet. In 9 days we had it published and printed. It was a fantastic effort. Those things are still in service today, and I still get requests for them. However they went out of print and were no longer available within five years. I wondered if we should ever do that thing again. After publishing almost 50 research papers, 39 maps and doing a lot of other wonderful things, this is the thing I feel that most proud of."

APPENDIX XIII

STAGE III: Information Gathered From Interviews with Science Educators

Included in this Appendix are:

1. Questions Used to Guide Interviews with Science Educators.
2. A Summary of Information from Interviews of Selected Science Educators in Stage III.

1. Questions Used to Guide Interviews with Science Educators

The interviews with science educators were basically conversational in nature. Though the researcher prepared the following guiding questions, it was necessary to be very flexible and encourage science educators to continue to discuss those areas which were important.

1. In the work you do with teachers and student teachers, how do you encourage them to implement a Canadian context for science education?
2. If we were to take the geology component of the Grade 8 program, what kinds of things would you do or have you done within your own classroom or in-service with student teachers and teachers that would provide direction in dealing with Canadian context?
3. From your own experience with teachers, where do you feel something would have to be built-in to the prescribed textual materials used in the geology component to ensure their teaching with a Canadian context?
4. We have materials that people perceive to be representative of a Canadian context for science education. How could teachers be assisted in putting those materials together for the geology component to represent the Canadian context?
5. In what parts of the geology component of the Grade 8 earth science program do you feel we must build in components giving direction to the teacher and which will bring out a Canadian context?
6. How would one go about building in a Canadian context, applied in Canada for Canadian science education?
7. Where do you perceive the science educator at a university or with Alberta Education fits in terms of implementing a Canadian context in science education?

8. Are there any other general comments that you would like to make about implementation of a Canadian context in science education and in particular the geology component of the Grade 8 earth science program?

2. A Summary of Information from Interviews of Selected Science Educators in Stage III

This summary of comments reflects the major views which were presented by the science educators interviewed and includes excerpts from the interviews to substantiate and elaborate. These have been coded with an SE. Science educators provided no information related to the specifics of teaching the geology program. Therefore the summary will be presented in two parts:

(1) General comments related to the desirability and relevance.

(2) General comments related to feasibility and implementation.

(1) <u>General comments related to desirability and relevance.</u>

- There is a need for a Canadian context for science education and we must respond to this need.

SE1 - "There is justification for some separate considerations of Canadian context for science education, not necessarily as a whole course, but certainly as a major module within one course at the university level of science education."

SE2 - "As a nation we don't have confidence in ourselves. We tend to say as we did in 1959 'we better let the Americans take care of science education and materials. We can't handle it.' That's wrong. We must see that a Canadian context is included in the science educational materials we use within our classrooms."

SE3 - "Over the last 50 years there has been a tendency towards science becoming an imperialistic type of way of knowing, and being perceived as being better than other ways of knowing, when it's just one of the many ways of knowing that we have. That is not nice. Science is increasingly being seen as an American/United States enterprise. If you look at it closely over the last 20, 30, 40 years you will see that what the States has done through its resources and projects that it engages in, is that it has attracted many scientists from many different countries (from many different national background and cultures) to work in it. So it still remains the sciences seen as more synonymous with the States, maybe somewhat with Britain and Europe, but it tends to exclude the contributions of other countries. So it would seem to be an important step for different countries to look at their contributions, either in an anthropological sense, or in a more formal science sense, to the discipline of science and application of science through technology to the way people do science. If that means including a Canadian context for science education, then that is what we should do."

SE4 - "In the past Science educators in Canada may not have specifically emphasized the Canadian context of science, but they have emphasized the curriculum. Our curriculum documents and guidelines across the country have evolved out of the last 10 or 15 years and are particularly in science education high quality documents. It is true that our view of science education has some unique characteristics as compared to the United States or Britain. Those educational materials and documents are artifacts that represent a distinctly Canadian view of science education, and embodied within it is science. We might think of it as sort of an implicit context for Canadian science. If this is true then maybe it is time to identify explicitly that context for Canadian science."

SE5 - "There is an intricate connection between science, technology and human culture. We are surrounded by products of technology and science - we live it, we breathe it, we eat it, we sleep it, it's modifying the way we think. It's helping us think and so on. That's part of our human culture or information culture in general. There are some Canadian, maybe North American ways of using science in a cultural way which is distinctively different from the way say maybe Japanese would use in their culture, or the way Brits would use it. There are cultural differences in the way people use science. We should identify those aspects so that students don't continue to go through live thinking that all things related to science are totally objective."

(2) **General Comments Related to Feasibility and Implementation.**

- A Canadian context for science education should be included in the school system in an interdisciplinary manner.

  SE6 - "Teachers feel that the current curriculum and current expectations within curriculum guidelines for the time available is just too much. They are overloaded. It's a cramped curriculum. Therefore we have to go through a process of simplication as well as an updating of the curriculum. Those two things seem to oppose each other. Where you are apparently including more information, more concepts and at the same time trying to simplify, one must follow the only possible course of action and that is to change the nature of the whole curriculum. To treat the schools' curriculum in terms of disciplines is not feasible. In order to find more effective ways of containing and delivering information, concepts, learning, we have to revamp our notion of the organization of the curriculum. It might be organized differently at different levels in the school. It's easier to integrate subjects totally and fully at the elementary level. For example in a junior or high school level where disciplines or fields of studies become more important, we need to look for other ways of organization. Instead of having a two dimensional approach, where you have subjects and divisions horizontally, and then grade divisions vertically in terms of scope and sequence, we have to think in terms of multi-dimensional curricula with multiple concerns that integrate things. You can look at themes that run across disciplines, for example the theme of geology and related issues could run through science/social studies/human values. This would certainly follow your Canadian context for science education."

SE7 - "One can look at the link between science and culture historically in several ways. First in terms of what I call formal science research, technology and inventions, applied technology in industry. We need to document more in the historical sense those things with respect to Canada to give our students and others a sense of Canadians' contributions to science, in a world-wide sense and also our particular scientific culture in history. There is also another sense in which science and culture can be interrelated and that is in terms of the simple technologies that different groups of people have used over time within Canada, particularly different bands of Indians. There is what you might call the anthropological context of science within that historical sense. We can move to the present and look to the current context of how Canada is contributing to the evolution of science and technology to current research efforts of research institutions of industries across the country. We must look to the source of technologies that we are contributing to, like the Canada Space Arm and some of the aerospace and airplane technology that we have been developing, all of which are also based on minerals technology. As well, what particular industries are doing in general in making parts used in earth science research may be distinctively Canadian and are students should be aware of that."

- A Canadian context for science education must be integrated and infused across the curriculum and all people working with the curriculum, whether they be teachers, authors of resource materials and textbooks, or curriculum developers, they must all be aware of its presence.

SE8 - "We have to infuse the whole curriculum with a concern for Canada, a concern for the Canadian context. We could stick in another module that says, 'The Canadian context of science' is a very efficient way to teach. But maybe again it's just asking teachers to teach more in a sort of linear fashion. Maybe at some stage during the school year one might be able to focus in one module on a

Canadian context in science in a certain level, but for all the rest of the curriculum it should be integrated and infused."

SE9 - "There has to be a model in which objectives related to a Canadian context for science education are very clearly identified prior to testing within a curriculum and I think we need to involve a lot of elements. The whole concept of Canadian focus is first of all a national attitude and the specifics of Canadiana and the Canadian focus need to be advertised, if you want to use that kind of word. To advertise ourselves to ourselves. This type of focus is missing in the kinds of resources that we are selecting. Even our authors do not have the type of focus required to bring in some examples, pictures and things like that. We don't enhance our own achievements, our own focus, our own strategy and being such a diverse nation, there is a richness in opportunity for learning and a description in terms of publishing becomes very much an onerous task. To have people knowledgeable of Canada they have to have been through it and around it and in it to have the kind of basis for their writing. There is no reason why there cannot be a mosaic. In order to do this we must have more people involved in the writing of materials who are familiar with the aspects of Canadian science. British Columbia has taken on some initiative in their curriculum branch towards curriculum resource development similar to this."

- The teacher's delivery is still the essential point in the whole issue of delivery of Canadian science education in a Canadian context to the students.

SE10 - "The teachers would have to be trained in utilizing a Canadian context, either through pre-service or in-service. We may have to change the method of in-service in the province to accomplish this. Just to provide supplemented materials with some kind of minor assistance to teachers would not ensure that the resources would get used. If this became part of the methodological training of teachers, then they would begin knowing that this is the way to go about their planning and designing of units and lessons. So it would have to be built on the whole system of producing teachers and having continuing education for teachers."

SE11 - "Implementation of a Canadian context in schools rests within the training of teachers and to this point that point has been very pure science with no focus on Canadian attitude or context. There has been no integration of science, technology and society."

- A Canadian context for science education should be built right in to the frameworks and guides provided by Alberta Education to teachers.

SE12 - "The program of study does not give enough direction to teachers to actually start implementing the aspects of a Canadian context for science education."

SE13 - "You can't expect teachers to develop resources, materials, and the whole curriculum from scratch. They need frameworks or guidelines that they agree to, within which they can work to guide their activity. Something like the clue structure for a Canadian context in science education could provide that type of framework if they agreed to it. Have them work through it, try to modify and adapt it, and improve it first, so that they feel they have some sense of ownership for it. I would turn the statements that you have the original into potential principles for a framework for a Canadian context for science education. But more than that, teachers whether or not they can or wish to function intellectually, are very concrete people. We are made as teacheres to be concrete people because of the nature of the classroom. And we also put some vignettes or examples with each of the questions or statements you have here to say this is the type of thing we are talking about. A document such as the clue structure could then be used in a workshop with teachers. That first of all raises our consciousness as to what the Canadian content in science could be."

SE14 - "Because of the lack of direction of our guides, the dependency on textbooks is a crucial handicap in developing a Canadian focus. Instead of using a tremendous amount of local resources which have a Canadian focus, we go to the United States for our textbooks. Rather than the presentation being dependent on the teacher's design, development, planning, and delivery it is usually dependent on the prescribed resource - the textbook."

- If we are to consider implementation of the Canadian context the key will be that teachers need information, resources, and education themselves.

SE15 - "When we consider infusing Canadian context in the earth science curriculum it is the same old problem with implementation. Teachers need information, resources, education themselves. Without that we get nowhere. But then even if teachers have that through teacher education, in-service education, material development and so on, that doesn't guarantee things get into the classroom. But there is still necessary preconditions. We won't get things into the classrooms unless we have, as the research on change shows, a more school-based approach to implementation and change, where groups of teachers across and within schools, are involved in developing a sense of ownership for this type of effort. This suggests to me that we need to engage groups of teachers across schools or within the schools in developing their own materials in some way, and look at how they would teach the Canadian context of science. We have to involve teachers in as many ways as possible in developing ownership for this stuff."

SE16 - "The quickest way to reach science teachers is to provide some materials that document or betray the Canadian context to science in all of its manifestations. That would help a lot. Also applying the same principles that teachers had, a national group funded by some outfit that will develop these materials in separate modules to be used in teacher education, would help. If you involve as many science educators across the country in that process, and at various stages bring in other science educators in the regional areas, they will all develop ownership. It would be more likely that they would use it in the science education courses. It would be developed in a way that will pertain to the way we currently function and teach."

SE17 - "We also have to take into account classroom reality. One way of doing it is by making many of the members of the teams that develop resource materials, that get the information, that develop the pedagogy, teachers. They then represent their own constituency, which is the classroom. Many of our previous efforts have been ideal, wonderfully ideal curricula, like all of the reform stuff of the sixties as fantastic curricula but many of them didn't take into account the reality of the classroom such as what was practical, and so on."

SE18 - "I think the resource development isn't the most important thing. When I see a teacher using a textbook as a source of information and the curricula guide as their plan book, then I know there is no context being applied for that particular classroom Canadian or otherwise. When you design the units using these and the resources, the curriculum guide, the textbooks and the library, they also design activities for students which will relate to their immediate environment and in that way we are promoting a Canadian context."

SE19 - "Some Boards have developed various packages which are teacher tested and the teachers were in-service. They need this total perspective, total package including universities and outside expertise and so on. Otherwise only what is written in text is going to be used."

SE20 - "When we are talking about providing resources for teachers, developing materials, we encountered one big problem. The problem boils down to whose going to pay for running the stuff of, whose going to pay for storing the stuff, where is it going to be distributed from and with today's economic problems, no one is willing to tackle that."

- To effectively promote a Canadian context for science education it must be integrated into the core materials being used and not left in a supplemental form.

SE21 - "In Alberta there seems to be a difference in attitude regarding whether the teacher is responsible for augmenting core material with examples of the local area and Canada whereas in other provinces the curriculum specifications are much more elaborate and usually outline the activities to be used, the kits which can be obtained, integration of the Canadian with the examples, and their immediate area. Possibly the freedom that teachers have asked for in doing their own thing can be identified as one of the major problems in implementing something like a Canadian context."

SE22 - "The whole process of supplementing units with a Canadian context is a very difficult one for a single individual or even a small group of individuals in a school jurisdiction. They do some localization and focus for themselves, but the whole area of development of resource materials is a lot of work and for a group of teachers to develop the resources for a jurisdiction is the same amount of work as for a group of teachers to develop the same kind of resource for the province. To get a good information base for resources, it is frustrating for a group to get something done in addition to their teaching responsibilities. Relief of teacher time is not adequate to allow for further development of some resources locally and maybe there needs to be some structure established in either the academic area or in Alberta Education to ensure that the development of resources does in fact meet the idea of establishing the focus on Alberta or the Canadian environment. The position then would be to authorize these resources for use."

SE23- "We don't use our libraries effectively to bring a focus of our own people's involvement in the development of science and creative ideas. So why would be use supplemental units."

S24 - "Superintendents across the province identified one of the major needs in the province of Alberta as some type of mechanism by which good ideas in science education can be shared throughout the province."

APPENDIX XIV

STAGE III: Print and Non-Print Instructional Material for Enhancement of Canadian Context in Grade 8 Geology

Included in this Appendix are:

1. Reference materials included in Stage III.
2. Analysis of Reference Materials for Enhancement of Canadian Context in Grade 8 Geology.

1. Reference Materials Included in Stage III

Print Materials

Alberta Education. (1979). Land and Life 9 (1979), Curriculum Guide. Edmonton, Alberta: Department of Education.

Coding used in Analysis - LL.

This guide was originally provided for by an optional course in Alberta Jr. High schools and provides information about Alberta's geology and its relationship to the elements, flora and fauna.

Baird, P. (1964). The Polar World. London: The Longman Group Ltd..

Coding used in Analysis - PW.

Baird, M.A. McGill University, Montreal. Canadian content is related to the Arctic regions with super background information related to landforms of the Arctic.

Beaty, C. (1975). The Landscapes of Southern Alberta. Lethbridge: The University of Lethbridge Production Services.

Coding used in Analysis - LSA.

Beaty is Department Head of Geography at The University of Lethbridge. This comprehensive guide describes the geology and geomorphology of Southern Alberta.

Bishop, M. et. al. (1976). Focus on Earth Science. (2nd Edition). Agincourt, Ontario: Charles E. Merrill.

Coding used in Analysis - FES.

Fairly detailed coverage of the Earth, its rocks and minerals and its crust and its atmosphere. Well-illustrated with U.S. examples, many end-of-chapter activities. Activities or laboratory work are supplemental rather than essential to the content presented. Reading level is likely above that of the average Grade 8 student but is useful as a teacher and/or student general reference. This is a recommended resource.

Chevraux, S. (1980). Alberta's Prehistoric Past. Edmonton, Alberta: Alberta Education.

Coding used in Analysis - APP.

This book is written in Alberta about Alberta's Paleontology and Archaeology.

Continents Adrift: Readings from Scientific American. (1972). San Francisco: W. H. Freeman and Co..

Coding used in Analysis - CA.

International concepts presented as a series of papers supporting crustal deformation, etc.. Of major interest is the article on sea floor spreading written by J. Tuzo Wilson.

Edmonton Public School District. (1982). Rundle Park Geology Unit. Edmonton, Alberta: Science Services, Edmonton Public School District.

Coding used in Analysis - RPGU.

This guide and field trip manual was put together by local science teachers in Edmonton, Alberta for use in one of Edmonton's parks.

Fenton, M. and Mougeoti, C. (1982). EDGEO Part III Glaciation and Quaternary Geology. Edmonton, Alberta.

Coding used in Analysis - EDGEO III.

These resource materials accompany Geology workshops conducted by Canadian geologists for Alberta Earth Science teachers each year.

Government of Newfoundland and Labrador. (1978). Geology Grade XI — A Laboratory Handbook for Teachers. St. John: Department of Education.

Coding used in Analysis - GGX1NF

Godfrey, J. (1980). EDGEO. Edmonton, Alberta: Research Council of Alberta.

Coding used in Analysis - EDGEO.

Godfrey, J. and Bayrock, L. (1986). Geological Guidebook Series - Sediment Transportation and Deposition in Stream. Edmonton, Alberta: Edmonton Public Schools.

Coding used in Analysis - GGBS.

Government of Alberta. (1986). Kananaskis Country Series. Edmonton, Alberta: The Kananaskis Country Environmental Education Library.

Coding used in Analysis - MB (mountain building); G (glaciation); SR (sedimentary rocks); RM (resource management); NRR (non-renewable resources); W (water).

This excellent series of materials is for use in Alberta's Kananaskis Park. Each of the hard copy materials include a slide set identifying the relevant features at this park location.

Greaves, D. and Williams, P. (1981). Canadians' Contributions to Science. Toronto: Science Department, Toronto Board of Education.

Coding used in Analysis - CCS.

Gross, R. (1985). Dinosaur Country: Unearthing the Badlands' Prehistoric Past. Saskatoon, Saskatchewan: Western Producer Prairie Books.

Coding used in Analysis - DCUB.

This book could be used with resource 23 as a field guide.

Hardy, W. (1979). Alberta: A Natural History. Edmonton, Alberta: M.G. Hurtig Publishers.

Coding used in Analysis - ANH.

This project of Alberta Education, funded by the Alberta Heritage Savings Trust Fund and dedicated to the Students of Alberta by the Government of Alberta is meant to serve as a resource to discuss the many aspects of our environment in Alberta.

Jankunis, F. (Ed.). (1972). Southern Alberta: A Regional Perspective. Lethbridge: The University of Lethbridge Production Services.

Coding used in Analysis - SARP.

This book can serve as a valuable resource when looking at the relationship between geological and geomorphological features, settlement patterns and urban development.

Koster, E. (1982). EDGEO Summary Statements. Edmonton, Alberta.

Coding used in Analysis - EDGEO 1982.

March, J. (Ed.). (1985). The Canadian Encyclopedia: Volume III. Edmonton, Alberta: Hurtig Publishers.

Coding used in Analysis - TCE.

Krueger, R. and Corder, R. (1974). Canada: a New Geography. (Revised). Toronto: Holt, Rinehart and Winston.

Coding used in Analysis - CG.

Written in Canada by Krueger; a Professor with the Department of Geography, the University of Waterloo and Corder, the Head of Geography at Bramalea Secondary School. Excellent sections regarding the formation of the land (Chapter 4), Man Changes the Landscape (Chapter 8) and Mining/Manufacturing (Chapter 10, 12).

Moore, T. (Ed.). (1981). Alberta Archaeology: Prospect and Retrospect. Lethbridge: The Archaeological Society of Alberta.

Coding used in Analysis - AAPR.

Excellent description of the archaeological history of Alberta and the contributions of Alberta and Canadian scientists to this field.

Nay, M. et. al. (1971). Curriculum Resources Information Bank (C.R.I.B.). Edmonton, Alberta: Edmonton Public School Board.

Coding used in Analysis - CRIB.

This material was produced in a cooperative venture of teachers of the Edmonton Public School Board system and members of the Department of Secondary Education. The loose-leaf binder format and well-documented deliverey system for Teacher/Students activities makes this resource a favorite of teachers. Local examples are included in many sections of the materials.

Neale, E. (1982). Lectures on Earth Science: with Emphasis on Newfoundland Examples. Newfoundland Department of Education.

Coding used in Analysis - LENE.

This resource provides many examples in geology related to Eastern Canada.

Nelson, S. (1970). Face of Time - The Geological History of Western Canada. Calgary, Alberta: Commercial Printers (Calgary) Limited.

Coding used in Analysis - FT.

Produced through the University of Calgary with assistance of many Canadian geologists, Bow Valley Exploration, Union Oil Co. of Canada Ltd., National Research Council of Canada and the Geological Survey of Canada.

Abundant photographs, plates and drawings of this area.

Nostbakken, J. and Humphrey, J. (1976). The Canadian Inventions Book - Innovations, discoveries and firsts. Toronto: Grecy de Pencier Publications.

Coding used in Analysis - C1B.

Science Research Associates (Canada) Ltd.. (1980). Seeds Teachers Resource Book. Toronto: Seeds Non-Renewable Sources of Energy.

Coding used in Analysis - SEEDST.

This series provides abundant activities and information related to Canada's oil and coal resources.

Sternberg, C. (1985). Hunting Dinosaurs in the Bad Land of the Red Deer River, Alberta, Canada. Edmonton, Alberta: New West Press.

Coding used in Analysis - HDBL

This inclusive guide could be used very effectively with a field trip to Drumheller, the Tyrrell Museum or Dinosaur Provincial Park.

Strahler, A. (1973). Introduction to Physical Geography. (3rd edition). New York: John Wiley and Sons, Inc..

Coding used in Analysis - IPG.

The Curriculum Committee on Geology. (1973). Laboratory Manual for Geology 012. Nova Scotia: Department of Education.

Coding used in Analysis - G12NS.

Non-Print Materials

Slides

Alberta Society of Petroleum Geologists. (1976). Color Slides of Canadian Geology. Calgary, Alberta: Institute of Sedimentary and Petroleum Geology, The University of Calgary.

Coding used in Analysis - CSCG.

This set of 156 slides provides Canadian examples for all aspects of geology which are discussed in the Grade 8 geology program.

Films and Videos

*Note: Descriptions of the portions of films to be used to supplement a Canadian context are described in the analysis section of this Appendix.

ACCESS. (1978). Alberta Resources in Review. (Video)

Coding used in Analysis - VC216501.

ACCESS. (1980). The Alberta Experience: A Pre-history. (Video)

Coding used in Analysis - VC228001.

ACCESS. (1987). Oil and Gas. (Video)

Coding used in Analysis - VC224201.

British Broadcasting Corporation and Open University. (1986). Fluvial Environments (Video)

Coding used in Analysis - VC269502.

British Broadcasting Corporation and Open University. (1987). Birth of the Rockies. (Video)

Coding used in Analysis - VC269512.

British Broadcasting Corporation and Open University. (1987). Before the Mountains. (Video)

Coding used in Analysis - VC269513.

British Broadcasting Corporation and Open University. (1987). The Foreland Basin. (Video)

Coding used in Analysis - VC269514.

Pacific Educational Media Center. (1978). The Eternal Harvest. (Video)

Coding used in Analysis - VC216504.

SASKMEDIA. (1979). Prairie Gold. (Video)

Coding used in Analysis - VC224203.

Kits

Geological Survey of Canada. New Materials of Canada's Mineral Industry. A guide and kit of 60 of Canada's minerals.

Coding used in Analysis - GSC.

Geological Survey of Canada. Prospector's Set of Mineral Chips. A guide and kit of 36 rock forming and ore minerals.

Coding used in Analysis - PSMC.

Geological Survey of Canada. Prospector's Set of Rock Chips. A guide and kit of 36 rocks from across Canada including igneous, metamorphic, and sedimentary samples.

Coding used in Analysis - PSRC.

2. Analysis of Reference Materials for Enhancement of a Canadian Context in Grade 8 Geology

In this summary a very brief description follows each of the resource codes. The clue structure elements associated with each of these descriptions or suggestions is then indicated.

CONCEPT C8.7

The crust of the Earth is formed of rocks.

The teacher may use these references to identify the specific crust bedrock areas which make up Alberta.

Students could plot cities, town, villages, etc. where mineral deposits are found (i.e., Crowsnest Pass). Discuss settlement of these areas in relation to the resources found there.

The teacher may use also these references to discuss Alberta's bedrock formation when comparing those formations of other regions in Canada (i.e., Alberta vs Quebec). Use the appropriate slides from the Color Slides of Canadian Geology to illustrate differences and similarities.

- LL - Lesson 1 - p.4. A description of the bedrock geology of Alberta.
- LSA - p. 15. Describes the bedrock geology of Southern Alberta.
- CG - pg. 68. Indepth discussion of Canadian bedrock.
- LENE - pp. 3; 12; 17. Discusses matter and fundamental building blocks.
- CCS - pp. 115-119. Sr. William Edmund Logan - his contributions to our knowledge about the earth's crust and field work leading to publication of The Geology of Canada.
- FT - Ch. 2. Bedrock geology of Western Canada.
- CSCG. Use of appropriate slides showing bedrock exposures of Canada.

1.1.1, 1.1.4, 1.1.5, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Education

1.2.5, 1.2.7, 1.2.9 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.6.3, 1.6.4 Science as Inquiry

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1, 2.4.2, 2.4.3 Problems of Regionalism

1. Common minerals are found within the Earth's crust.

The teacher could organize a local field trip to collect specimens. The handout could be used as an informational and identification source.

The teacher could supply samples or students find samples and use the handout to help identify the specific structures of the minerals.

Teacher could discuss the early discovery of minerals in Canada and the significant contributions of Sir William Edmond Logan in 1843 which resulted in the work Geology of Canada (1863).

Again have examples of minerals on hand for identification.

The teacher could have students compare minerals located in the different regions of Canada (i.e., Alberta vs Newfoundland). Using the Geological Survey of Canada's Prospector's Set of Rock Chips identify each of the following igneous rocks, note where it could be found within Canada and its relationship to mining activities in the area: granite, diorrite, peridotite, andesite, basalt, tuff, syenite, gabbro, rhyolite, breccia and feldspar. Now using the Prospector's Set of Mineral Chips have students identify some of the minerals which are found in similar locations. Have students start to draw relationships between some of the igneous rocks found in the same area as the minerals. The teacher should now initiate a discussion related to the types of skills that a geologist would have to have to locate mineral deposits.

- VC - 224203. This program shows the abundant wealth found in Saskatchewan's resources centering around salt mining, potash mining, coal mining, rare metals, petroleum, clay and other minerals.
- LENE - pp. 15; 21-25. Focuses on common minerals found in Canada.
- G12NS - pp. 1-14. A good lab reference for identification of minerals found in Canada.

- C1B - pp. 32-33. Derivation and invention of kerosene by Dr. Abraham Gesner in Nova Scotia.
- FT - Ch. 2. Minerals of Western Canada.
- PSMC and GSC. These kits use Canadian rocks and minerals gathered from across Canada.
- CCS - pp. 115-119. Canadian Contributions to Science
- PSMC and PSRC. Prospectors' Set of Mineral Chips and Prospectors' Set of Rock Chips for use in identification labs.

1.1.1, 1.1.4, 1.1.6, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Education

1.2.1, 1.2.3, 1.2.5, 1.2.6, 1.2.7, 1.2.8 1.2.9 Canadian Science - Canadian Society Interaction.

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

1.7.1 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

Most minerals are made up of elements from a group of only nine naturally occurring elements.

The teacher should make a chart of the natural elements to be placed on the board as they are being discussed.

The teacher could bring to class a number of elements or objects such as salt, tin foil, milk, etc.. Have the students identify the mineral elements founds in each. Students devise their own basis for classifying these.

Have students make a list of objects found in their homes which contain any of the 9 elements that compose the Earth's crust. After this the teacher should introduce the derivation and invention of kerosene by Dr. Abraham Gesner in Nova Scotia.

- IPG - p. 270
- C1B - pp. 32-33. Canadian Inventions Book

- LENE - pp. 21-25.
- CG - p. 340. From Canada's sixty minerals, the ten leading minerals serve as examples to move from composition of each through to rocks associated with the minerals where and how it is mined and its significance to Canada's economy.
- CGNS - pp. 7-15. Discussion of minerals found in Canada in terms of the natural elements.
- PSMC and GSC. Prospectors' Set of Mineral Chips and New Materials of Canada's Mineral Industry are used in identification labs.
- CSCG. Color Slides of Canadian Geology.

1.1.1, 1.1.3, 1.1.4, 1.1.6, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.3, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.9 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

1.7.1 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment.

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.3.1 Adaptation of Foreign Science Instructional Materials to a Canadian Context

2.4.1, 2.4.2, 2.4.3 Problems of Regionalism.

2. Rocks are formed from a mineral or a mixture of minerals.

The teacher could use this rock classification key when introducing and explaining the process of rock formation (excellent definitions). Using the classification key provided with the Prospector's Set of Mineral Chips, classify the following and identify where they may be found throughout Canada and what their relationship is to mining endeavors in Canada: graphite, gelena, pyrrhotite, pyrite, hematite, feldspar, limonite, garnet, asbestos, fluorides, gypsum, mica, calcite and hornblende. Depending on the classroom climate involved, the teacher could use the video Prairie Gold as closure for this area focusing on the science society interface related to Saskatchewan's resources of salt mining, potash mining, coal mining, rare metals, petroleum, etc..

The teacher could use the model for Rundle Park to set up a field trip to a local area, for the study of rocks found in that locale. The Teacher should previously tour the site in order to develop a worksheet relevant to the area (i.e., Lethbridge River Valley).

- RPGU - pp. 30-36. This lab focuses on identification of common rocks.
- LENE - p. 4. Discussion of minerals found in Newfoundland.
- FES - pp. 334, 394. Discussion of the Canadian Shield.
- PSMC and GSC. Prospectors' Set of Mineral Chips and New Materials of Canada's Mineral Industry.
- CSCG. Color Slides of Canadian Geology.
- VC - 224203. This program shows Saskatchewan's mineral wealth.

1.1.1, 1.1.4, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.3, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.9 Canadian Science - Canadian Society Interaction

1.4.1, 1.4.3, 1.4.4 Philosophy Underlying Canadian Science

1.5.1, 1.5.2, 1.5.3, 1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2 Science as Inquiry

1.7.1, 1.7.3, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1, 2.4.2, 2.4.3 Problems of Regionalism

3. Rocks can be categorized into three main groups.

The teacher could supply samples of the three different types of rocks for study and examination or students could gather rocks from around their school, or from around their homes, then group them into three different classes. The teacher should use The Prospector's Set of Rock Chips as a template for classification that the students can use (initially without the identification key). Have the students try to group their rocks into similar sets and then based on the characteristics involved, see if they can put their samples into the correct classification area. Following this use the The Face of Time to discuss rocks in their formation throughout Western Canada. This will be an appropriate time to start to introduce some of the Canadian scientists and their discoveries using this resource.

At this point it would be good to bring in a local human resource, a geologist, who could not only speak to the context component involved with categorization rocks into their major areas and the processes of origin, but can also speak to what it is that a geologist does, the role of geology in relation to science - technology - society and reel off examples of what is being discussed in class. In the Lethbridge area Dr. C.B. Beaty, who wrote Landscapes of Southern Alberta should be contacted. He would be an excellent speaker to have visit the class to discuss rocks and their formation. He is a Geology Professor with the University of Lethbridge. In the Calgary area, call upon Dr. Michael Wilson or in the Edmonton area, Dr. John Godfrey to do the same. All have indicated they would be willing to come in.

- RPGU - pp. T13-T15. Focuses on collection and identification of rocks found in the Edmonton area.
- SR - p. 1. Introduction to rocks found in South West Alberta.
- LENE - p. 27. Discussion of the rock cycle in terms of collection sites throughout Canada.
- FT - Ch. 3. Discusses rocks in their formation. Identifies the distribution of these rocks throughout Western Canada, their discovery, and related Canadian scientists.
- FES - p. 71 - Lab activities test Rocks; p. 102 - Specimens; p. 394. Rating Rocks in the Canadian Shield.
- PSRC. Prospectors' Set of Rock Chips.
- CSCG. Colour Slides of Canadian Geology.

1.1.1, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.12 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.1, 1.5.3, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

1.7.1, 1.7.2, 1.7.3, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.3 Problems of Regionalism

(a) Initially all rocks were formed by the cooling magma of the earth.

These references could be used by the teacher for an introduction or background on the formation of igneous rocks. The teacher could use activities on p. 71 to help students better understand igneous rock theme. The teacher could also show a film/video on the topic i.e., Rocks that form Underground (C2417).

This package contains a good example of the formation of igneous rock, using volcanic activity for explanation. Therefore the teacher could use this information to introduce the class making sure the appropriate emphasis is placed on the Canadian examples included. The Color Slides of Canadian Geology provides excellent examples which can be used in combination with these materials.

- CG - p. 70-71. Igneous rocks and their distribution throughout Canada.
- LENE - PP. 4; 27-28; 32-41. Igneous rocks in terms of distribution throughout Canada.
- G12NS - p. 14. Use of topographic maps and other information from Department of Mines and Technical Surveys of the Government of Canada.

- CSCG. Colour Slides of Canadian Geology.

1.1.9 Interdisciplinary Nature of Science Education

1.3.3 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.2, 1.5.3, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2, 2.4.3 Problems of Regionalism

Texture and mineral content of igneous rocks can be used for identification.

These are activities a teacher could do with the class to show how crystals form igneous rock.

The teacher could provide the required rocks for identification from local sources or the teacher could take students to a local river bank (i.e., Old Man River Bottom) or perhaps a gravel pit to try and collect various types of igneous rocks for identification. The teacher should then use the guide provided.

- LENE - pp. 42-43. Labs oriented toward identification of common igneous rocks found in Canada.
- G12NS - p. 14-15. Rock identification guide is used for labwork.
- PSMC. Prospectors' Set of Mineral Chips.
- CSCG. Colour Slides of Canadian Geology.

1.1.8 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.2, 2.1.3, 2.1.4, 2.1.5 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2 Problems of Regionalism

(b) Erosion and/or deposition form sedimentary rocks.

The teacher should point out that all layered rocks are not sedimentary. Using the Color Slides of Canadian Geology, teachers should focus students' attention on the thick pile of lava from the interior of British Columbia or the one form the Columbia Plateau. The law of superposition should then be applied to these rocks. Have students note the difference in the rocks from the sedimentary layers deposit in water. Pass out the samples of the salts from your rock kits.

Visit two areas where a sedimentary sequence is exposed. Select areas where at least one unit is common to both sections. Measure a section and record all the properties of each rock unit. Determine the criteria that you found most useful in making the correlation.

The teacher could use the activities listed to help students better understand sedimentary rocks.

The teacher can illustrate the composition of sedimentary rock in South Western Alberta (Face of Time is an excellent resource for this.)

The teacher could arrange a field trip to the Kananaskis to study the area (note reference for Kananaskis materials).

The teacher could also utilize films, videos or slides of the area. An excellent film to use is the The Foreland Basin which documents the erosion of a massive basin near Banff, Alberta which includes many important sources of hydrocarbons. Teachers should have their students focus on the kinds of evidence that scientists use to identify the prehistoric seas in the area and how they interpret the effects of varying water levels on rates of deposition.

- VC 269514. The results of erosion on this massive basin near Banff include many important sources of hydrocarbons. The program presents evidence of pre-historic seas in the area and the effects of varying water levels on rates of deposition.
- LSA - pp. 15-16. Sedimentary rocks in Southern Alberta.
- SR - pp. 1-4. Rock fragmentation and sedimentary rocks within the Kananaskis area. Slides are included.

- LENE - pp. 4; 28-29; 53-61. Formation and distribution of sedimentary rocks within Eastern Canada. Excellent section using Canadian examples to demonstrate how features in sedimentary rocks can be used to decipher the environment in which the rocks were formed.
- G12NS - p. 18. Formation and distribution of sedimentary rocks within Eastern Canada. Excellent section using Canadian examples to demonstrate how features in sedimentary rocks can be used to decipher the environment in which the rocks were formed.
- PSMC. Prospectors' Set of Mineral Chips.
- CSCG. Colour Slides of Canadian Geology.
- PSRC. Prospectors' Set of Rock Chips.
- CG - p.71.

1.1.1, 1.1.2, 1.1.4, 1.1.9 Interdisciplinary Nature of Science Education

1.2.4, 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10 Canadian Science - Canadian Society Interaction

1.3.2 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.2, 1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

1.6.2 Science as Inquiry

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2, 2.4.3 Problems of Regionalism

Grain size and/or mineral content of sedimentary rocks can be used for identification.

The teacher could provide observable examples of different grain shapes and sizes from local surroundings. Using these Kananaskis resource materials the teacher can focus on the clues to life history of the rocks and their significance in Southern Alberta including aspects such as settling patterns, transportation, economics, etc..

The teacher could use the table found on p. 19 to illustrate the grain and particle sizes of sedimentary rocks. If the teacher hasn't already used it in this section, The Face of Time could be used to discuss sedimentary rock in terms of location in Western Canada, influence of climate and topography on sediments, and the characteristics of sedimentary rock.

- SR - p. 9. Description of selected South West Alberta examples of sedimentary rocks in terms of clues to the life history of the rock and their significance in South West Alberta, including economic significance.
- FT - Ch. 3. Discussion of sedimentary rock in terms of location in Western Canada, influence of climate and topography on sediments, and characteristics of sedimentary rock.
- G12 NS - pp. 18-21.

1.1.3, 1.1.4, 1.1.6, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10 Canadian Science - Canadian Society Interaction.

1.3.2, 1.3.3 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.2, 1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

1.6.2 Science as Inquiry

1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction.

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2, 2.4.3 Problems of Regionalism

(c) Sedimentary and igneous rocks can be reconstituted to form metamorphic rocks.

The teacher can use these references as basic information sheets which describe metamorphic rocks and how their formation occurs in Canadian locations. Economic implications in terms of mining and mineral resources could be reinforced.

The teacher could bring samples to the class for observation.

Using the activity sheet in the materials, have students look at the metamorphic rocks included in The Prospectors' Set of Rock Chips and have students hypothesize as to how they may have been formed. Have students speculate as to areas these rocks may have been found in. They could use the clues such foliation or non-foliation, rocks with banding, and then the teacher could use The Color Slides of Canadian Geology to provide Canadian examples.

- CG - p. 71. Discussion of metamorphic rocks and economic implications in terms of mining and mineral resources.
- LENE - p. 4; 29; 61-65. Distribution of metamorphic rocks throughout Eastern Canada and their identification.
- G12NS - p. 22-24. Composition of metamorphic rocks commonly found in Canada.
- PSRC. Prospectors' Set of Rock Chips.
- CSCG. Colour Slides of Canadian Geology.

1.1.2, 1.1.3, 1.1.4, 1.1.6, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.9 Canadian Science - Canadian Society Interaction

1.3.2 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.1, 1.5.2 Pure Science, Canadian Applied Science and their Interrelationships

1.6.2, 1.6.4 Science as Inquiry

1.7.1, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction.

2.1.2, 2.1.3, 2.1.4, 2.1.6 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2, 2.4.3 Problems of Regionalism

Metamorphic rocks are classified on the basis of their mineral content and structure.

The teacher could use these resources to help identify the various forms of metamorphic rocks. Go out into local area and try to locate examples of metamorphic rock.

- LENE - pp. 66-71. Mineral identification and uses.
- G12NS - pp. 22-25. Mineral identification in labs.
- PSMC. Prospectors' Set of Mineral Chips.
- CSCG. Colour Slides of Canadian Geology.

1.1.8 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

CONCEPT C8.8

The crust of the Earth is constantly being changed.

The teacher may use this reference when introducing the concept of the Canadian Shield and how it was formed.

The teacher may make comparison of Canadian landscapes by using slides of the various regions. Following this on a sketch map of Canada show the location of the major geosynclines of mezzazoic age. This can be confirmed by using The Face of Time. Two areas the students may be very interested in are the Cordilleran Geosyncline in the Rocky Mountains, and the other is situated in the Vancouver Island-Queen Charlotte Islands area which is the insular trough. Students could compare the structure of Vancouver Island with that of the Georgian Basin for example.

The teacher may show the video and have pre-prepared worksheet stressing the key aspects of the video.

The teacher may derive an assignment in correlation with the information presented in the video.

These materials could be used by the teacher to explain the formation of mountains and the change which occurs within mountain ranges.

- LSA - p. 9. Definitions in terms of local features found in Southern Alberta including results of previous volcanism from Mt. Mazama (Crater Lake).
- CG - p. 76-80. The history of Canada's rock foundations is described in terms of formation of the Canadian Shield, the Appalachian Mountain system, Innuitian Mountains and the Western Cordillera.

- CSCG. Colour Slides of Canadian Geology.
- MB - p. 4. Discusses mountain building in the Kananaskis area. Field trips are identified.
- LR (Film/Video) Planet of Man: Shield of Plenty (201 007).
- FT Face of Time.

1.1.3, 1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.3, 1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2 Problems of Regionalism

1. Landforms are being built up by movements within the crust.

The teacher may use these lessons to develop a general understanding of how the various regions of Canada differ in respect to the landforms.

The teacher may also focus only on the province in which they live in order to make the lesson meaningful. Within Alberta there are five distinct landforms, and the teacher could explain and describe each. Field trips would also be effective here.

The video may be used with a worksheet stressing the key points within the video. The students will enjoy the aerial views of the Trans Canada tour through the Foothills and the ranges of the Rocky Mountains and Waterton National Park to the East Coast.

- VC 269512. This video tape takes viewers on a Trans Canada Highway tour - including aerial views - of the geology of the Foothills, front ranges, main ranges, and West ranges of the Rocky Mountains, together with a visit to the same thrust belt running through Waterton National Park in South Western Alberta.
- LL - Lesson 2 - p. 1. Landforms of Alberta are discussed including the Rocky Mountains and Foothills, the Prairies, the Parklands, the Woodlands and the Precambrian Shield.

- CSCG. Colour Slides of Canadian Geology.
- LR - (Film/Video) Lay of the Land: Solid Land (120 502).

1.1.3, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

2.1.1, 2.1.3, 2.1.4 Maximum use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Methods

(a) Earthquakes are the results of movements of masses of rock.

The teacher would use this material to explain that an earthquake is energy of wave motion which is transmitted through the surface layer of the earth, like ripples. The teacher could demonstrate this in class by dropping a pebble or marble into a still container of water.

The teacher may have the students research local libraries, etc. for any history of earthquakes in their area and present this research to the class. The students could study a seismic map of Canada and note the area of British Columbia is included in the high risk belt. The summer of 1976 of GEOS magazine includes an article "Earthquake - Studies of the Seismic Risk in British Columbia" by W. G. Milne and shows the seismic zoning map of Canada. GEOS is available free of charge to teachers from editor, GEOS, Energy Mines and Resources, 588 Booth Street, Ottawa, Ontario, K1A 0E4. Copies of this article are distributed without charge on request.

Have students obtain information on major earthquakes which have occurred in Canada. Plot a map of the epicenters for each of these quakes. Discuss structural stability of each epicenter area. Students should also focus on where Federal Governments seismographs throughout Canada are located.

- LENE - p. 131. Discussion of earthquakes with an emphasis on P, S and L waves, epicenters, etc. using examples of the Federal Government's seismographs throughout Canada and in particular the one at St. John's, Newfoundland.
- CSCG. Colour Slides of Canadian Geology.

- IPG - p. 417.

1.1.1, 1.1.2, 1.1.3, 1.1.6, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.3, 1.2.4, 1.2.6, 1.2.7, 1.2.8, 1.2.10, 1.2.12 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.2, 1.5.3, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.2, 1.6.3, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(b) Faulting and folding are the result of large forces in the crust.

These resources can be used by the teacher to provide very good information illustrating faulting and folding in Southern Alberta.

A field trip may be used to show areas which have faults and folds that are visible (i.e., Waterton Park, St. Mary's River Valley).

To show faulting a teacher could put together different colors of playdough and then cut it in half to show the different levels which are moved during faulting.

To show folding the teacher could use colored towels placed one on top of the other, then pushed together forming folds.

Films and slides would also illustrate these concepts. Before the Mountains uses aerial footage to exemplify the processes of deposition and upthrust that produce today's massive limestone formations in the Canadian Rocky Mountains along the Alberta-British Columbia boundary.

The teacher may use this reference as a presentation to show Alberta's various areas containing faults and folds.

Students could develop their own models illustrating faulting and folding. Students could be challenged to reconstruct the sequence of events during the geological history for the region of Alberta in which they live. Is it possible to make block diagrams depicting each major tectonic setting? What stage of mountain building, if any, is represented by the present tectonic setting of the area in which they live? A somewhat more complicated map of a full mountain belt in which major thrust faults cut the section is illustrated by the geological map of Mt. Eisenhower, in Alberta and contained within the supplemental materials. Students could select a geologic map of some part of Canada and attempt to construct a geologic structure section. The map should show different strike symbols to be useful for this exercise.

- LL - Lesson 2 - pp. 1-13.
- LSA - p. 18-20; 52; 53. The focus is on exposure of evidence of folding and faulting throughout Southern Alberta.
- MB - pp. 4; 6-7; 25-27. Folding and faulting are discussed in terms of the Little Red Deer River area, the Bow Valley (Canmore to Cochrane), the Foothills south of the Bow Corridor and the Kananaskis Valley area. Slides are also provided.
- LENE - p. 72-86. Focuses on anticline, synclines, dip and strike in terms of examples found in Eastern Canada.
- VC 269513. Explains the environments that existed along the Alberta-British Columbia boundary before the uplift that created the Canadian section of the Rocky Mountains. Much use is made of aerial footage to exemplify the processes of deposition and upthrust that produce today's massive limestone formations.
- CSCG. Colour Slides of Canadian Geology.

1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2, 1.6.3 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(c) Volcanism is associated with faulting in the crust.

The teacher could use the films to demonstrate volcanic eruption.

The teacher may set up with administration a proposal to take a field trip to Mt. St. Helen's area in order to examine the effects on the surrounding area following a volcanic eruption or the teacher can draw on students' memory of the event to discuss the distribution of the ash and the immense power demonstrated.

The teacher could construct a model volcano with the class, to illustrate what takes place during the eruption. Remember to use the new replacement chemicals for the dichromate.

- LENE - p. 39. Discussion of major volcanic eruptions from 1968-1975 and their relationship to continental margins. Students are challenged to identify where in Canada earthquakes and volcanoes could possibly occur.
- CSCG. Colour Slides of Canadian Geology.
- LR (Film/Video) Earth the Restless Planet (133 702) and/or Planet of Man: The Fire Within (201 003).

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

1.7.2, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2. Weathering weakens rock formations.

The teacher could show the film, discuss types of weathering (what takes place), and then survey local areas for different aspects of weathering.

This could be used as background information to describe how rocks are affected by weathering. The teacher should ensure that in the discussion of the weathering and erosion shown within the Kananaskis area that not only are these processes emphasized but also the implications for such things as human development within the area i.e., Nakiska, the golf course and the numerous other facilities that are being built in the area.

- CG - p. 72. Weathering is described in terms of landform formations throughout Canada. The Niagara Escarpment is used as an example of an escarpment formed by erosion.
- W - p. 9. Weathering and erosion are discussed in terms of examples from the Kananaskis area. Slides are also provided.

- CSCG. Colour Slides of Canadian Geology.
- LR (Film/Video) Planet of Man: The Uneventful Day (201 011).

1.1.3, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.3, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment.

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(a) Mechanical weathering makes small pieces out of large ones.

The teacher could use these references to explain what mechanical weathering is, and how it takes place.

The teacher could use this lesson to illustrate how weathering occurs when material of the earth's crust is broken down.

NOTE: The CRIB resource book contains numerous lessons and activities which pertain to this concept. The teacher should take full advantage of the sample questions provided in the teachers' information sheets as they would direct the investigation in a manner which will support inclusion of the number of the elements of a Canadian context.

This material could be used to discuss mechanical weathering.

The students could plot, on a map of Canada, areas where excessive mechanical weathering is known to take place.

Students could go on a field trip to Table Mountain to study the effects of mechanical weathering.

- CRIB, A1, a, LP-T and LP-S, IS.1. Lab investigates the expansion and force of freezing water. This information is then used and applied to conditions in Southern Alberta and effect of Chinooks, such as talus slopes and the Frank Slide.

- CRIB, A1, b, LP-T and LP-S, IS.2. Stresses induced by changes in pressure or temperature.
- LENE - pp. 48-49. Mechanical weathering is described in terms of landforms found throughout Eastern Canada.
- CSCG. Colour Slides of Canadian Geology.
- W - p. 9. Kananaskis Country Series - Water

1.2.8 Canadian Science - Canadian Society Interaction.

1.4.1 Philosophy Underlying Canadian Science.

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry.

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment.

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2 Problems of Regionalism

(b) Chemical weathering changes the rock itself.

This information could be used to discuss chemical weathering. Once students are familiar with the processes involved in the formation of clays, discussion should center on development of clays throughout and the relationship of these processes to things like cave formation and impacts on buildings, such as deterioration of old masonry work. A field trip can then be reinforced using the video Fluvial Environments. Students should be directed to focus their attention on similarities between what they saw at the river valley and those sedimentary structures from Saskatchewan, Quebec and British Columbia that serve as examples in the video.

The teacher could have students locate clay which is a product of chemical weathering.

The teacher could use this lesson to introduce chemical weathering to the class.

- LENE - p. 46-48. Weathering of rocks is described in terms of old masonry work, development of clays throughout Canada and cave formation on the west coast of Newfoundland due to dissolving of limestone.
- CRIB, A2, a,b,c,d LP-T and LP-S, IS.1-11. Lab activities.

- CRIB, A2, a,b,c,d,e, LP-T and LP-S, IS.12. Lab activities.
- CRIB, A2, a,b,c,d,e, LP-T and LP-S, IS.13. Lab activities.
- a - water leaches soluble minerals out of rock
- b - oxygen combines with minerals
- d - water combines with some minerals
- e - plant acidity breaks down rocks
- CSCG. Colour Slides of Canadian Geology.

1.2.4, 1.2.8, 1.2.10 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1 Problems of Regionalism

3. Erosion changes the landforms.

The teacher could arrange a field trip to Frank Slide Interpretive Center to view the site and damage which can be caused by erosion.

The teacher could access slides which depict areas which have changed due to erosion.

The teacher could use the film to expand on erosion of the local area.

Have students collect photographs from newspapers, etc..

The teacher could set up field trip to the nearest research station, where the effects of erosion in the area can be described.

NOTE: Chester B. Beaty's book: Landscapes of Southern Alberta is an excellent resource for this area could be demonstrated.

- LL - Lesson 2, p. 1-17. Changes in landforms are discussed in terms of examples throughout Alberta.
- RPGU - pp. 1-19. Geological features are concentrated on in the Edmonton area.

- LENE - p. 50-52; 89-90. Evidence of the results of weathering are given by examples from Eastern Canada including those related to gravity such as rock falls and talus cones.
- APP - p. 28. Eroded formations are discussed using examples of the Badlands Provincial Park and the Drumheller area.
- MB - p. 10 - Slope Processes. Landscape change is defined in terms of slope processes using examples from the Kananaskis area. Slides accompany discussion.
- EDGEO III - pp. 14-16. The Drumheller area is described in the context of Alberta's geological history.
- CRIB, B1, a,b,c,d,e,f, CD IS.1. Model that can be made - experiment based on formation of coulees in Lethbridge.
- CRIB, B1, a,b,c,d,e,f, CD IS.2. Overview of erosive elements
- CRIB, B1, f, LP-T and LP-S, IS.14. Gravity experiments.
- CRIB, D1, a, LP-T and LP-S, IS.1. Man as a Catalyst - Experiment
- CRIB, D1, a, LP-T and LP-S, IS.2. Man as a Catalyst lab.
- CRIB, D1, a, LP-T and LP-S, IS.3. Amount of Garbage discussion and lab.
- CRIB, D1, a, LP-T and LP-S, IS.4. Man as a Moderator discussion and lab.
- CRIB, D1, a, LP-T and LP-S, IS.4. Soil Erosion Prevention discussion and lab.
- CSCG. Colour Slides of Canadian Geology.
- LA - pp. 19-21.
- LSA. The Landscapes of Southern Alberta. Identifies local field trips.
- LR (Film/Video) Erosion: Levelling the Land (B2368).

1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.3, 1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.6.1, 1.6.2, 1.6.3 Science as Inquiry.

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(a) Erosion is caused by running water.

These materials provide excellent examples of how streams erode the area in which they flow. It discusses the maturity of streams and provides good illustrations for the students during the facet of erosion. The teacher could also acquire slides which depict these stages.

The teacher could follow up with a field trip to the river bottom to observe the erosion which has taken place.

- RPGU - p. 49-70. T1-T2 - Surface stream action; T29-T39 - Outlines the surface stream action of the North Saskatchewan and related stream river characteristics.
- EDGEO - IV - 13-18. An ecological transsect is done from the river's edge to the prairie with a discussion focusing on the Red Deer River. Interrelationships are described in terms of the geomorphology, vegetation, and fauna to be found in Midland Provincial Park.
- SARP - p. 12. Erosion by rivers is discussed in terms of the Milk River Ridge in the Cypress Hills.
- W - p. 9-15. Erosion by running water is discussed focusing on the streams, rivers and lakes of the Kananaskis area. Slides may be used to accompany discussion.
- VC 269502. The nature of ancient rivers is revealed by comparing preserved sedimentary structures with sedimentary structures found beneath modern rivers. River systems in Saskatchewan, Quebec, British Columbia, Texas and South Wales are explored.

- CSCG. Colour Slides of Canadian Geology.
- LL - Lesson 2 - pp. 11-12.

1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.4, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.2 Problems of Regionalism

(b) Erosion is caused by wind.

The school class could visit a local nature center i.e., Helen Schuler Coulee Center. In the case of the Lethbridge area, the teacher and resource persons supplied could discuss how wind has been responsible for the formation of the coulees and ultimately where Lethbridge was settled (a similar trip could be arranged for other parts of Alberta). The CRIB materials focusing on the formation of Lethbridge coulees and other local features serve as an excellent resource.

- CRIB, B1, d, LP-T IS.10-13. "Sandblasting" action as related to local features.
- CRIB, B1, d, LP-S IS.10. Changes in sand dunes discussion and lab.
- CRIB, B1, d, LP-S IS.11. Action on earth's surface.
- CRIB, B1, d, LP-S IS-12. How landforms are created is the focus of this discussion and lab.
- CRIB, B1, d, LP-S IS.13. Formation of Lethbridge coulees is used as a focal point for discussion and field trip.
- LSA - pp. 11; 71-77. The origin and derivation of local features throughout Southern Alberta is explained in terms of wind and water erosion.

- CG - p. 86-88. The Canadian landscape is described in terms of erosion due to wind and water and is related to aspects of climate.
- EDGEO IV - 13. Drumheller and the Hoodoos are the focus of this discussion of the sculpting ability of wind and water.
- CSCG. Colour Slides of Canadian Geology.

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(c) Erosion is caused by glaciation.

The teacher could set up a field trip to Columbia Ice Fields to study glacier erosion or other glacial sites.

If this is not possible, the teacher could also use slides or films to better illustrate glacial erosion, i.e.,

- RPGU - pp. 37-43, T16 - T25. Glacial action is discussed and then related to local evidence of glaciation in the Edmonton area. The effects of continental and alpine glaciation on the landforms and features of Alberta is discussed. Periods of advance and retreat of the Wisconsin glaciation are highlighted.
- LL - Lesson 2 - p. 5-10.
- PW - p. 70. Landforms of the Arctic are discussed in terms of the North West Territories and Ellesmere Island.
- LSA - pp. 11-12 - Types of Glaciers; pp. 33-41. Landforms caused by Glaciation; pp. 54-55; 58; 64.
- CRIB, B1, c, CD-IS.3 - Glacial Action
- CRIB, B1, c, LP-T IS.7-9 - Glacial Action

- CRIB, B1, c, LP-S IS.7 - Speed laboratory.
- CRIB, B1, c, LP-S IS.8 - Glacial Action discussion and lab.
- CRIB, B1, c, LP-S IS.9 - Resulting Landforms
- CG - pp. 90-97. Glacier erosion and resulting glacial landforms are discussed in terms of the Canadian topography and the resulting relationship to tourism, agriculture, forestry, etc..
- SARP - 12. The effect of pleistocene on the landforms of Southern Alberta and resulting settlement patterns is discussed. Formation of Porcupine and Cypress Hills as well as Milk River are included.
- MB - p. 12. Discusses the process of landscape change related to snow and ice in the Kananaskis area. Slides accompany information.
- FES - p. 299. Discusses glacial origin
- G - p. 1-56. Indepth discussion of glaciation of the Kananaskis area is provided in terms of effects of glaciation upon the regional landscape including the Little Red Deer region, Bow Valley, Jumping Pond, Elbow and Sheep drainage basins, Highwood basis and Kananaskis valley. Slides are also provided.
- CSCG. Colour Slides of Canadian Geology.

1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.5, 1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.5.3, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(d) Erosion is caused by ground water.

The teacher could use a field trip to the Crowsnest Pass Caverns or perhaps Logan Pass to view the Weeping Walls. Both are good examples of ground water erosion.

The teacher could use these lessons to explain that soil is porous, therefore, ground water can move through it.

The teacher may use various soils from the area to test the soil porosity.

- CRIB, B1, a, LP-S IS.1 and 3. Movement of water lab.
- CRIB, B1, a, LP-T IS.2-4. Ground water action lab.
- CRIB, B1, a, LP-S IS.2. Soils hold water discussion and lab.
- CRIB, B1, a, LP-S IS.4. Materials contained.
- CRIB, B1, a, LP-T and LP-S, IS.5. Action; Eroded Landforms.
- CRIB, B1, a, LP-T and LP-S, IS.6. In caves.
- PW - pp. 70-80. Permafrost and related features of Northern Canada are discussed in terms of effects of ground water and other erosional processes.
- CSCG. Colour Slides of Canadian Geology.

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.2, 2.1.3 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(e) Agents of erosion help lay down sediments.

The teacher could split the class into groups and have them research or study the different types of deposits and where they may be found. Then have the class present their findings. An example could be used from the materials provided focusing on the Alpine areas in Jasper Park and their interpretation in terms of various agents of erosion and the resulting sediments. The same could be done for any of the local areas.

- LL - Lesson 4 - pp. 1-2. Discussion of formation of soils throughout Alberta and their resulting impact on the distribution of vegetation and therefore settlement throughout the province.

- EDGEO IV - 714. Focuses on the North Saskatchewan river system and the area around Edmonton in terms of landform features and sedimentary deposition.
- EDGEO III - pp. 11-13. Landform features resulting from erosion of alpine areas near Jasper Park are interpreted in terms of various agents of erosion and their resulting sediments.

1.1.2, 1.1.3, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.4.1 Philosophy Underlying Canadian Science

1.5.4 Pure Science, Canadian Applied Science and their Interrelationship

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

4. Dynamic processes are at work within the Earth.

The teacher should initiate discussion regarding the Rocky Mountains and the types of features that represent different kinds of processes at work. Examples of these would include anticlines and synclines, folds and landslides. Once students have started to generate a number of examples, focus on one of these areas which most students seem to be familiar with. In the case of Southern Alberta the Frank Slide would be an excellent example. Using the materials provided discussion should focus not only the geological process identified, but also the historical aspects that lead to the disaster of 1903 when a large portion of Turtle Mountain slipped down and covered most of the mining town of Frank causing the death of 66 people. These resource materials will help students to appreciate the role of the Canadian scientist who took part in the investigation and their contributions to international science, not only at that time but to the present. This would include discussion of monitoring of faults and cracks within the earth's surface and the relationship of freeze-thaw action. A field trip to the Interpretative Center located at Frank would be a tremendous asset.

- LL - Lesson 2 - p. 13. Discussion centers on the Rocky Mountains and using examples such as Folding Mountain just outside Jasper National Park. Results of processes such an anticlines and synclines, folds and landslides are discussed.

- LSA - pp. 41-44. The Frank Slide of Southern Alberta is discussed. Not only are geological processes identified but historical aspects related to this disaster of 1903 when a large portion of Turtle Mountain slipped down and covered most of the mining town of Frank causing the death of 66 people, is interpreted in terms of the Canadian scientists who took part in the investigation and the contributions to international science that have been made over the years due to the monitoring of other faults and cracks within this structure and the relationship to freeze-thaw actions.

1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

1.5.2, 1.5.3, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

1.7.1, 1.7.3 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.1, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(a) Forces acting on the crust are due to the structure of the Earth.

The teacher could use an hourglass to show how gravity works on a particular substance.

The teacher could have a resource person such as Dr. C. B. Beaty come in and discuss where the shape of the earth's crust has caused various forces to act upon it (i.e., Frank Slide).

- LSA - pp. 13-14. Landforms throughout Southern Alberta are again interpreted in terms of composition and materials and the effects of agents such as gravity.

1.1.3, 1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(b) Theories have been advanced to explain how forces have acted on the crust to produce the present landforms.

The teacher can use this material to relate a number of different theories that internationally famous geologists have devised concerning forces acting on the earth's crust.

The teacher should pay special attention to Canadian Dr. J. Tuzo Wilson and his impact on geology.

The teacher could use the video to further illustrate a theory dealing with the makeup of the earth.

This material could also be used to provide more information on the formation of the earth. This should then be realted to tectonic forces described in terms of landforms found in the local area.

NOTE: It is suggested that these theories be taught separately due to the advanced subject matter.

- LSA - pp. 21; 45-48; 83-84. Tectonic forces are described in terms of landforms found throughout Southern Alberta.
- LENE - pp. 137-145. Mountain building, continental drifts, sea floor spreading, plate tectonics are related to the present formations found in Eastern Canada.
- EDGEO - p. 1-3. Presents theories regarding land formation in terms of the Alberta landscape.
- CA - pp. 28; 35; 48. Continents Adrift.
- LR (Film/Video) Planet of Man: The Inner Limit (201 009).

1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.9 Interdisciplinary Nature of Science Education

1.2.5, 1.2.8 Canadian Science - Canadian Society Interaction

1.3.4 History of Canadian Science

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

1.6.1, 1.6.3, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

Continental drift, plate tectonics and sea floor spreading are theories advanced to explain crustal deformation.

The teacher would need to paraphrase the article into a lecture format lesson, to explain the theory of continental drift as proposed by J. Tuzo Wilson.

The teacher could use CCS to expand on Dr. Wilson's contributions to science.

The teacher could use this video to illustrate the concept of plate tectonics.

The teacher could have the students build their own models depicting the various plates which make up the earth's crust.

The teacher may also use a slide presentation to further illustrate the theory.

The teacher should use the article to initiate discussion of sea floor spreading. Once students seem to have grasped the idea of sea floor spreading, relate this process to what the students saw on their latest field trips with specific attention given to strata, bed, formation, unconformities and contact areas. Students can begin to speculate on what kinds of processes have taken place in addition to this action on the plate boundaries.

- CA - pp. 12-14; 68-70; 74-81. Discusses the plastic layer of the earth's mantle and in particularly focuses on J. Tuzo Wilson's theories of continental drift and the relationship to plate tectonics.
- MB - p. 9. Tectonic plates are discussed in terms of the Rocky Mountains. Accompanied by slides.
- CCS - pp. 208-213. Provides an indepth biography of the geophysicist Dr. John Tuzo Wilson of the University of Toronto. The nature of the source rock dealing with coal formations and their economic significance is discussed in terms of South West Alberta and the Kananaskis area.
- CA - pp. 41-45. Continents Adrift.

- LR (Film/Video) Planet of Man: Jigsaw Fit.

1.1.3 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

1.6.1, 1.6.2 Science as Inquiry

2.1.1, 2.1.3 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

CONCEPT E8.1

Materials from the crust have had an important influence on mankind's daily living.

The film could be used to illustrate the various energy sources found beneath the earth's surface.

The teacher could discuss the first commercial oil well in the world drilled by James Miller Williams of Hamilton, Ontario.

The teacher could arrange field trips to local oil wells, gas plant, coal mines, etc..

The teacher could discuss the 1846 invention by Dr. Abraham Gesner (of Nova Scotia) of the distillation of kerosene from coal.

The teacher could have students select a natural resource, research that resource and write a report.

This information could be used to illustrate coal deposits in Southern Alberta.

This information could also be used to explain the formation of oil and gas deposits in the students' local environment.

- NRR - pp. 33; 65. The search for resources throughout the Kananaskis area serves a focal point for introduction of the role of the Canadian scientist and explorers played on the settlement patterns in the area and subsequent resource use.
- FES - p. 148 - Salt as an industrial mineral
- CSCG. Colour Slides of Canadian Geology.

- LR (Film/Video) Energy: Sources of Resources (125 103).

- C1B - pp. 32-35. Canadian Inventions Book.

1.1.1, 1.1.3, 1.1.4, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.6, 1.2.8, 1.2.9 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.1, 1.5.3, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship

1.6.1, 1.6.2 Science as Inquiry

1.7.1, 1.7.2, 1.7.3, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

2.1.2, 2.1.3, 2.1.4, 2.1.5 Maximum Use of the Local Environment.

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1 Problems of Regionalism

1. Fossil fuels and their products are important in the economy of Alberta.

The teacher could use the reference material as a starting point for for students when writing reports.

The video Oil and Gas can be used to initiate discussion and spark interest for students when writing their reports. The video provides a lively look at Alberta's petroleum industry - where oil and gas are found, how it gets to the market and how it is used. Students can use these main areas to identify the kinds of things that they would include in their reports. Using the supplemental materials provided, the teacher could initiate a comprehensive look and interpretation of a Cascade Coal Basin in the Kananaskis area starting with early geologists' 1886 writings about Kananaskis and the Cascade Coal Basin through to the latest interpretations by present-day scientists. The teachers should emphasize the environmental conditions in Alberta leading to the formation of oil and gas and invite students to speculate as to the future directions we should take regarding non-renewable resources.

- VC 224201. This video film provides a lively look at Alberta's petroleum industry - where oil and gas are found, how it gets to the market and how it is used.

- SARP - pp. 18-19. Locations of fossil fuels including coal, petroleum and natural gas are identified throughout Southern Alberta. Discussion also centers on the impact to the economic development of the region and future patterns of use.
- NRR - pp. 10-15; 19; 21-24; 62-63; 79. Coal, natural gas and minerals found in South Western Alberta are discussed in terms of geological formation, previous environmental conditions, presence importance in trends and related consolidated materials found in the area. Finds throughout the Kananaskis and Cascade coal basin are explored.
- EDGEO - p. 24. Discussion centers on petroleum, natural gas and coal finds surrounding the Edmonton area.
- C1B - pp. 34-35. Discusses the first commercial oil well in the world in Lambton County, Ontario by James Miller Williams of Hamilton, Ontario.
- CSCG. Colour Slides of Canadian Geology.

1.1.1, 1.1.4, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10, 1.2.11, 1.2.12 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.3, 1.4.4 Philosophy Underlying Canadian Science

1.5.1, 1.5.3, 1.5.4 Pure Science, Canadian Applied Science and Their Interrelationship

1.7.1, 1.7.2, 1.7.3, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

2.1.3, 2.1.4, 2.1.5, 2.1.6 Maximum Use of the Local Environment.

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1 Problems of Regionalism

2. Since crustal materials are limited, exploitation must be managed for maximum benefit.

This information could be used to explain the position our resources are in at the present time.

The teacher could use this material to develop a conserving attitude towards our natural resources.

The teacher should discuss geologist William Dawson's attempt to use these issues to raise the level of professionalism of science in Canada and the founding in 1856 of Canada's first scientific journal, The Canadian Naturalist and Geologist (TCE, p. 1655).

- VC 216504. Shows how the growth of British Columbia is closely related to the history of the development of its natural resources and how continued growth is dependent upon their abundance and availability. Deals with the problems of non-renewable resources and the development of renewable resources - those resources that replenish themselves.
- RM - p. 9. Resource management policies for Southern Alberta and the Kananaskis area in particular are discussed in terms of energy and natural resources, environment, recreation and parks, and the energy resources conservation board with slides.
- NRR - pp. 42, 60, 79.
- TCE - pp. 1653-1661.

1.1.1, 1.1.4, 1.1.6, 1.1.7, 1.1.8 Interdisciplinary Nature of Science Education

1.2.4, 1.2.6, 1.2.9 Canadian Science - Canadian Society Interaction

1.4.1, 1.4.2, 1.4.4 Philosophy Underlying Canadian Science

1.5.3, 1.5.4 Pure Science, Canadian Applied Science and Their Interrelationship

1.7.2, 1.7.3, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and Their Interaction

2.1.3, 2.1.5, 2.1.6 Maximum Use of the Local Environment.

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

CONCEPT E8.2

Evidence for determining the past history of the Earth comes from a study of the crust.

The teacher should use these materials to provide a comprehensive look and interpretation of the Cascade Coal Basin in the Kananaskis area starting with early geologists' 1886 writings about Kananaskis and the Coal Basin through to the latest interpretations by present-day scientists. Attention should also be focused on the environmental conditions in Alberta during the oil and gas formation periods of the Devonian, Mississippian and Cretaceous periods.

- NRR - pp. 42; 59-60; 79. Provides a comprehensive look and interpretation of the Cascade coal basin in the Kananaskis area starting with early geologists' 1886 writings about Kananaskis and the Cascade coal basin through to latest interpretations by present-day scientists. Environmental conditions in Alberta during oil and gas formation serve as a focus for discussion of Devonian, Mississippian and Cretaceous times.
- Refer to Concept E8.1.2.
- Face of Time is an excellent resource for this section.

1.1.1, 1.1.2, 1.1.4, 1.16, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.4, 1.2.8 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.3 Pure Science, Canadian Applied Science and Their Interrelationship

1.6.3, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.3.1, 2.3.2 Adaptation of Foreign Science Instructional Materials to a Canadian Context

1. Age determinations can be estimated on the basis of rates of changes of crustal materials.

The teacher could use this resource to illustrate delineation between the various periods in time, i.e., Precambrian. This geological time scale would be applied to production of fossils fuels, silica at Bruderheim, salt at Lindbergh, bentonite at Rossiland, sodium sulphate at Metiskaw and others. Students should begin to appreciate that these resources were not formed at the same time, and therefore gain a greater appreciation of the impacts of each of these geological periods.

The teacher could have students make a time tape for earth, which illustrates different periods from the beginning of time, up to the present. Once students have made the tape for the earth, they should go back and start to put in information about the various periods they have learned in terms of the geological history of Alberta.

- EDGEO III - pp. 8-12; 24. Information is provided regarding the physical and chemical changes associated with different elements of the earth's crust as it is associated to what we have learned while attempting to manage Canada's natural resource well. The geological time scale is applied to production of fossil fuels, silica at Bruderheim, salt at Lindbergh, bentonite at Rossiland, sodium sulphate at Metiskaw and others. An exercise is used developing a collage of recent headlines from newspapers and geological journals to indicate current topics of concern in pure geology and then related to the past geological time scale.

1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(a) Sediments have been laid down throughout the life of the earth.

These are activities which can be used to illustrate how sediments have been laid down throughout time. The teacher should attempt to get the students to focus on their immediate environment and relate this to the larger scale.

The teacher can use this resource to illustrate how rivers cut into various layers of sediment which have been laid down through time.

A field trip to a local river can help illustrate this point.

- RPGU - pp. 44-48 T26-T28. How soils are formed from rock in the Edmonton area serves as a starting point to then relate back to earliest

Precambrian times and discusses the types of sediment which would have been laid down through each of the geological eras and periods leading up to the Quaternary period.

- LENE - p. 116. Using examples from Eastern Canada the discussion focuses on the change through time and the record in the rocks revealed by sedimentary rocks. Principles of superposition and correlation of rocks are used to make some sense of the geologic history of the area.
- CSCG. Colour Slides of Canadian Geology.

1.2.8 Canadian Science - Canadian Society Interaction

1.4.1 Philosophy Underlying Canadian Science

2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.3 Problems of Regionalism

(b) Radioactive elements decay at measurable rates.

This resource could be used by the teacher to illustrate the process of decay through melting a candle and measuring the time that passes during melting. This could be compared to when discussing the concept of half life. Following this introduction, discussion should continue with radio active decay, isotopes and half-lives and then this earth clock should be applied to the geological time scale from Precambrian to Cenozoic times periods in terms of specific Newfoundland events using the resources provided. Then have students do the same for what they have learned about Alberta.

The teacher could set up a field trip to the Tyrrell Museum of Paleontology to view the area used for research purposes.

This material could be used to give a simple explanation of radio-active decay.

- LENE - pp. 9; 128-130. Following an introduction concerning radio active decay, isotopes, and half lives, this earth clock is applied to the geological time scale from Precambrian to Cenozoic time periods in terms of specific Newfoundland events ranging from gneisses and granites of the Great Northern Peninsula as well as sediments and volcanic rocks of

Avalon and Burren Peninsulas through to pleistocene glacial deposits and sediments deposited on the Continental Shelf of Newfoundland and Labrador.

- EDGEO III - p. 812. Discussion centers on the radio active dating using the lava and ash volcanoes with its small amounts of radio active potassium changing to argon to assist with dating artifacts in areas such as Buffalo Lake, Cypress Hills and areas in Southern Alberta using Mt. Mazama ash from about 6600 years ago. Fossil evidence can be used to relate past events in the history of the earth from one place to another.
- APP - pp. 23-24; 75-76.

1.1.9 Interdisciplinary Nature of Science Education

1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.3, 1.3.4 History of Canadian Science

1.4.1 Philosophy Underlying Canadian Science

1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1, 2.4.2 Problems of Regionalism

2. Fossil evidence can be used to relate past events in the history of the earth from one place to another.

Discuss the Great Canadian Dinosaur Rush of 1914 (from DCUB) - the competition between the American Museum of Natural History and the Canadian Geological Survey.

This supplemental information would help the teacher discuss the prehistoric era.

The teacher could devise an activity where the students can match various fossils to their time period.

The class could take a field trip to either Prehistoric Park in Calgary or Tyrrell Museum of Paleontology to study the remains and fossils.

- CG - p. 81. The rock foundations of Canada are discussed not only in terms of fossil evidence, but also in terms of geological time scale and implications on resource development of today. For example, Tar Sands along the Athabasca River during the time of the Cretaceous Sea and the huge volumes of salt found in Southern Ontario resulting from salty seas of the Devonian period.

- APP - pp. 11; 17; 21; 27; 31-35; 39-48; 49-51. The significance of fossil finds throughout Alberta is brought to light through extensive information provided about Canadian and Albertan Archaeological Society digs.
- LENE - pp. 113; 122-123. Discussion of fossils as evidence of life of the past is given relevance through application to sites throughout Eastern Canada.
- EDGEO III - p. 9. Fossils found along the North Saskatchewan River in the Edmonton area are related to the geological history of Alberta.
- HDBL pp. 1-221. This new edition of the most remarkable guide to the richest cretaceous fossils fuels in the world tells of the labors of Charles H. Sternberg who pioneered fossil collecting techniques and made some of the most important dinosaur discoveries of his time in the Red Deer Valley.
- CSCG. Colour Slides of Canadian Geology.
- DCUB - pp. 87-105.

1.1.1, 1.1.3, 1.1.6, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education
1.2.5, 1.2.6, 1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction
1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science
1.4.1, 1.4.4 Philosophy Underlying Canadian Science
1.5.3, 1.5.5 Pure Science, Canadian Applied Science and Their Interrelationship
1.6.3, 1.6.4 Science as Inquiry
2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5 Maximum Use of the Local Environment
2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(a) There are different kinds of fossil evidence: remains, casts, molds, and replacement fossils.

The teacher could use these references to illustrate and explain different types of fossil evidence.

The teacher could set up a field trip to Tyrrell and/or Calgary's Prehistoric Park.

- DCUB - pp. 3-25. This superbly written guide to the Badlands' prehistoric past takes us through every stage of development of the late cretaceous low-lying marshy plain that now has been revealed by the Red Deer River. The systematic excavations of fossils, their identification and implication on modern scientific theories is spellbinding. The reference to the 500 specimens of dinosaurs alone that have been recovered for museum research and exhibition purposes from this area gives support to Canada's position as being an absolute leader in this area of research.
- G12NS - p. 43. Focusing on fossils found in Eastern Canada calcification, silicification, pyritization, and carbonization are discussed.
- G112 - p. 35. Using fossils found in Nova Scotia students are lead through a guided inquiry of fossils and types of fossil preservation.
- CSCG. Colour Slides of Canadian Geology.
- LENE - pp. 1-15. Labs identify systems for classifying fossils.
- HDBL - inclusive.

1.1.6, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education
1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction
1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science
1.4.1 Philosophy Underlying Canadian Science
1.6.3, 1.6.4 Science as Inquiry
2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5 Maximum use of the Local Environment
2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(b) Earth's history can be divided into periods of geologic time on the basis of the type of fossil evidence.

The teacher should use the video The Alberta Experience: A Pre-history to initiate discussion of the pre-history of Alberta interpreting Precambrian, Devonian, and Carboniferous periods in terms of the fossil evidence. Dr. Michael Wilson does an excellent job within the video of extending this discussion all the way through to the settlement of human beings in Alberta. Discussion following the video could make use of the materials produced by the Canadian Scientists of the National Museum of Canada.

- VC 228001. Covers the pre-history of Alberta including the Precambrian, Devonian, and Carboniferous. This discussion is extended all the way through discussion of settlement of human beings in Alberta. The skull of a child found at Taber, Alberta is estimated to be 70,000 years old and archaeologist Dr. Michael Wilson discusses the implications of this find. Explores the life of the Plains Indians, their hunting, art and common interpretation of this fossil record prior to the arrival of the White Man.
- APP - pp. 23-24, 75-76. Geography of ancient times is discussed in terms of the fossil record of Alberta from earliest Precambrian life through to the extinction of the dinosaurs. An attempt is made to present the information as interpreted by the team of Canadian scientists led by Dr. Dale Russell of the National Museum of Canada.
- DCUB - pp. 87-113. The great Canadian dinosaur rush maps out the work of the American Museum of Natural History and the Canadian Geological Survey throughout this time period from the earliest 1900's on. The relationship of the fossil finds to establishment our geological record is quite fascinating. Early involvement by the University of Alberta and the Provincial Museum in Edmonton as well as later involvement by the Tyrrell Museum of Paleontology at Drumheller and the National Museum of National Sciences in Ottawa, serve to give students an excellent idea of the world class contributions made by Canadians in this area.

1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.2.8 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.2, 1.4.3 Philosophy Underlying Canadian Science

1.5.2, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.3, 1.6.4 Science as Inquiry

1.7.1, 1.7.2, 1.7.3 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.3, 2.1.4, 2.1.5, 2.1.6 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

(c) Fossil evidence is used in oil and gas exploration.

The teacher should use the video Alberta Resources in Review to introduce the exploration techniques involved in the oil and natural gas areas. This video sets an excellent stage for the class to use Alberta: A Natural History (available in all school libraries) and to relate resource extraction in the oil and natural gas industry in terms of the fossil records, the types of fossils evidenced, the kinds of rocks involved and implications for geologists in finding favorable areas for oil and gas discovery. These resources are excellent tools for making students aware of the contributions made by Canadian geologists in this area of exploration and will quickly identify the relationship between local varieties of fossils and some of the great geological explorers of Alberta including Selwyn, Tyrrell, Dowling, Dawson, McConnell, McLaren and others.

- VC 216501. Showcases some of Alberta's valuable assets, their current use and future potential. Using maps, graphs and stills, and on-location reports, the program elaborates on exploration techniques involved in the oil and natural gas areas and stimulates thought on how these resources should be managed.
- SEEDST - p. 11-47. Using a number of activities ranging from discovery of how fossils are formed through to how an oil well works, these

materials present an excellent integrated approach to the relationships between geological evidence, exploration, and resource extraction in the coal, oil and natural gas industries.

- ANH pp. 21-52. The fossil record within the rocks of Alberta is discussed through each of the eras of the geological time charts outlining the types of fossil evidenced, the kinds of rocks involved and implications for geologists in reconstructing maps of the sea margins and the depths of the waters in the past in order to find favorable areas for oil and gas discovery. Students will be fascinated by the very articulate relationship between the fossil beds located at very common place names throughout the province and how scientists turn this information into a Heritage Trust Fund. There is an excellent correlation between the local varieties of the fossils and the Canadian geologists who were the great geological explorers of Alberta including Selwyn, Tyrrell, Dowling, Dawson, McConnell, McLaren, and many others.

1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7, 1.1.8, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10. 1.2.11, 1.2.12 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.2, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.3, 1.4.4 Philosophy Underlying Canadian Science

1.5.1, 1.5.2, 1.5.3, 1.5.4, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.3, 1.6.4 Science as Inquiry

1.7.1, 1.7.2, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

2.4.1, 2.4.3 Problems of Regionalism

APPENDIX XV

Instructional Exemplars for Expanding the Canadian Context in the Grade 8 Geology Component

Included in this Appendix are:

1. Exemplar Ia - A lesson plan based on one of the authorized textbooks and supplementary materials where some Canadian context is already evident.
2. Exemplar Ib - A lesson plan based on the same concept as Ia but enhanced for Canadian context by inclusion of information from Stage III.
3. Exemplar IIa - A lesson plan based on one of the authorized textbooks in which American examples are used.
4. Exemplar IIb - A lesson plan based on lesson plan IIa with Canadian examples substituted.
5. Exemplar III - A lesson plan based on the integration of several concepts and sub-concepts providing large scale coverage of Canadian context.

1. Exemplar Ia - A lesson plan based on one of the authorized textbooks and supplementary materials where some Canadian context is already evident.

Concept:

C8.8 The Crust of the Earth is constantly being changed.

Sub-Concept:

1. Landforms are being built up by movements within the crust.

(a) Earthquakes are the result of movements of masses of rock.

Behavioural Objectives:

At completion of this information set, a student should be able to:

1. Explain the causes of an earthquake.
2. Explain where earthquakes are most likely to occur.
3. Explain how earthquakes are measured.
4. Distinguish between the three kinds of waves produced by earthquakes.
5. Relate the epicenter of an earthquake to the focus.

References and Acknowledgements:

1. Heller, R.L. et al. (1976). Challenges to Science: Earth Science. Scarborough: McGraw-Hill.
2. NASA. Earthquake Below. Alberta Junior High School Learning Resources Manual. listed video.

Background Information:

It is assumed that students have read about earthquakes in the Challenges to Science textbook, pages 114-122, and therefore have been exposed to the examples provided including the Alaskan Good Friday earthquake, a brief discussion of causes of earthquakes and detecting earthquakes, and the discussion of prediction of earthquakes in relation to San Francisco and the San Andreas Fault.

Design and Activities:

This lesson may be introduced by reading a newspaper article of a recent earthquake and asking students such questions as:

a) What causes earthquakes?

b) Where are earthquakes most likely to occur? and

c) Has anyone ever experienced an earthquake?

This would lead to discussion of other things related to or resulting from earthquakes such as land slides, tsunamis or the shocks felt around the world.

Following the video of the film "Earthquake Below", students are asked again to reflect on the questions which were posed earlier and to discuss the information provided in the film including those points related to epicenter, focus and three kinds of waves produced by earthquakes. Subsequent activities following this could include demonstration of the three kinds of waves using a 'Slinky' or the actual building of a seismograph similar to that outlined on page 118 of the Challenges to Science text in Activity 6.1 where Ottawa is mentioned as one of the centres for the seismograph activity.

To conclude, have the students pose possible ways of identifying exactly where an earthquake occurs in terms of use of seismograph stations.

Canadian Context Elements Included:

1.2.8, 1.2.11, 1.2.12 Canadian Science - Canadian Society Interaction

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2 Science as Inquiry

2.1.2, 2.1.3, 2.1.4 Maximum Use of Local Environment

2. Exemplar Ib - A lesson plan based on the same concept as Ia but enhanced for Canadian context by inclusion of information from Stage III.

Concept:

C8.8 The Crust of the Earth is constantly being changed.

Sub-Concept:

1. Landforms are being built up by movements within the crust.

(a) Earthquakes are the result of movements of masses of rock.

Behavioural Objectives:

At completion of this information set, a student should be able to:

1. Explain the causes of an earthquake.
2. Explain where earthquakes are most likely to occur.
3. Explain how earthquakes are measured.
4. Distinguish between the three kinds of waves produced by earthquakes.
5. Relate the epicenter of an earthquake to the focus.

References and Acknowledgements:

1. Heller, R. et al. (, 5). Challenges to Science: Earth Science. Scarborough: McGraw-Hill.
2. Province of British Columbia. (1977). Geology 12. Victoria, B.C.: Schools Curriculum Branch, Ministry of Education.
3. Neale, E.. (1982).Lectures on Earth Science: with Emphasis on Newfoundland Examples. Newfoundland Department of Education.
4. Alberta Society of Petroleum Geologists. (1976). Colour Slides of Canadian Geology. Calgary, Alberta: Institute of Sedimentary and Petroleum Geology, The University of Calgary.

Background Information:

It is assumed that students have read about earthquakes in the Challenges to Science textbook, pages 114-122, and therefore have been exposed to the examples provided including the Alaskan Good Friday earthquake, a brief discussion of causes of earthquakes and detecting earthquakes, and the discussion of prediction of earthquakes in relation to San Francisco and the San Andreas Fault.

Design and Activities:

Based on students' responses to the question of what are earthquakes, the teacher could continue to explain the relationships of earthquakes in terms of energy of wave motion which is transmitted through the surface layer of the Earth, like ripples. The teacher could then demonstrate this by dropping a pebble or a marble into a still container of water. Using slides such as Slide 120 and 107 from the Colour Slides of Canadian Geology, a teacher can relate this transmission of energy in terms of fault evidence found in the Rocky Mountains and the Brazeau formation of Alberta.

Using information provided in Geology 12 or Newfoundland Examples supplemented by library research, students may present a history of earthquakes throughout Canada and possibly their own area. The students could study a seismic map of Canada and note the areas of high risk such as British Columbia. The Summer of 1976 GEOS Magazine includes an article "Earthquake — Studies of the Seismic Risk in British Columbia" by W.G. Milne and shows the seismic zoning map of Canada. GEOS is available free of charge to teachers from The Editor, GEOS, Energy, Mines and Resources, 588 Booth Street, Ottawa, Ontario, K1A 0E4. Copies of this article are distributed without charge on request.

Students can plot a map of the epicenters for each of the quakes identified in their research. Discussion of the structural stability of each epicenter area could follow. Students should focus on where federal government seismographs throughout Canada are located and how, using P, S, and L waves, earthquake epicenters can be identified. As a follow-up activity, students can make a map of the areas of fill in the local school district. They should note whether any large structures have been constructed on deposits of fill. Invite a structural engineer to discuss the Building Code of Canada and the precautions that are taken to construct high buildings to resist earthquake damage. In the discussion of these preventative measures and where they would be absolutely necessary, share the following information:

1. The Queen Charlotte Fault that runs through British Columbia is an extension of the San Andreas Fault system of California and, in 1949, a major earthquake shook the Queen Charlotte Islands very severely. It is an example of the large earthquakes that tend to be associated with transform

faults. The 1949 earthquake generated long period waves of sufficient strength that chandeliers in Jasper, Alberta were caused to swing and an astronomer in Ottawa found it difficult to keep telescopes trained upon a fixed star during the passage of these great earth waves.

2. Severe earthquakes affected the west coast of Vancouver Island in 1918, 1957, and 1972, while earthquakes of a moderate size affected the San Juan and Gulf Islands area of the southern Strait of Georgia (Vancouver and Victoria) in 1909, 1920 and 1946.
3. An earthquake in 1872 severely shook the whole lower Fraser River valley of British Columbia. Students could be asked what effects such an earthquake would have in the Fraser Valley today.

Canadian Context Elements Included:

1.1.1, 1.1.2, 1.1.3, 1.1.6, 1.1.9 Interdisciplinary Nature of Science Education

1.2.1, 1.2.3, 1.2.4, 1.2.6, 1.27, 1.2.8, 1.2.10, 1.2.11, 1.2.12 Canadian Science - Canadian Society Interaction

1.3.1, 1.3.3, 1.3.4 History of Canadian Science

1.4.1, 1.4.2 Philosophy Underlying Canadian Science

1.5.2, 1.5.3, 1.5.5 Pure Science, Canadian Applied Science and their Interrelationship

1.6.1, 1.6.2, 1.6.3, 1.6.4 Science as Inquiry

2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5 Maximum Use of Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

3. Exemplar IIa - A lesson plan based on one of the authorized textbooks in which American examples are used.

Concept:

E8.1 Materials from the crust have had an importance influence on mankind's daily living.

Sub-Concept:

2. Crustal materials are limited and exploitation must be managed for maximum benefit.

Behavioural Objectives:

At completion of this information set, a student should be able to:

1. Identify minerals of major economic importance and relate the substance of value which are obtained from them.
2. Infer relationships between the location of these minerals and structural features of the Earth's crust.
3. Gain an appreciation for the non-renewable nature of these resources.

References and Acknowledgements:

1. Heller, R. *et al.* (1976). Challenges to Science: Earth Science. Scarborough: McGraw-Hill. (non-metric version).

Background Information:

Prior to this lesson, students will have read pages 80 to 86 in their Challenges to Science textbook and be familiar with those sedimentary mineral resources identified with the major headings of iron, aluminum, gold, coal, petroleum and gas, and other sedimentary resources.

Design and Activities:

This lesson could begin with part of the class taking part in Activity 4.6, panning for gold, found on page 81 of the Challenges to Science textbook, where students attempt to separate pieces of quartz, pyrite, galena, and feldspar of approximately the same size. While students are engaged in this panning activity, the rest of the class could work through a chorus of the "Honest Miner's" song and begin a discussion of the 1848 California Gold Rush at Captain Sutter's sawmill on the American River in California. Following this brief activity, discussions could move on to cover the following:

- gold — bearing hydrothermal quartz veins of the mother lode in Sierra Nevada;
- hematite — the main iron ore mineral in the Lake Superior region of the United States;
- magnetite — found in Montana and the western States;
- aluminum and its main mineral, bauxite and "the only important bauxite deposits in North America" found in Arkansas;
- petroleum and the first commercial oil well in the United States at Titusville in northwestern Pennsylvania drilled in 1859 by Edwin Drake with lengthy discussion of Texas oilfields and the natural gas of Pennsylvania;
- discussion of the number of million barrels of oil used every day in the United States from 1940 to 1970, its relationship to world consumption based on the fact that the United States with about 6% of the world's people uses over 30% of its petroleum.

Closure could be brought to the class through a discussion related to the finite status of these non-renewable resources and measures which must be taken to conserve resources for the future.

Canadian Context Elements Included:

1.2.8 Canadian Science — Canadian Society Interaction

2.1.6 Maximum Use of the Local Environment

4. Exemplar IIb - A lesson plan based on lesson plan IIa with Canadian examples substituted.

Concept:

E8.1 Materials from the crust have had an importance influence on mankind's daily living.

Sub-Concept:

2. Crustal materials are limited and exploitation must be managed for maximum benefit.

Behavioural Objectives:

At completion of this information set, a student should be able to:

1. Identify minerals of major economic importance and relate the substance of value which are obtained from them.
2. Infer relationship between the location of these minerals and structural features of the Earth's crust.
3. Gain an appreciation for the non-renewable nature of these resources.

References and Acknowledgements:

1. Heller, R. et al. (1976). Challenges to Science: Earth Science. Scarborough: McGraw-Hill. (non-metric version).

Replacement information obtained from the following sources:

a) Nelson, S. (1970). Face of Time — The Geological History of Western Canada. Calgary, Alberta: Commercial Printers (Calgary) Ltd..

b) March, J. (Ed.). (1985). The Canadian Encyclopedia, Volume III. Edmonton, Alberta: Hurtig Publishers.

c) Government of Alberta. (1986). Kananaskis Country Series. Edmonton, Alberta: The Kananaskis Country Environmental Education Library.

d) Geological Survey of Canada. New Materials of Canada's Mineral Industry.

e) Geological Survey of Canada. Prospector's Set of Mineral Chips.

Background Information:

Prior to this lesson, students will have read pages 80 to 86 in their Challenges to Science textbook and be familiar with those sedimentary mineral resources identified with the major headings of iron, aluminum, gold, coal, petroleum and gas, and other sedimentary resources.

Design and Activities:

Using assorted mineral samples from the two kits provided, students should select minerals from the same regions in Canada and place these in a pie pan partially filled with sand and water. They should then attempt to sort out specific minerals noting the various properties that seem to come into play. Following a discussion of mineral identification, students could then be led through a discussion revolving around a time a hundred years ago when 5,000 men were searching for gold in the Cassiar area of British Columbia. This was nearly 30 years before news of the great Klondike Gold Rush ripped through the world like a raging storm. Continuing discussions would then include the following:

- Examples of the lead — zinc — silver deposits of British Columbia including Pine Point, Monarch and Kicking Horse and Kootenay King mines. Location of these mines could be identified on a map of western Canada with discussion of the basic geology surrounding the mine, the type of deposit in which the ore materials are found, and the kinds of ore minerals found in each.
- An economic geologist could be invited to the class to discuss some aspect of geology as it relates to the mineral deposits in Canada, or more specifically in western Canada.
- Canada's role as a mineral producer for the world could include statistics such as Canada and Norway supply 74% of the world's nickel, Canada and South Africa supply 85% of the world's asbestos, Canada, Nigeria and Zaire supply 97% of the world's tantalum.
- The discussion of oil and natural gas in terms of Canada would be handled in a later section, however it could be introduced at this stage by pointing that the largest deposit of heavy oil in the world is found in Northern Alberta and is known as the Athabasca Tar Sands.

- The mining industry plays an important part in the development of the Canadian economy, especially over the last ten years. In 1974, mineral production in Canada (excluding coal, oil and gas) was valued at 6.5 billion dollars, the equivalent of 4.6% of the total output of goods and services as measured by the value of Canada's gross national product and about 10% of the value of the total output of goods producing industries. In 1974, the mining industry directly and indirectly provided employment for about 10% of Canada's total employed labour force and spent nearly 800 million dollars on new capital expenditures.
- Other significant mineral deposits that could be introduced based on the abundant material found in those resources listed in the References and Acknowledgements include Canada's uranium deposits, copper concentrates, lead-zinc mines and so on.

Discussion could conclude with an overview of the growth of Canada as related to the history of the development of its natural resources and how continued growth is dependent upon their abundance and availability. This discussion of problems of non-renewable resources and the development of renewable resources could be applied to the resource management policies for southern Alberta and the Kananaskis area in terms of energy and natural resources, environment, recreation and parks, and the Energy Resources Conservation Board using slides provided in this kit from Kananaskis Country. Before leaving this section, the teachers should discuss geologist William Dawson's attempt to use issues related to a conservating attitude towards our natural resources to raise the level of professionalism of science in Canada which led to the founding in 1856 of Canada's first scientific journal, The Canadian Naturalist and Geologist.

Canadian Context Elements Included:

1.1.1, 1.1.4, 1.1.6, 1.1.7, 1.1.8 Interdisciplinary Nature of Science Education

1.2.4, 1.2.6, 1.2.9 Canadian Science — Canadian Society Interaction

1.4.1, 1.4.2, 1.4.4 Philosophy Underlying Canadian Science

1.5.3, 1.5.4 Pure Science, Canadian Science and their Interrelationship

1.7.2, 1.7.3, 1.7.4 Canadian Science Policy, Current Emphasis in Canada and their Interaction

2.1.3, 2.1.5, 2.1.6 Maximum Use of the Local Environment

2.2.1, 2.2.2, 2.2.3 Canadian Science Instructional Materials

5. Exemplar III - A lesson plan based on the integration of several concepts and sub-concepts providing large scale coverage of Canadian context.

Concept:

C8.7 The crust of the Earth is formed of rocks.

C8.8 The crust of the Earth is constantly being changed.

E8.1 Materials from the crust have had an important influence on mankind's daily living.

E8.2 Evidence for determining the past history of the Earth comes from the study of the crust.

Sub-Concept:

All sub-concepts related to the concepts listed.

Behavioural Objectives:

At completion of this information set, a student should be able to:

1. Apply concepts learned in the classroom related to the geology component of the Grade 8 Earth Science program to their immediate environment.
2. Relate concepts identified with earth processes to the geomorphological features found around them.

3. Apply investigative processes learned in the classroom to a field study situation.

References and Acknowledgements:

1. Beaty, C. (1975). The Landscapes of Southern Alberta. Lethbridge, Alberta: The University of Lethbridge Production Services.
2. Nelson, S. (1970). Face of Time — The Geological History of Western Canada. Calgary, Alberta: Commercial Printers (Calgary) Ltd..

Background Information:

Integrated Approach to Using a Field Trip Methodology

For a fully integrated approach to these units, one could use an approach based on a field trip similar to the one prepared by the researcher which follows. The following Field Trip guide for the Lethbridge to the Crowsnest Past Area would be used with a one-day bus trip stopping at the appropriate places indicated for further investigation. The questions should be used to initiate discussion and focus attention. The teacher could actually reproduce these sheets and distribute them to students prior to the trip. In all cases advantage should be taken of the opportunities through some of the students' answers to promote interdisciplinary treatment of the information and present the information in a spirit of inquiry, and society - technology - science interaction. Before leaving, students should be made well aware of the contributions made by Canadian scientists in the areas that would be dealt with during the day trip. If possible, access to a local resource person such as Dr. C. B. Beaty to lead such a trip would provide an unforgettable experience for many of the students. The following figures and pictures from Landscapes of Southern Alberta should be given to students ahead of time and allow them the opportunity to use these to answer some of the questions asked on the trip. In this manner students will become better aware of the itinerary for the trip and will be on the lookout for the features in question. The following checklist may be of assistance.

- Figure 9 - Structure conditions along the Rocky Mountain Front in Northern Waterton Lakes National Park.

- Figure 43 - Generalized cross-sectional sketch showing sub-surface structural conditions in Southern Foothills Belt.
- Figure 69 - Modern stream systems of Southern Alberta and the late - glacial and immediately post-glacial channels of the plains.
- Figure 49 - Map showing distribution of the boulders of the Foothills Erratics Train.
- Figure 50 - One of the thousands of boulders in the Foothills Erratics Train located West of Ft. McLeod.
- Figure 51 - Diagrammatic cross-sectional sketch of the Porcupine Hills showing general structural characteristics.
- Figure 53 - South Eastern flank of the Porcupine Hills west of Ft. McLeod.
- Figure 34 - Northeast - Southwest cross-sectional sketch of Turtle Mountain showing fundamental structural features.
- Figure 33 - Scar of the Frank Slide on Turtle Mountain.
- Figure 31 - Hypothetical development of terraces.
- Figure 29 - Stream terraces in the Crowsnest River Valley just north of Lundbreck.
- Figure 56 - Pine Coulee west of Parkland.
- Figure 57 - Sketch showing the probable origin of melt water channels on the eastern slope of the Porcupine Hills.
- Figure 14 - Structural conditions as Crowsnest Mountain.
- Figure 15 - Chief Mountain as seen from near Police Outpost Provincial Park.

If the teacher were to utilize the reference materials that have been indicated in this package as supplementary resource materials for students and encourages more than one or two word responses on this trip, there would be an opportunity for inclusion of virtually all the elements identified in a clue structure for a Canadian context for science education. Many of these are also built into the programming offered at the Frank Slide Visitor Interpretative Center operated by Alberta Culture. Similar programs are offered throughout the province. The teacher could use this template and adapt its use to local features throughout Alberta.

Design and Activities:

FIELD TRIP — LETHBRIDGE TO CROWSNEST PASS AREA:

ITINERARY

Travelling:

What is the name of the volcano that exploded 660 years ago and covered the city of Lethbridge with approximately 30 cm of ash?

Where is some of this volcanic ash located?

What other volcanic mountain exploded in 1980 covering Lethbridge with fine ash?

Oldman River Coulee:

What evidence of coal mining can be observed on the west bank?

How was the river used in the late 1800's?

What feature is located on land, near the High Level bridge?

What erosional effects are man and his motorcycles creating?

What kind of obstacles would engineers have had to overcome in building the bridge?

What has caused or will cause the disappearance of the gravel bars in the Oldman river?

What type of feature is located near the golf course?

Where is the selenite found?

Can the selenite scratch your fingernail?

Selenite is the crystal form of what mineral?

What might it be used for?

How many shale layers can be seen on this hillside?

What is happening to much of this shale?

Of what significance are the large holes on the hillside?

What inference can be drawn from these holes?

Are there other examples of slumping?

What is a SLUMP?

Find a sample of leaching. Where does this leaching occur?

Test this sample with the vinegar (crush this leaching with another rock to make a powder). What happens to the powder?

What mineral does this sample of leaching contain?

Look for rocks that are rounded in nature. These are known as the Saskatchewan gravels.

Where did these gravels come from?

How are the grains of soil arranged in the upright cliffs?

what colors do you observe in this bank?

What are VARVES?

What condition existed in Lethbridge that produced these varves?

Travelling:

Describe the features of the land as we approach Coalhurst.

What caused these features?

Monarch: What made the wide bend on which theer is a farm?

What is occurring on the outside curve of the river?

What is happening on the inside curve?

What is the geological name of this feature?

What is direction of the prevailing winds?

Look at the old homestead towards the south. Why are there trees?

Why are there no trees on the east side?

Detour:

Where was the river bed previously?

Why did the highway have to be changed?

What is the color of the oldman river?

What is causing this color?

Locate the gullies, in which direction are they moving?

Where is the Loess soil (wind blown soil) located?

Note the direction the fields are planted. Why do you think they are oriented in this way?

How many alluvial cones are there?

How many glacier layers are visible?

What is being (was) taken from the river?

Look at the rock strata near the south-east side of the river, in which direction is it tilted?

Travelling:

Sand dunes are located on each side of the highway. What is their alignment?

What is the approximate height of a dune?

What is the approximate length of a dune?

How many of these sand dunes did we cross?

Look at the farmstead on the north west side of the highway. Why are there trees?

What is the purpose of the dugout?

Describe the general terrain after the curve on the highway.

Find Chief Mountain, the Klippe that marks the eastern limit of the Precambrian Mountains that slide over our foothills in the Lewis Overthrust Fault. What is its profile?

What type of erosional mechanism caused this feature?

Describe what the soil is like near Fort Mcleod.

The top of the Porcupine Hills is slightly more than 1200 metres in altitude. Can you see the Livingstone Range of Mountains behind these hills?

Can you see the foot of these mountains?

Why can you not see more of the mountains which are over twice the altitude of the hills in front of them?

Do the clouds give you a clue?

What kinds of clouds are there?

Where do the trees grow on the Porcupine Hills?

How many meltwater channels (Steppes) can you count?

Look for evidence of glaciation as we are travelling. Name some of these features.

Look for evidence of two tracks on either side of the highway. What do you think make these tracks?

Look for evidence of soil erosion. Where did this soil come from?

Where was this wind blown soil deposited?

Where on this trip were you FIRST able to see FRANK SLIDE on Turtle Mountain?

Brocket Area:

The ridge at Brocket seems to be an extension of the Porcupine Hills; on what evidence is this statement made?

Why are they NO longer joined?

Look across the valley at the river terraces (steppes) made by glaciation. How many terraces are there?

Where else on this trip can you see river terraces?

Pincher Creek Area - Washroom Stop

Look at the amount of foothills. Why are they so abrupt and not so gradual as elsewhere where there are mountains?

Look at the mountains. Look for and identify horns, aretes, cirques, hanging valleys and ground moraine. What is the present level of snow near Pincher Creek? In the mountains.

Travelling - Complete the Following Questions

Describe the rock strata on each side of the highway in several locations.

In which direction is this rock strata tilted?

What force made the ridges tilt away from the horizontal formation in which they were formed?

Lundbreck Falls: Estimate the height of the falls. Over what kind of rock (resistant is the waterfalls descending?

What part of the rock structure will likely fall into the water below?

On what do you base your prediction?

In another thousand years where will the falls be located?

What is the age of this river? (a) young; (b) mature; (c) old. This river could not have carved this valley. Another name for this type of river is?

Where are the potholes located?

Where does cross bedded sandstone occur?

Where downstream did the waterfalls start its work of eroding the rock upstream?

Look at the cracks in the rock strata near the bridge. What force was the probable cause of these cracks?

Rock Creek:

What effect did the rock strata have on this creek?

What is the age of Rock Creek? (a) young; (b) mature; (c) old.

Leitch Colleries:

Walk through the Interpretive centre and listen to the self-guided tour. This plant was operating in the 1920's, but lasted only one year after a strike. The coal was brought by train about 3 km farther north. The long structure with red bricks contained about 100 coking ovens. What were the coking ovens used for?

Travelling:

In which direction is the rock strata tilting just west of Leitch Colleries?

What evidence is there of coal mining at Maple Leaf?

What force made the Seven Sisters behind Crowsnest Mountain?

What other evidence is there that indicates coal mining at Bellevue?

Detour - Past Bellevue to Back of Frank Slide. Lunch Stop. Put ALL Garbage into Garbage Bags!!!

The coral fossils are MISSISSIPPIAN era fossils, dating about 350 million years old. Corals are seal animals that live in warm, shallow seas. What has happened in the years between then and now?

Turtle mountain is over 2100 metres in altitude. Locate the SKI JUMP over which the limestone slab became airborne.

About how high up Turtle Mountain is it?

Are there any large rocks next to the base of the mountain?

What are the THREE theories explaining the cause of this of this slide?

Who were the Canadian scientists involved in this investigation? What impact have they and others had on the field of geology?

Where might the next slide occur?

Why?

Can you hear any stones or rocks falling onto ice at the bottom of joints?

The Lewis Overthrust is a slab of limestone that overrode our foothills. You can see this evidence by looking closely about one-third of the way up the mountain (ski-jump).

Describe the landforms around the river.

What information does the roar of the river tell you?

Test several rocks with your vinegar. What happened to the rocks?

Test several rocks for hardness, with your fingernail, with a nail file. Record your results.

Which mineral is present in limestone?

What living creatures are in this area at present?

Why did the Provincial Government spend time and money cleaning the rocks of names and paint?

Why can we NOT remove any fossils from this site?

From the top of Goat Mountain one can see the lights of Lethbridge on a clear night. What is located at the bottom of Goat Mountain?

Frank Slide contains a variety of fossils. These are the HORN CORALS, BRACHIOPODS, SPONGES, BRYOZOANS AND CRINOIDS. Locate each of the above, with the help of your teacher, and make an ACCURATE drawing of each on a separate sheet of paper. DO NOT wander off on your own. STAY CLOSE TO THE GROUP.

Travelling:

Name two interesting features from Frank Slide to the main highway.

Look for other evidence of coal mining along the highway and its impact on the environment. Write down your observations. Stop at the Frank Slide Interpretive Centre. Walk through, see the slide presentation and the play about the boom times of Frank.

Viewpoint - Volcanic Rock:

A sign gives the following information: The volcanic rock consists of ash and cinders with some large blocks similar to pumicestone bombs thrown out by modern volcanoes. There is little actual lava. This suggests that the eruptions were violent and explosive like those of Mount Vesuvius. These rocks date 100 million years old, which make them older than the Rockies. the location of the volcano has not been found. Mountain-building and erosion have erased any trace of it. The only other igneous rock is located as bedrock in the north east corner of the Province. The Purcell Sill is located in Waterton and the Castle River area.

Locate Window Mountain. What is happening to the shale rock at the top?

What erosional feature caused the shape of Crowsnest Mountain?

Where is a rock glacier located?

Where are a few truncated spurs located?

What is located at the top of the mountain above Crowsnest Lake?

What is the shape of the valley between Crowsnest Mountain and Window Mountain?

What caused this shape?

Do other valleys have this shape?

Point out HORNS, ARETES, CIRQUES, ROCHE MOUTONNES and other glacial features.

The river below is a MISFIT in a large valley, why?

What would be the actual age of this river? (a) young; (b) mature; (c) old. Why?

What is the effect of the wind on the evergreen trees?

What color are the lichens on the rocks?

What is their texture?

Look at the rock that we are standing on; what color is it?

Does it contain crystals?

If this rock does contain crystals, what would you guess them to be?

Look for small GARNET crystals in the pyroclastic rocks of the volcanic area. What does PYROCLASTIC mean?

Use a rock pick or hammer and chisel to extract some of these garnets. Did the garnets form quickly or slowly?

How many sides do these garnets have?

Look for faults on the cliff face alongside the highway. How many did you count?

Travelling: Stop - Hike:

What color is the water in the spring?

What gives the water that color and this odor?

Why is it termed a spring?

Where was this spring originally?

What mineral is present in the limestone rock besides calcium carbonate?

This used to be a hot spring bathhouse similar to those found at Banff and Jasper. Why might the water no longer be hot?

Examine the rock strata. In which direction is it tilting?

What are the ruins on the hillside above the spring?

Hike to Turtle Mountain Inn or Shell Service Station for Washrooms. Stay Close to Your Instructor!!

Travelling: Stop - Information Signs:

Locate the Oxbow lake. Where is the channel now for the Oldman River?

Where was the swinging meander before?

What is the age of the river at this point?

What happens to the river beyond this point?

What is being taken from the inside curve of the Oxbow?

How many glacial layers are visible at this point?

Travelling: Lethbridge River Bottom:

How many glacial layers are visible on the east bank of the river?

Canadian Context Elements Included:

The design and nature of this activity would incorporate all the Canadian context elements identified in Appendix VI except for elements 2.3.1, 2.3.2 of component 2.3 *Adaptation of Foreign Science Instructional Materials to a Canadian Context.*