DOCUMENT RESUME

ED 225 873 SE 040 366

AUTHOR Taylor, Hugh, Ed.
TITLE British Columbia Science Assessment 1982. Summary Report.
INSTITUTION British Columbia Dept. of Education, Victoria.
REPORT NO ISBN-0-7719-9081-2
PUB DATE Sep 82
NOTE 64p.; For related documents, see ED 190 598, SE 040 365-367.
PUB TYPE Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Academic Achievement; Bilingual Students; *Educational Assessment; Elementary School Science; Elementary Secondary Education; *Science Education; Science Interests; *Science Programs; Science Teachers; Secondary School Science; Sex Differences; *Student Attitudes; Student Characteristics; Teacher Attitudes; Teacher Characteristics; *Teacher Education
IDENTIFIERS *Canada

ABSTRACT

This summary report is a condensation of the British Columbia Science Assessment 1982, General Report, summarizing and highlighting data and recommendations relative to the status of elementary and secondary science education in British Columbia schools. The report is divided into four major sections: (1) purposes and organization of the assessment; (2) attitudes and achievement of science students; (3) backgrounds and opinions of science teachers; and (4) recommendations. Achievement and attitudes of over 80,000 students were assessed at grades 4, 8, and 12, and included a sample of approximately 2,000 grade 10 students. In general, attitudes of students toward various aspects of science were quite positive. However, achievement, as judged by informed members of various panels, was rated low. Achievement measured including science processes, knowledge (recall and understanding), and higher level thinking. Sex-related and language background differences are also considered. Approximately 2,000 elementary and secondary science teachers responded to questionnaires (modified by a 1978 survey). Findings summarized focus on teacher characteristics, science background, science curriculum/programs, pre-/in-service teacher education, classroom activities, and impact of the 1978 survey on science education. Eleven major recommendations are provided in the final section, with pre-/in-service teacher education singled out for special consideration and priority recommendations. (Author/JN)

1982
BRITISH COLUMBIA
SCIENCE ASSESSMENT

Summary Report

A REPORT TO
THE MINISTRY OF EDUCATION
PROVINCE OF BRITISH COLUMBIA

The 1982 B.C. Science Assessment

SUMMARY REPORT

Hugh Taylor, Editor

Submitted to the
Learning Assessment Branch
Ministry of Education

The Science Assessment Contract Team

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September, 1982

Canadian Cataloguing in Publication Data

Main entry under title:

British Columbia science assessment : summary report

Spine title: Summary report, science assessment 1982.

Bibliography: p.

ISBN 0-7719-9081-2

1. Science - Study and teaching - British Columbia - Evaluation. 2. Educational tests and measurements - British Columbia. 3. Curriculum evaluation. I. Taylor, Hugh. II. British Columbia. Ministry of Education. III. British Columbia. Learning Assessment Branch. Science Assessment Contract Team. IV. Title: Summary report, science assessment 1982.

LB1585.5.C3B741 507'.10711 C82-092324-9

THE 1982 B.C. SCIENCE ASSESSMENT

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PREFACE

This Summary Report is a condensation of the British Columbia Science Assessment 1982, General Report which is available from the Learning Assessment Branch, Ministry of Education. These reports present data and recommendations relative to the status of science education in the schools of British Columbia.

Achievement and attitudes of pupils were assessed at Grades 4,8, and 12 and included an approximate 2,000 pupil sample at Grade 10. In general, attitudes of pupils towards various aspects of science were quite positive. However, achievement, as judged by informed members of various panels, was rated low.

The achievement data and responses of teachers to questionnaires dealing with science teaching conditions were studied by the Contract Team and the Science Assessment Advisory Committee. A number of recommendations evolved. These are presented in Chapter 4 of this report.

It is the hope of the Contract Team that the Ministry of Education, the universities, the teaching profession and the public at large will seriously consider and act upon these relatively conservative recommendations.

Hugh Taylor
for the Contract Team

ACKNOWLEDGEMENTS

Hundreds, in fact thousands, of individuals helped assess the status of science education in the schools of British Columbia. The Contract Team would like to thank all of them for their contributions. Certain individuals and groups need special thanks as they stand out because of their special and unique efforts. These include:

<u>teachers and students</u> -

without the work of hundreds of teachers and their 80,000 pupils, the assessment would not have taken place.

<u>the Advisory Committee</u> -

for their many hours of detailed study of questionnaires, assessment items and final reports. The names of the committee members appear elsewhere in this report.

the <u>Review Panels</u> and <u>Interpretation Panels</u> -

members of the panels helped improve the validity of the assessment and, as well, set the important standards upon which the results were judged.

the <u>B.C. Research</u> group -

Mary Cooper, Barbara Holmes, and their assistants deserve praise for their detailed work related to questionnaire and assessment forms development as well as the subsequent collection and analysis of the data.

the Learning Assessment Branch personnel -

- David Bateson and Al Haynes, were most influential in harmonizing the activities of all groups associated with the assessment;
- Nancy Greer and Joyce Matheson, Directors of the Learning Assessment Branch during different phases of the assessment;
- Michael Marshall and Robert Wilson for helpful advice and technical guidance during the early phases of the assessment.

the University of Victoria group -

- Michele Bond who typed most of the first drafts of the reports
- Heather Bryan who typed and helped proof-read the final draft of the General
- Heather Crampton who wrote many of the original Grade 4 and 8 assessment items
- Jean Dey who examined the pool of Grade assessment items for readability
- John Hall who offered helpful criticisms of the Grade 4 pool of items
- Sandra Joss who prepared statistics, developed tables and aided in proof-reading the General Report
- Georgina Page who researched science attitudes and aided in the development of the scales
- David and Heather Sheppy for their creation of diagrams used on the Grade 4 and 8 assessment forms
- Larry Yore who offered suggestions on the suitability of the assessment objectives

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CHAPTER 1

1982 SCIENCE ASSESSMENT: PURPOSES AND ORGANIZATION

1.1 Purposes of 1982 British Columbia Science Assessment

During the spring of 1982, over 80 000 students and nearly 2000 teachers in British Columbia participated in the 1982 Science Assessment. The assessment was the second evaluation in the area of science, the first occurring in 1978. The assessments were part of the continuous assessment cycle in various subject areas of the school curriculum and were conducted by the Learning Assessment Branch, British Columbia Ministry of Education. In general, the basic purpose of assessments is to ensure that important decisions about education are based on reliable and valid current data concerning both the learning conditions and pupil achievement at provincial and school district levels.

The 1982 Science Assessment was also planned to provide information to persons involved in science education in British Columbia. Therefore, the following aims formed a framework around which the assessment was designed:

1. Establishment of baseline provincial and school district student achievement data on selected domains rated as priorities in the updated Science Curriculum Guides.
2. Provision of provincial and school district data on changes in student achievement on Curriculum Guide objectives in selected domains from the 1978 Science Assessment.
3. Development of a bank of B.C. curriculum-related test items for subsequent production of achievement instruments for optional use by classroom teachers as part of their evaluation of students.
4. Documentation of current classroom practices and identification of significant changes since the 1978 assessment.
5. Assessment of the extent to which change has taken place in the non-achievement areas (e.g., facilities, equipment, supplies, attitudes) which were identified as concerns in 1978.
6. Identification of the current context within which science curricula are used.
7. Examination of initial reactions to changes/revisions/updates in science curricula since 1978.

1.2 Organization of the 1982 Science Assessment

The assessment was a cooperative enterprise which included over one hundred individuals from various parts of British Columbia. The vast majority of participants involved in the planning, development and completion of the assessment were practising science teachers. Names of the various participants are listed at the beginning of this report and in the Appendices.

The assessment was accomplished through the activities of three major groups: the Learning Assessment Branch, a Contract Team, and a Technical Agency (see Figure 1). The main responsibilities of these groups are briefly described in the following three sections.

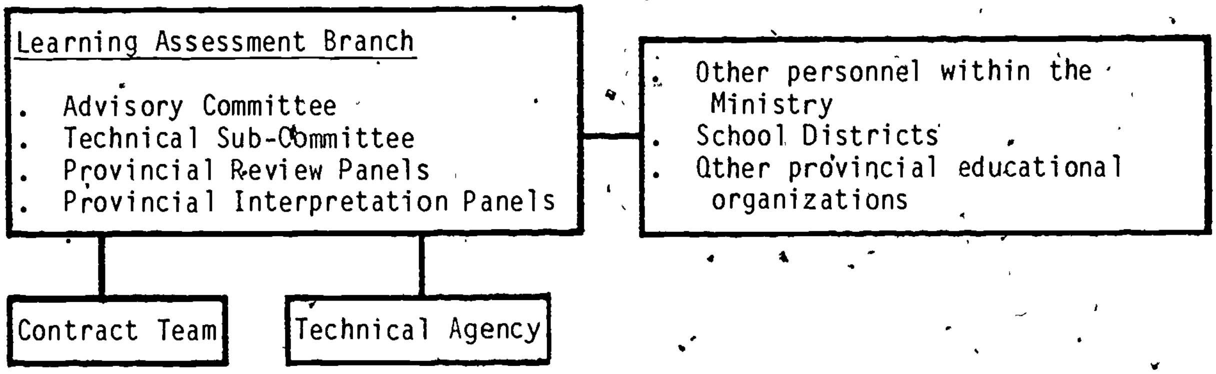


Figure 1. Organizational structure of the 1982 Science Assessment.

1.2.1 Learning Assessment Branch

The Learning Assessment Branch, Ministry of Education was responsible for, and coordinated, all activities. These included, among others:

- establishing the terms of reference for the Contract Team and Technical Agency and coordinating the selection of these groups
- chairing the Advisory Committee and the Technical Sub-Committee
- arranging and conducting the Provincial Review and Interpretation Panels
- printing all survey instruments and final provincial reports
- coordinating all necessary arrangements with districts and schools for the conduct of the assessment

1.2.2 Contract Team

The Contract Team consisted of three members of the Faculty of Education, University of Victoria and a science teacher from the Greater Victoria School District. The specific responsibilities of the Contract Team included:

- developing instruments appropriate for assessing student learning on a province-wide basis, including amplifying curriculum objectives, developing a pool of achievement items, and generating final achievement forms based on feedback from provincial Review Panels and pilot survey results
- designing a Table of Specifications for the achievement survey instruments used at grades 4, 8 and 10/12
- developing items for constructing strands tests at the grade 3/4 and 7/8 levels
- developing instruments suitable for a survey of instructional practices
- preparing contents of instruments for the pilot phase
- participating as resource personnel during the Interpretation Panels
- developing and preparing provincial reports of methods, results, and recommendations, including a Summary Report and a detailed professional General Report

1.2.3 Technical Agency

The Technical Agency consisted of personnel from B.C. Research, the technical operation of the independent, non-profit British Columbia Research Council located on the campus of the University of British Columbia. Specific responsibilities of the Technical Agency included:

- developing selection criteria for building final achievement survey forms
- printing, packaging, distributing, and collecting instruments for the pilot phase
- scoring and analyzing pilot data
- packaging, distributing and collecting all final survey forms
- scoring, analyzing, and preparing reports of analyses of final data

- designing, preparing, printing, and distributing district and independent schools reports of assessment results
- conducting follow-up analyses of a specific nature to identify areas of the province or groups of students requiring assistance

1.2.4 Advisory Committee

An Advisory Committee, convened by the Ministry of Education, guided the Contract Team by giving advice on the science content under consideration, providing advice for the development of all survey materials, and assisting at Review Panel and Interpretation Panel meetings. The members of the Advisory Committee were selected from across the province to reflect a cross-section of opinion on the areas of science being assessed.

The Advisory Committee was composed of:

- practising teachers and administrators
- teacher educators
- a School Board Trustee
- chairman of the Contract Team
- representatives of the Technical Agency
- representatives of the Learning Assessment Branch

Advisory Committee members in the first three categories sat as informed individuals and not as representatives of specific organizations.

1.2.5 Technical Sub-Committee

The Technical Sub-Committee consisted of a technical coordinator from the Learning Assessment Branch, the chairman of the Contract Team, a representative of the Technical Agency, and the chairman of the Advisory Committee. The sub-committee served as a forum for detailed discussions on issues of a technical and statistical nature.

1.2.6 Review Panels

In late August, 1981, a series of meetings was held in various parts of British Columbia for the purpose of reviewing materials produced by the Contract Team. Over 50 individuals participated in the various Review Panels (see Appendix A). These panels, chaired by members of the Advisory Committee, were composed of practising teachers/administrators as well as subject matter specialists.

The main task of the Review Panels was to judge, with the use of specially designed rating scales, all of the potential expanded objectives, achievement survey items and attitude/opinion statements. The panel ratings proved valuable to the Contract Team who used them to either omit, or revise and improve the quality of the various items prior to the pilot phase.

1.2.7 Provincial Interpretation Panels

In early June, 1982, the Learning Assessment Branch convened provincial Interpretation Panels to evaluate provincial results for each level of the science program assessed.

Interpretation Panels (see Appendix B) were composed of:

- practising teachers/administrators from all levels of the education system
- teacher educators
- members of interested and informed groups
- trustees, parents, and members of the public

Panelists received, in advance of their first meeting, a copy of the Table of Specifications and a copy of the achievement survey items classified in terms of learning objectives. Prior to the first session, panelists were asked to respond to the items and, for each, set percentage figures for "acceptable" and "desirable" levels of performance for the province as a whole, based on the percentage of students they felt should be able to correctly answer each item.

At their first session, panelists were given copies of the actual 1982 results for each item in terms of the proportion of students who answered the item correctly (p-value). They were then asked to individually rate the performances by comparing the actual results with their previously estimated acceptable and desirable levels. Ratings were made on a five-point scale from "Weak" to "Strong". These ratings were discussed in small groups and then in one large group in an attempt to reach a consensus. Both consensus and minority views were recorded.

At a final session, groups of panelists were asked to develop ratings (on the same five-point scale) for each of the objectives and domains assessed and to contribute interpretive comments and recommendations in light of the provincial performances. The ratings and conclusions of the various Interpretation Panels form important parts of future sections of this report.

CHAPTER 2

SCIENCE PUPILS: ATTITUDES AND ACHIEVEMENT

2.1 Teaching Goals and Assessment Domains and Objectives

The 1982 Science Assessment was based on the goals of the British Columbia science program as they were stated in the 1981 draft forms of the Elementary Science Curriculum Guide Grades 1-7 (1981) and the Junior Secondary Science, Curriculum Draft Materials. The four goals may be called:

Goal A, Attitude

Goal B, Processes and Skills

Goal C, Knowledge

Goal D, Thinking

From these goals, affective scales and three cognitive domains were defined thereby ensuring that the assessment results would reflect the British Columbia science curricula.

Figure 2 illustrates the relationship between the curriculum goals and assessment domains. A few sub-areas, shown in different typeface, were not included in the goal statements but were added for assessment purposes (for example, it seemed more appropriate to evaluate knowledge of safety procedures than to attempt to assess an attitude toward safety).

2.2 Science Pupils: Attitudes, Interests and Opinions

The British Columbia science curriculum guides, at both the elementary and secondary levels, encourage teachers to help pupils develop positive science attitudes. The guides suggest that opportunities should be provided to:

- develop curiosity about, and interest in trying to understand, natural events
- discuss how scientific endeavour is important to our society
- foster an appreciation of the impact of technology on the world
- develop a more responsible attitude towards self and society through the examination of social and environmental issues
- use scientific knowledge and skills to help clarify personal values and beliefs

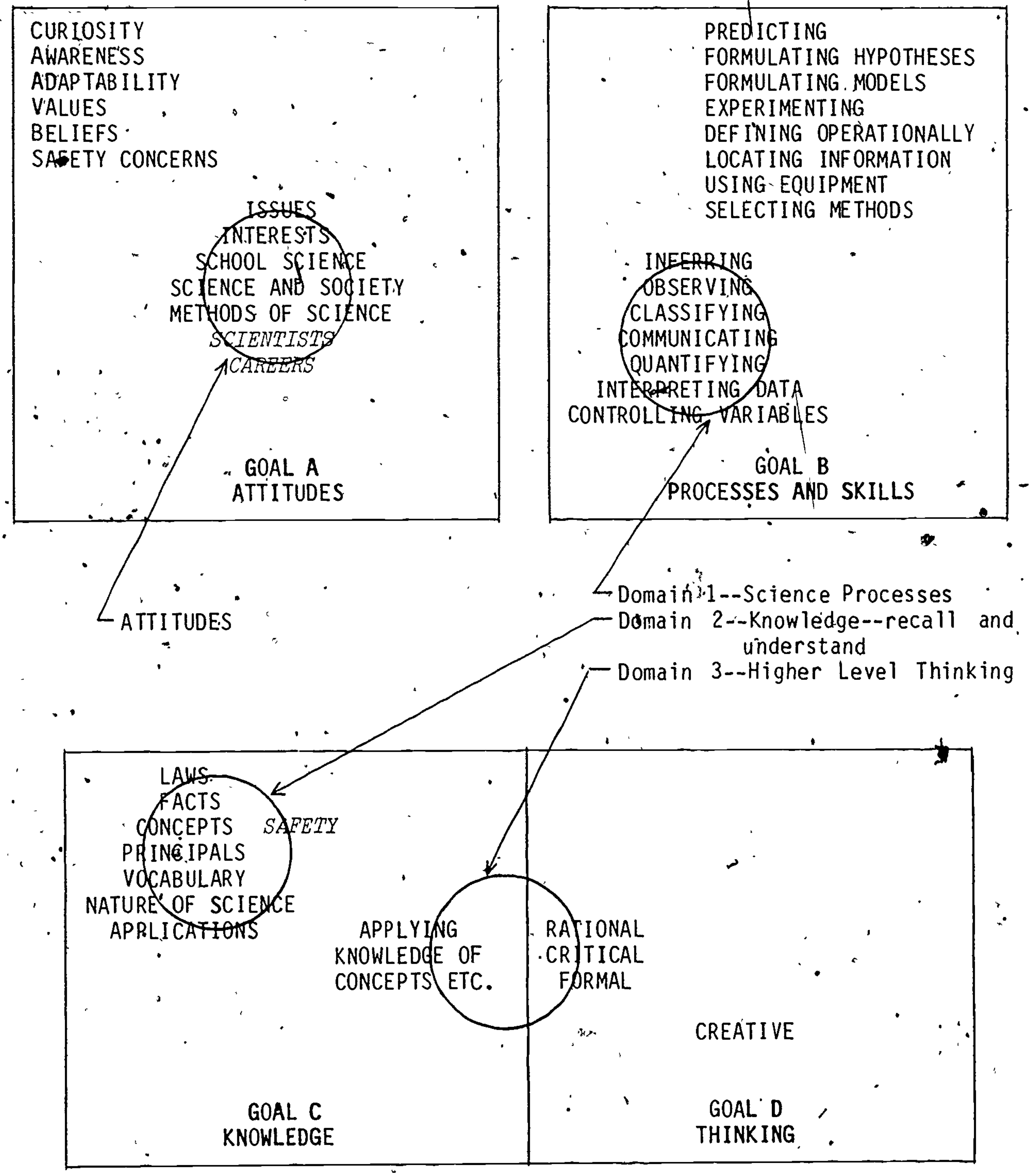


Figure 2. Curriculum goals and assessment domains.

- discuss some science-related activities which could be done during leisure time

- deal with problems in an open-minded manner

Using these general statements as guidelines, the Contract Team developed a number of affective scales, clusters and items. The following are brief descriptions of the scales and item clusters along with examples of both positive and negative statements used in the final forms. Most of the scales contained 10 statements. The exceptions were School Science at Grade 4 (7 items) and Science and Society (12 items).

School Science

Statements were designed to assess pupils' generalized attitude toward science as a school subject. Care was taken to eliminate references to important, but perhaps too specific, types of activities that may have confounded the interpretation of the scale. Therefore, activities such as enjoying science laboratory work, going on science field trips, or taking pride in doing careful work in science were not considered appropriate references in a scale designed to measure science as an interesting and valuable school subject.

Examples:
I like to study science in school.
I do not enjoy science.

Science Careers

An attempt was made to develop a questionnaire that would measure willingness to enter a career in the field of science.

Examples:
A career in science would be very satisfying.
Scientific work does not interest me.

Scientists

Scientists, of course, differ as much in their abilities and personal characteristics as do members of any other professional group. Therefore, as a concept, "Scientists" cannot be considered unique and one would expect to encounter great difficulty in developing a unidimensional scale. However, allowing for this limitation, it was decided to repeat some of the statements from the 1978 B.C. Science Assessment and develop a scale related to generalized affective reactions to scientists.

Examples:
Scientists have been very helpful to mankind.
Scientists are usually odd compared with most people I know.

Science and Society This scale was developed to measure a broad area that includes the interrelationships and interdependencies of science, technology and society.

Examples:
Scientific progress and the progress of man go together.
Science is not important in everyday life.

Methods of Science Literature in science education shows that the attitudinal target entitled "Methods of Science" is extremely complex. Therefore, this scale was developed to assess a variety of cognitive and affective components related to scientific knowledge, the processes of scientific inquiry and the nature of scientific inquiry.

Examples:
Science is getting closer and closer to the truth.
When traditional beliefs are in conflict with scientific discoveries, it is better to accept traditional beliefs.

Interest in Science Topics Three topics were chosen in the areas of physical science, biological science, earth/space science and technology for pupils in grades 4 and 8 to respond to in terms of how interested they were in learning about the topic. Different topics based on the content of the elementary and junior secondary science curriculum guides were used at the two grade levels.

Examples:

Grade 4	How animals live	(Biological)
	The moon and stars	(Earth/Space)
Grade 8	Chemicals in foods	(Physical)
	How computers work	(Technology)

Specific Issues This item cluster dealt with opinions about areas such as conservation, pollution, animal experimentation, creation of life and the use of herbicides/insecticides. Ten equivalent statements were used at both grade 8 and grade 10/12.

Examples:
Factories should be required to reduce smoke pollution even if prices go up.
Scientists should conduct experiments on animals if they think people will be helped.

Affective results were calculated in the following manner: For each scale, a pupil's raw score was determined by summing the weighted scores of all the items. Responses were weighted 1 if a pupil chose "Strongly Disagree" to 5 if the choice was "Strongly Agree" for a positively worded statement. Negative statements were weighted in the opposite direction. The sum of the weighted responses was then divided by the number of items. Thus, individual mean scores ranged from 1 to 5. A frequency distribution was made of the mean scores, and they were then divided into the five categories on the basis of the following equal interval classification scheme:

Classification	Mean Score Range
Strongly Negative	1.00 - 1.80
Negative	1.81 - 2.60
Neutral	2.61 - 3.40
Positive	3.41 - 4.20
Strongly Positive	4.21 - 5.00

The proportions of pupils obtaining scores within these intervals are reported as percentages in Table 2.1. The table shows that, on all scales, the proportion of pupils responding positively was greater than the proportion responding negatively, and we may thus conclude that pupils at all grade levels have positive attitudes toward most of the attitudinal objects. However, there is an exception, in that pupils in Grade 8, 10 and 12 definitely do not demonstrate a high interest in pursuing a career in science. In fact, mean scores here were the lowest obtained on the attitude scales. These results are unfortunate in view of the probable increased need for scientifically talented personnel in our future work force.

The results of the School Science scale show a slight increase in negative affect at the upper grades along with an increase in the proportions within the neutral category. At these age levels, pupils are beginning to clarify their vocational goals and to opt for major study in areas other than science.

A Potpourri of Attitudes, Interests and Opinions

Grade 4

- About 80% of the pupils feel that the study of science in school is important
- Boys like Physical Science and Technology topics
- Girls like Biology topics

Grade 8

- Sixty-seven percent of the boys and 59% of the girls like to study science
- Sixty percent of the girls and 47% of the boys agree that, or are undecided as to whether or not, the planets determine one's success or failure in life!
- Only 19% of the pupils would be willing to enter a scientific career
- Sixty percent of the pupils (males = 71%, females = 48%) are very interested in learning how to work computers

Table 2.1: Summary of Affective Scale Results by Grade (Percentages)

Affective Scale	Grade	Classification				
		Strongly Negative	Negative	Neutral	Positive	Strongly Positive
School Science	4	2.2	9.4	17.0	42.5	28.7
	8	1.7	9.1	26.0	49.0	14.2
	10	2.0	10.8	28.5	45.5	13.2
	12	2.3	12.8	30.8	42.5	11.5
Scientists	8	0.2	1.8	24.2	65.1	8.6
	10	0.3	2.2	28.2	63.0	6.1
	12	0.1	2.1	30.5	61.6	5.5
Science and Society	8	0.3	4.0	28.2	57.7	9.6
	10	0.1	3.0	23.1	63.2	10.3
	12	0.2	2.2	22.2	62.5	12.7
Careers in Science	8	3.6	19.9	36.2	32.4	7.7
	10	6.3	22.8	34.6	28.5	7.6
	12	5.1	22.6	35.6	27.7	8.8
Methods of Science	10	0.0	1.0	27.8	67.0	4.1
	12	0.0	0.9	31.0	64.3	3.6

Grades 10 and 12

- Boys to a greater extent than girls claim to use scientific ideas or facts in their everyday lives
- Only 18% of the pupils in Grade 10 and 21% in Grade 12 would be satisfied to spend their lives as scientists
- Boys have considerably more faith in technology than do girls
- Pupils are overwhelmingly in favour of conserving energy, but are not in favour of having highway speed limits reduced
- Pupils are equally pro, con, and undecided on supporting research related to genetic engineering

2.3 Science Pupils: Achievement

Three assessment forms (X, Y, and Z), each containing different achievement items, were administered at Grades 4 and 8, and two forms (X and Y) were administered at Grade 12. A total of over 80 000 pupils wrote the various assessment forms. The actual numbers of pupils involved are shown in Table 2.2.

Table 2.2: Pupil Participation in the Assessment

Grade	Form			Total
	X	Y	Z	
4	9 330	9 310	9 304	27 944
8	9 917	9 917	9 865	29 699
10	986	1 004	-	1 990
12	11 063	11 047	-	22 110

Table 2.3 shows the total number of items associated with the various domains and objectives within each of the three main grade levels.

Three Interpretation Panels, one for each of grades 4, 8, and 12, judged the provincial achievement data and rated the item, objective, and domain results using the following five-point scale:

Strong	--	ST
Very Satisfactory	--	VS
Satisfactory	--	S
Marginal	--	M
Weak	--	W

The panels consisted of informed individuals who based their judgements upon the expected difficulty of the items, item importance, and the pupils' actual performance. The following three sections present summaries of the Interpretation Panels' ratings.

2.3.1 Domain 1--Science Processes

One of the goals of science education is to develop pupils' abilities to use the processes of science, that is, pupils should develop scientific intellectual skills. The curriculum guides list twelve such processes but only the six deemed most important and easily measurable were used in the 1982 Assessment. Table 2.4 summarizes the pupils' performance and the Interpretation Panels' ratings for Domain 1--Science Processes at the three grade levels assessed.

In the Contract Team's opinion, the overall performance of pupils in this domain was disappointing although performance was actually considered stronger by the Interpretation Panel than performance in the other domains.

The Elementary Science Curriculum Guide divides scientific processes into basic and integrated processes. At the primary level, only the basic processes are emphasized.

Table 2.3: Number of Items Used Within the Domains and Objectives at Each Grade Level

DOMAIN/OBJECTIVE	Grade 4	Grade 8	Grade 12
DOMAIN 1--Science Processes	60	36	22
Objective:			
Observe and Infer	18	--	--
Classify	18	9	--
Communicate	18	9	--
Quantify	6	--	--
Interpret Data	--	9	10
Identify and Control Variables	--	9	12
DOMAIN 2--Knowledge--recall and understand	33	57	30
Objective:			
Biological, Physical and Earth/Space Concepts	18	33	16
Applications of Science (Technology) and the Nature of Science	6	12	6
Safety Procedures	9	12	6
DOMAIN 3--Higher Level Thinking	15	27	18
Objective:			
Apply Biological, Physical and Earth/Space Concepts	9	15	--
Use Rational and Critical Thinking	6	12	--
Evaluate Evidence for Conclusions	--	--	6
Solve Abstract Problems	--	--	12
Total Number of Items	108	120	70

Table 2.4: Domain 1--Science Processes: Results and Panel Ratings

Grade/Objective	Number of Items Rated by Panel in Each Category						Mean Percent Correct		Overall Rating	
	W	M	S	VS	ST	Total	Obj.	Domain	Obj.	Domain
Grade 4										
Observe and Infer	2	2	2	8	4	18	74.5		VS	
Classify	1	5	6	5	1	18	65.3		S	
Communicate	3	8	3	3	1	18	55.9		M	
Quantify	0	4	2	0	0	6	60.4		M	
								64.8		S
Grade 8										
Classify	1	1	2	3	2	9	66.6		VS	
Communicate	0	2	2	3	2	9	66.3		VS	
Interpret Data	1	1	4	2	1	9	55.9		S	
Identify and Control Variables	2	4	2	1	0	9	45.2		W	
								58.5		No Rating Given
Grade 12										
Interpret Data	1	5	2	2	0	10	53.0		M	
Identify and Control Variables	1	4	6	0	1	12	56.8		S	
								55.1		M

At Grade 4, the Interpretation Panel concluded that students were learning to use the basic processes to a satisfactory level, although there was concern about the objectives of communication and quantification.

At Grade 8, the Interpretation Panel rated the two basic processes as "Very Satisfactory", but felt that, although performance on the integrated process, Interpret Data, was "Satisfactory", pupils showed "Weak" performance on Identify and Control Variables.

The latter two integrated processes were assessed at Grade 12. The Interpretation Panel rated performance for interpreting data as "Marginal" and for identifying and controlling variables as "Satisfactory". The Grade 12 panel was disappointed with pupils' overall performance in the process domain.

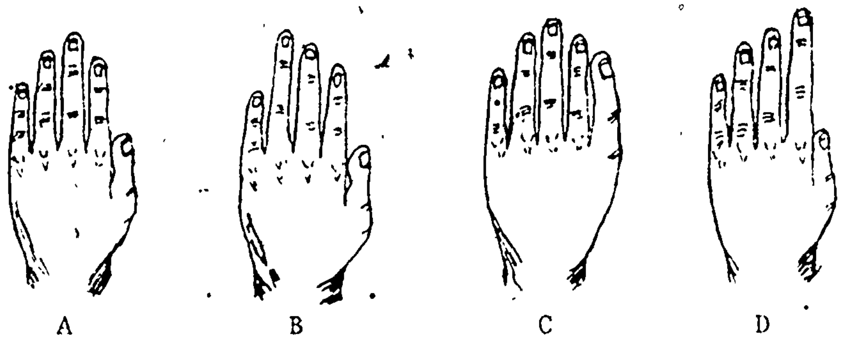
Observe and Infer

Observation is the basic skill of science and pupils must develop some facility as observers if they are to develop the other processes. The Assessment format severely restricted the range of observation skills which could be measured. Only question Z20 from the Grade 4 test, illustrated below, escaped the limitation that observations be made on drawings rather than on real objects.

It was still possible, at the Grade 4 level, to ask questions about similarities, differences, symmetry, relative shapes and sizes, collection of observations, and which observations are actually relevant. Grade 4 pupils did well on this objective.

Grade 4--Z20

Look at your left hand. Which diagram below is most like your hand?



A.	90*
B.	2
C.	4
D.	2
I don't know	2

* correct response

Classify

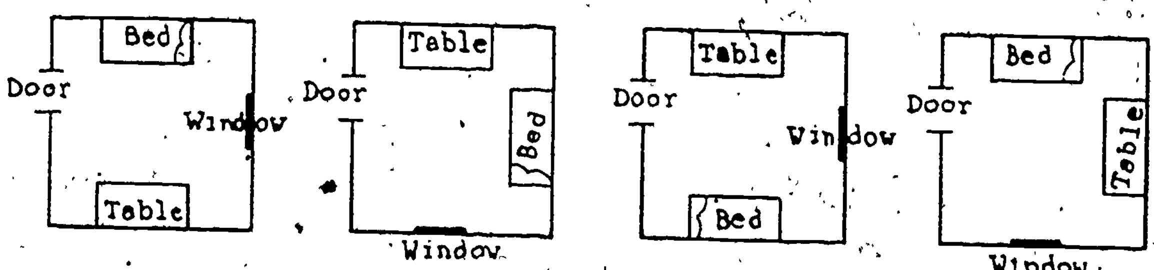
Questions on classification skills were asked at both Grade 4 and Grade 8. A few of the same questions were used at each grade. Some of the Grade 8 questions probed considerably more advanced skills than those at Grade 4. It was not possible to give pupils specimens to classify or to have them construct their own classification systems. Drawings, diagrams, or memories of familiar objects had to be used. It was possible to measure a range of skills such as matching by attributes, deleting the least similar from a set, placing new objects in the best set, using classification charts, recognizing the basis for sorting, using dichotomous keys, and recognizing and applying a class rule. Often, this last skill was measured by constructing imaginary creatures, but question X29 expected pupils to recognize, from pictures copied from a well-known British Columbia flower book, that the sepals and petals of lilies total six. Grade 8 pupils found this item more difficult than most of the items for this objective. Overall, Grade 8 pupils achieved very well on classification skills.

Communicate

Pupils receive and construct communications in science in many ways: the spoken word, written prose, pictures, diagrams, maps, symbols, charts, tables and graphs. Only the understanding of a communication could be measured in the assessment. Questions were asked to assess this objective at both Grade 4 and Grade 8 but there was only one item which was used at both levels. The Grade 4 Interpretation Panel expressed concern about students' performance and, in particular, felt that graph-using skills were under-developed. The Grade 8 Interpretation Panel felt communication skills were well-developed. The common item is illustrated below and shows substantial growth between Grade 4 and Grade 8 in ability to understand a written description.

Grade 4--Z31 Grade 8--Z22

A girl enters a room. There is a bed along the wall to her LEFT, a window in the wall in FRONT of her and a table along the wall to her RIGHT. Which of the rooms did she enter?



A.   B   C   D

	Grade 4	Grade 8
A.	57*	87*
B.	7	1
C.	12	6
D.	14	5
I don't know	7	1

* correct response

Quantify

While quantification as a science process includes counting and estimating, the majority of important quantification skills involve metric measurement. Although this is an exceedingly important skill in science, it was decided not to stress this process in the 1982 Science Assessment, but to use only six questions at Grade 4. This decision was made because this process was stressed in the 1981

Mathematics Assessment where pupil performance received "Marginal" ratings at both Grade 4 and Grade 8. The Science Assessment Interpretation Panel's "Marginal" rating of quantifying at Grade 4 was consistent with the Mathematics Assessment findings. Together, the Assessments identify an important area which must be of concern to teachers.

Interpret Data

In science classes, it is usual to require students to interpret data by generating conclusions from data which they have previously collected. In contrast, the Assessment data had to be presented in concise forms. Students then selected from alternative interpretations. Questions were also asked about some general problems concerning the use of data, for example, the need to replicate data in experiments. This objective was measured at both the Grade 8 and Grade 12 levels; all data used at the Grade 12 level were quantitative. There was significant growth from the Grade 8 to the Grade 12 level on the two common items, one of which is shown below.

Grade 8--Y08 Grade 12--Y11

The treeline is the highest altitude at which trees can grow. The following table relates treeline to distance from the equator.

Distance from Equator	Treeline
1000 km	4000 m
2500 km	3500 m
5000 km	3000 m
6500 km	1500 m

According to the table above, the farther you are from the equator

	Grade 8	Grade 12
the higher the treeline.	12	5
the lower the treeline.	63*	79*
the taller the trees.	4	2
the smaller the trees.	11	9
I don't know.	9	5

* correct response

27

Identify and Control Variables

Central to experimentation is the identification of suitable variables whose values can change (independent), that can be observed (dependent or responding), or that can be controlled. Since experimentation is one method which is uniquely scientific, this process is considered to be of great importance in science teaching. Upper grade elementary school pupils should have encountered situations requiring them to think about the variables involved in an experiment. The frequent use of the "I don't know" response by Grade 8 pupils indicates an unexpected and disturbing degree of unfamiliarity with this process. While the Panel rated performance on this process "Satisfactory" at the Grade 12 level, it indicated that it actually had higher expectations for student performance. A fairly typical question for this objective is the one below which was used at the Grade 12 level. Its difficulty was nearly average for the objective, yet it is hard to see how approximately one-fourth of the students chose option B when the stem of the question clearly states that two kinds of cloth were used. The concept of holding a variable constant seems poorly understood by many students.

Grade 12--X16

Which variable below must be held constant if you want to find out which of two kinds of cloth absorbs water better?

The length of time the cloths are in water	58*
The kind of cloth	22
The colour of the cloth	1
The height that the water rises in each cloth	14
I don't know	4

* correct response

2.3.2 Domain 2--Knowledge--recall and understand

The Elementary Science Curriculum Guide Grades 1-7 (1981) Goal C states the following:

The Elementary School Science Program should develop in students scientific knowledge.

The student should demonstrate and apply knowledge of the following:

- facts, generalizations, concepts, principles, and laws;
- scientific vocabulary;
- relationships between various scientific disciplines;
- the history, philosophy, and nature of science;
- the application and limitations of science in the practical world. (page 9)

While the proposed junior science program amplifies some of these areas of knowledge, it follows the same outline. The knowledge domain, as developed for the assessment, added a component on knowledge of safety procedures and it assessed the ability to apply facts, generalizations, concepts, principles and laws in the higher thinking domain (see Figure 2).

Table 2.5 summarizes pupil performance and the Interpretation Panels' ratings in the knowledge domain.

Table 2.5: Domain 2--Knowledge--recall and understand: Results and Panel Ratings

Grade/Objective	Number of Items Rated by Panel in Each Category						Mean Percent Correct		Overall Rating	
	W	M	S	VS	ST	Total	Obj.	Domain	Obj.	Domain
Grade 4										
Biological, Physical and Earth/Space Concepts	1	9	6	2	0	18	54.8		M	
Applications of Science (Technology) and the Nature of Science	0	1	3	2	0	6	66.8		S	
Safety Procedures	3	1	3	1	1	9	68.8		M	
								60.8		M
Grade 8										
Biological, Physical and Earth/Space Concepts	6	8	13	6	0	33	53.1		S	
Applications of Science (Technology) and the Nature of Science	1	8	3	0	0	12	49.8		M	
Safety Procedures	2	5	5	0	0	12	65.6		W	
								55.1		No Rating Given
Grade 12										
Biological, Physical and Earth/Space Concepts	0	6	9	1	0	16	52.4		M	
Applications of Science (Technology) and the Nature of Science	0	2	3	1	0	6	59.6		S	
Safety Procedures	2	4	2	0	0	8	55.6		M	
								54.6		M

Two of the three Interpretation Panels independently judged pupil performance in this domain as "Marginal". It is noted that two of the three "Satisfactory" ratings given were for objectives which had very few items.

Biological, Physical and Earth/Space Concepts

In this objective, an attempt was made to evaluate pupils' knowledge of basic vocabulary, facts, generalizations, concepts, principles and laws. Questions were at the level of recall or comprehension. At all three grade levels, many of the questions asked were change items (repeated from the 1978 Assessment). Since there is scope for different curriculum choices in the elementary grades, any new question used at the Grade 4 or 8 level had to relate to a topic in at least two of the three major programs. The following question is typical of a knowledge item used at both Grade 4 and Grade 8.

Grade 4--Y14 Grade 8--X37

Seeds come from which one of the following parts of a plant?

	Grade 4	Grade 8
Bark	**	4
Flower	50*	70*
Leaf	5	7
Root	30	8
Stem	9	6
I don't know	6	5

* correct response
** At Grade 4 the option "Bark" was not included.

The Grade 4 item has one less distractor than the Grade 8 item since there was a need to keep the reading level appropriate at Grade 4. Note too the improvement in the number of pupils selecting the correct option, from 50% at Grade 4 to 70% at Grade 8. Even so, considering pupils' contacts with plants both inside and outside of school, it is surprising that more than one-fourth of the Grade 8 pupils were unable to choose the correct answer. This question was also asked at both grade levels in the 1978 Assessment with very similar results.

The following item was used at both Grade 8 and Grade 12. It also was repeated from the 1978 Assessment.

Grade 8--X31 Grade 12--Y18

Green plants are important to animals because the plants

	Grade 8	Grade 12
consume both food and oxygen.	16	7
consume food and give off oxygen.	15	5
consume food and give off carbon dioxide.	8	4
produce food and give off oxygen.	43*	64*
produce food and give off carbon dioxide.	11	5
I don't know.	6	5

*correct response

Again, there is significant growth from Grade 8 to 12. The 1978 results were very similar: 1% higher in Grade 12, 2% lower in Grade 8. It is disappointing, however, that more than one-third of the pupils about to graduate from secondary school failed to understand the photosynthetic relationship which is the energy basis for almost all life on earth. The question also illustrates the typical male-female differences on knowledge items, although the sex-related difference here is larger than normal. At Grade 12 on this item, the mean percent correct for boys was 71 and for girls 57. At Grade 8, the mean percent correct for the boys was 49 and girls 38.

It was only at Grade 8 that the Interpretation Panel judged the performance of pupils to be "Satisfactory" in knowledge of science concepts. At Grade 4, although assessment of processes was stressed, the low scores are possibly the result of primary teachers often giving insufficient time to teaching science. The Grade 12 Panel strongly stressed that students showed an "inadequacy of knowledge". At both Grade 8 and 12, achievement in earth/space sciences was below that in the other science content areas.

Applications of Science (Technology) and the Nature of Science

Science and society interact in many ways. For instance, science has affected society enormously by creating many technological changes. The pupils' knowledge of these applications was assessed in the knowledge domain of the 1982 Assessment. Another way in which science has affected society is by providing a set of modes and criteria for thinking. In the 1978 Assessment, this subobjective was called Scientific Literacy. Knowledge of thinking modes was combined with knowledge of applications to produce a 1982 Assessment objective.

Note that only a small number of items was used to assess this objective at Grades 4 and 12, and the knowledge displayed by students was judged to be "Satisfactory". At Grade 8, where a substantial number of items were used, the results were judged to be "Marginal". The Interpretation Panels at both Grades 8 and 12 felt that the applications of science were insufficiently stressed in most teaching.

Question Y35, reproduced below, is one item used to test knowledge of applications at Grade 8. It illustrates an interesting point about the application of science in medicine in that a successful technique may soon make obscure the disease against which it operates. Some Interpretation Panel members felt that, in this case, pupils may not have known about polio. This explanation may partially account for the choice of the second option by many pupils.

Grade 8--Y35

Today, almost no one gets polio because

bad water, which used to cause polio, has been cleaned up. . .	3
doctors have found new drugs which cure polio.	18
people eat better food and get more exercise to stay healthy.	8
people are given a vaccine which keeps them from getting polio.	63*
I don't know.	6

* correct response

Grade 8 Item X30 was designed to measure knowledge of the nature of science. The pupils' responses suggest that most have not yet learned clear distinctions between different kinds of scientific statements. Another item, Grade 8 Item X12, asked pupils to differentiate between a theoretical and observational statement and produced only a 52% correct response at Grade 8. Even at Grade 12, one-third of the students were unable to make this distinction on a similar question.

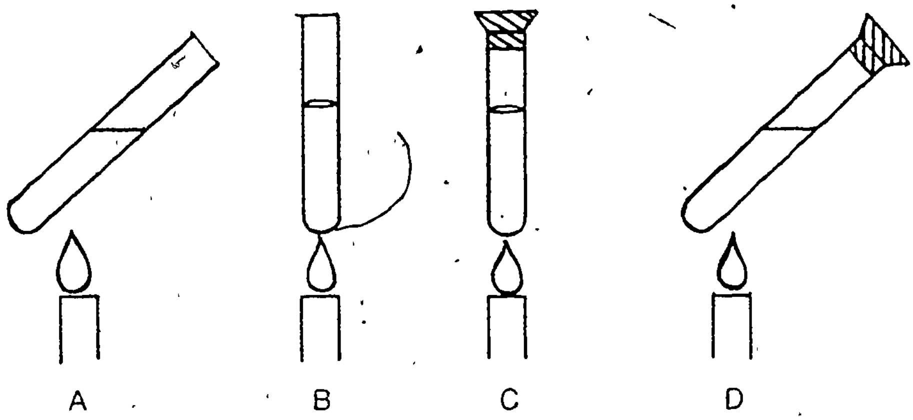
Safety Procedures

Questions on the knowledge of safety procedures were of two types. Most of the items asked pupils to choose the safe procedure from a set of options. A few items asked what the hazard was in a particular situation. The Interpretation Panels at all three grade levels had very high expectations for pupils' knowledge about safety, and the relatively high mean percents correct at Grades 4 and 8 were still not considered adequate. All three panels judged the results on this objective to be "Marginal" or "Weak". Recommendations regarding steps to improve safety and pupils' knowledge of safe procedures are prominent in the last chapter of this report.

A typical safety item, used at both Grade 8 and 12, follows.

Grade 8--Z34 Grade 12--Y16

Look at the diagrams below.



Which is the correct method of heating a liquid in a test tube?

	Grade 8	Grade 12
A	32*	67*
B	45	13
C	10	4
D	10	13
I don't know	2	3

* correct response

It is encouraging to note that the percentage of correct responses to this question more than doubles from Grade 8 to 12. It is discouraging that one-third of the Grade 12 pupils chose incorrect options although all of them must have heated test tubes of liquid in junior secondary schools. An obvious conclusion is that teachers in all grades need to focus more attention on teaching safety in science.

2.3.3. Domain 3--Higher Level Thinking

At the Grade 4 and 8 levels, this domain consisted of two objectives: the application of scientific knowledge to new situations and the use of critical, rational, and formal thinking. As far as possible, these objectives adhered to the definitions in the curriculum guides. At the Grade 12 level, the two objectives used were given descriptive terms. Table 2.6 summarizes the pupils' performance and the Panel ratings for the Higher Level Thinking domain.

Table 2.6: Domain 3--Higher Level Thinking: Results and Panel Ratings

Grade/Objective	Number of Items Rated by Panel in Each Category						Mean Percent Correct		Overall Rating	
	W	M	S	VS	ST	Total	Obj.	Domain	Obj.	Domain
Grade 4										
Apply Biological, Physical and Earth/Space Concepts	1	3	3	0	2	9	57.5		S	
Use Rational and Critical Thinking	0	0	3	3	0	6	71.7		VS	
								63.2		S
Grade 8										
Apply Biological, Physical and Earth/Space Concepts	1	5	5	4	0	15	49.7		S	
Use Rational and Critical Thinking	3	3	4	2	0	12	45.9		M	
								48.0		M-S
Grade 12										
Evaluate Evidence for Conclusions	1	2	2	0	1	6	58.3		M	
Solve Abstract Problems	2	4	6	0	0	12	44.7		M	
								49.2		M

Because of their age and experience, Grade 4 pupils were expected to have limited ability in higher level thinking. Their performance was pleasantly surprising.

At the Grade 8 level, pupils were judged able to apply knowledge at a "Satisfactory" level but were judged "Marginal" on Use Rational and Critical Thinking. The Panel stated that teachers need in-service training in teaching both process and critical thinking skills.

For this domain, the performance of Grade 12 students was deemed to be "Marginal" and much concern was expressed becuase of the importance of thinking at higher levels in out-of-school situations. Teacher-made tests were criticized by the Interpretation Panels for their frequent failure to require higher level thinking.

Apply Biological, Physical and Earth/Space Concepts

Application is the ability to recognize appropriate principles or concepts and to use them in new situations. To correctly answer a question at the application level, a pupil must possess the requisite knowledge and then use it correctly. However, the problem situations used in an Assessment question may not have been new to some pupils and some pupils may, therefore, have been able to answer on the basis of knowledge alone. The Grade 8 question (Y37) illustrates these points. In order to answer this question at the application level, pupils needed to know the forms of energy and to have some basic ideas of how a car engine works. It is possible, but not likely, that pupils had encountered this situation previously, and therefore recalled the correct answer.

Grade 8--Y37

Which of the following is described by this sequence of energy changes?

Chemical Energy ——> Heat energy ——> Mechanical energy (with wasted heat)

A flashlight is turned on.	9
A candle is burned.	9
Gasoline is burned to power a car.	46*
Electric current is used to run a refrigerator.	16
I don't know.	19

* correct response

Use Rational and Critical Thinking

To think rationally is to seek natural causes for events. To think critically is to evaluate statements for bias or assumptions, for logical coherence, and for congruence with adequate data bases or with other statements. It also includes drawing the best conclusions possible from inadequate data. Even at the Grade 4 level, it was possible to construct valid questions to sample this objective. Question Y17 asked Grade 4 pupils to identify the point of view (bias) of the person who wrote the given selection. It also illustrates a problem in assessing this objective: the need to provide pupils with adequate information on which to base their thinking:

Read the following and then answer questions 16 and 17.

Trash causes problems. It pollutes air, water, and soil. Trash can harm people by making them sick. Sometimes, rats live in trash.

Cleaning up litter costs a lot of money. Cities and provinces have to hire people to pick up trash after games and picnics. If people make too much trash in years to come, what will happen? What can people do about it right away?

Grade 4--Y17

The person who wrote this probably wants

bigger garbage dumps made	7
more people hired to pick up garbage	20
people to make less garbage	66*
someone to kill rats	4
I don't know	4

* correct response

Solve Abstract Problems

This objective, used at the Grade 12 level, consisted entirely of questions repeated from the 1978 Assessment. One such example is Question Y10.

Grade 12--Y10

A man whose blood type is OA marries a woman whose blood type is OB. Their offspring could not have which of the following blood types?

AA	50*
AB	10
OA	2
OB	2
OO	15
I don't know	19

* correct response

2.3.4 Achievement By Grades

Table 2.7 summarizes the Interpretation Panel ratings referred to in earlier sections.

Table 2.7: Summary of Interpretation Panel Ratings of Pupil Achievement by Grade and Objective

DOMAIN/OBJECTIVE	Grade 4	Grade 8	Grade 12
DOMAIN 1--Science Processes	S	No Rating*	M
Objective:			
Observe and Infer	VS	--	--
Classify	S	VS	--
Communicate	M	VS	--
Quantify	M	--	--
Interpret Data	--	S	M
Identify and Control Variables	--	W	S
DOMAIN 2--Knowledge--recall and understand	M	No Rating*	M
Objective:			
Biological, Physical and Earth/Space Concepts	M	S	M
Applications of Science (Technology) and the Nature of Science	S	M	S
Safety Procedures	M	W	M
DOMAIN 3--Higher Level Thinking	S	M-S	M
Objective:			
Apply Biological, Physical and Earth/Space Concepts	S	S	--
Use Rational and Critical Thinking	VS	M	--
Evaluate Evidence for Conclusions	--	--	M
Solve Abstract Problems	--	--	M

* The Grade 8 Interpretation Panel felt that variability of performance within this domain was too great for a single rating to be meaningful.

Grade Four

The Grade 4 Assessment forms stressed four science processes. Pupils achieved well on questions relating to observation and classification but only marginally on questions relating to communication in science and to quantification.

Although the Assessment gave less stress to measurement in the knowledge domain, the results of pupil achievement in knowledge of basic science concepts were found to be disappointing.

For the level of knowledge which they possess, the Grade 4 pupils were judged to be able to apply it satisfactorily and able to employ the skills of critical thinking that were measured.

The overall picture from the Grade 4 results is that pupils are learning certain basic science processes well, that knowledge of concepts may be underemphasized, and that higher level thinking is being adequatedly developed. As will be shown in Chapter 3, the amount of time given to science in the primary grades seems to be inadequate for doing the job well, and many teachers are not using as much time as recommended by the Ministry for science teaching.

Grade 8

The Interpretation Panel ratings for the objectives in Grade 8 were more variable than those in the other grades, and therefore the Panel could not give meaningful domain ratings in two of the three domains.

Pupil achievement was considered to be very good in the two basic processes of classification and communication which are stressed in the primary grades and further developed in the intermediate years. On the two integrated processes assessed, pupils were judged "Satisfactory" in interpreting data but "Weak" in identification and control of variables.

The Assessment explored knowledge of science concepts quite extensively at Grade 8, and found that pupils had a satisfactory knowledge of elementary science facts and concepts, with the exception that knowledge in earth science seemed weaker than in other areas. However, knowledge of the uses of science and of the nature of science was only "Marginal".

The overall picture from the Grade 8 Assessment is that pupils are leaving elementary school with an adequate knowledge of basic science concepts, with an ability to apply this knowledge in simple situations, and with well-developed skills in at least some basic processes. However, they have inadequate knowledge of the nature and utility of science, and they show less than satisfactory ability in scientific reasoning.

Grade 12

The Interpretation Panel judged achievement in all three domains at the Grade 12 level as "Marginal", and gave the same rating to five of the seven objectives.

In the Science Processes domain, pupils' performance on the questions relating to the identification and control of variables was rated as "Satisfactory". The ability of Grade 12 pupils to interpret data from graphs and tables was judged to be "Marginal". Since these two processes are vital to scientific thinking, it is disappointing that the results are not higher for pupils so near the end of their public schooling.

Pupils' knowledge of scientific concepts was also judged "Marginal", as was their knowledge of safety procedures. The only "Satisfactory" rating in the knowledge domain was for Applications of Science (Technology) and the Nature of Science.

In the Higher Level Thinking domain, where pupils were required to apply scientific knowledge to new situations or to select appropriate conclusions based on data, the results were judged "Marginal".

The overall picture from the Grade 12 Assessment is discouraging. In no areas assessed could it be said that pupils were achieving well. A substantial number of Grade 12 pupils had completed, or were about to complete, their last formal course in science. It is disheartening, therefore, to learn that many secondary school graduates do not have adequate knowledge of basic science concepts, cannot use some of the central processes of science adequately, and do not apply scientific knowledge well.

The Contract Team hopes that appropriate implementation, including extensive in-service, of the revised junior secondary science curriculum will do much to remedy this situation.

2.3.5 Comparisons with 1978

Because of differences in procedures in administering the achievement forms at the Grade 4 level, direct comparisons between 1978 and 1982 cannot be made. When judgements of the Interpretation Panels of the two Assessments are compared, one finds that, in 1978, there was overall satisfaction with the success of the primary program, but, in 1982, there are now a number of concerns as well as areas of strength.

The overall performance of Grade 8 pupils in 1982 was very similar to that in 1978 on Assessment questions which were repeated, and, on these, the 1982 Interpretation Panels' ratings were similar to those in 1978. The areas in which change was assessed were given "Satisfactory" ratings. The areas of Grade 8 weakness in 1982 that caused concern are areas which were not explored in 1978. Table 2.8 summarizes the change domains for Grades 8 and 12.

Table 2.8: Pupil Performance on Change Domains, 1978 and 1982

Grade/Domain	Number of Items	1978 Mean Percent Correct	1982 Mean Percent Correct
Grade 8			
Processes	9	55.9	56.0
Knowledge	15	55.2	56.7
Grade 12			
Knowledge	15	54.3	52.4
Higher Level Thinking	12	46.6	44.6

The overall performance of Grade 12 pupils in 1982 was approximately two percent below that of 1978 on the items which appeared in both Assessments. The overall 1982 Panel ratings were higher than those of 1978 but still indicated weaknesses in pupil achievement. It would be fair to say that, while the 1982 Panel had lower expectations than the 1978 Panel for Grade 12 performance, Grade 12 pupils are falling below these expectations.

2.3.6 Sex-Related Differences in Achievement

Table 2.9 shows the differences in achievement between boys and girls on samples of approximately 10% of those who wrote the achievement instruments. The table includes a sample of Grade 10 students as well as Grades 4, 8, and 12.

The outstanding finding of the analysis of achievement results by sex was that there is a significant and substantial difference in knowledge of science concepts between boys and girls, in favour of boys. This trend begins in the primary grades and persists throughout the school years. In the early elementary grades, there are small differences in favour of girls' achievement in the Science Processes, but these are erased by Grade 8, and the differences which exist at Grade 12 favour boys. However, this finding may be due to the fact that different processes were tested at different grades. Boys outperform girls wherever knowledge of scientific concepts is necessary as a prerequisite to performance (as in Higher Level Thinking at Grade 8 and Grade 12).

Table 2.9: Sex-Related Differences in Achievement

DOMAIN/OBJECTIVE	Grade 4	Grade 8	Grade 10	Grade 12
DOMAIN 1--Science Processes	G**	ns	ns	B**
Objective:				
Observe and Infer	G**	--	--	--
Classify	ns	ns	--	--
Communicate	G*	B*	--	--
Quantify	ns	--	--	--
Interpret Data	--	ns	B**	B**
Identify and Control Variables	--	G*	ns	ns
DOMAIN 2--Knowledge--recall and understand	B**	B**	B**	B**
Objective:				
Biological, Physical and Earth/Space Concepts	B**	B**	B**	B**
Applications of Science (Technology) and the Nature of Science	ns	ns	G**	G**
Safety Procedures	G**	ns	B**	B**
DOMAIN 3--Higher Level Thinking	ns	B**	B**	B**
Objective:				
Apply Biological, Physical and Earth/Space Concepts	ns	B**	--	--
Use Rational and Critical Thinking	ns	B**	--	--
Evaluate Evidence for Conclusions	--	--	B*	B**
Solve Abstract Problems	--	--	B**	B**

ns = not significant
* p < .05
** p < .01

G--Girls' mean exceeds Boys' mean
B--Boys' mean exceeds Girls' mean

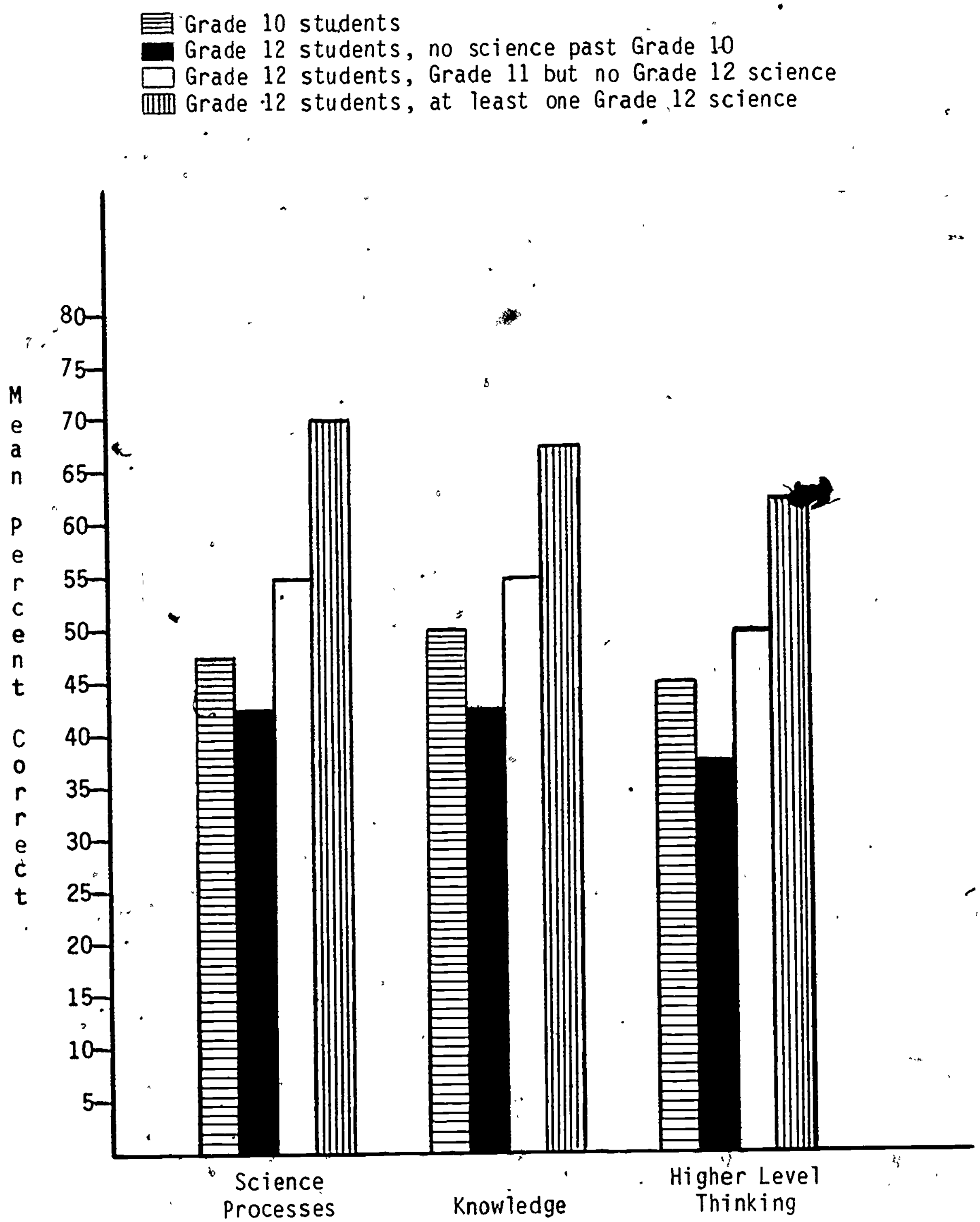
2.3.7 Differences Related to Language Background

At all grade levels, pupils who most commonly speak a language other than English had lower mean scores on all domains and objectives, and the statistically significant differences were usually substantial (between 4.2% and 9.7% on domain means). This group of pupils is being constantly replenished by immigration of non-English speakers to British Columbia while also being depleted by families moving to English as their most common language. When domain mean scores of those whose first language was not English are also examined, such mean scores lie between those who currently speak English at home and those who currently speak another language at home. The difference between these means and the means of those who now speak English at home decreases with increasing grade level. The overall picture is that failure to speak English at home is related to poorer performance in science. The size of the deficit is reduced, and perhaps eventually erased, by increasing familiarity with English acquired by learning to use it at home and by using it as the language of learning in school.

2.3.8 Other Differences

In the Grade 12 Assessment it was found, as expected, that mean performance was closely and positively related to the amount of science taken since Grade 10 and that a sample of current Grade 10 pupils had better scores than Grade 12 pupils who had taken no senior secondary science courses.

Grade 12 pupils who planned to go to university or college outperformed those who had other plans or who had not yet formulated plans. Pupils whose plans included scientific study performed much better than those who planned further study in non-scientific areas. Figure 3 shows Grade 12 pupil achievement in relation to the number of science courses taken in the senior secondary grades.


Grade 10 students
Grade 12 students, no science past Grade 10
Grade 12 students, Grade 11 but no Grade 12 science
Grade 12 students, at least one Grade 12 science
Mean Percent Correct
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Science Processes
Knowledge
Higher Level Thinking

CHAPTER 3

SCIENCE TEACHERS: BACKGROUNDS AND OPINIONS

In order to identify the current context of science teaching in British Columbia, to document current classroom practices and to assess changes since the British Columbia Science Assessment 1978, responses were sought from teachers of science through the use of questionnaires. The questionnaires, one for elementary and one for secondary teachers, were modifications of the ones used in 1978. After a brief description of the teacher samples, this chapter presents a summary of the major findings from the questionaires which are detailed in Chapters 6 and 7 of the 1982 British Columbia Science Assessment: General Report.

Samples of teachers were selected to participate in the Assessment. Excluded were all principals, vice-principals, school district staff, and any teacher who had been previously selected to answer a Science Council of Canada Science Education Survey questionnaire. A total of 1322 elementary and 529 secondary teachers completed the questionnaires. These totals represented a return rate of over 80%. The samples were considered representative of the science teaching population in British Columbia.

3.1 Teacher Characteristics: Age, Gender, and Teaching Experience

Since the 1978 Assessment, the median ages of teachers from all school levels have increased by about two years. Similarly, the medians of teaching experiences have also increased by about two years. In 1982, the median experience was 10 years for both elementary and junior secondary teachers and 13 years for senior secondary teachers. British Columbia science teachers are thus an aging population and are becoming more distant in time from their pre-service training.

At all levels, the mean age of females is less than that of males. Females tend to drop out of teaching for periods of time with many returning to teaching at the elementary level but rarely at the secondary level. There is a failure at the secondary level both to recruit young women and to retain most of those few women who start out teaching science.

At the secondary levels, both in 1978 and 1982, the majority of teachers were male. Even though there was a small increase since 1978 in the number of females at the junior secondary level, nine out of ten secondary teachers in 1982 were male. At the elementary level, there was a slight increase in the number of male teachers over the four-year period, but females still comprise 62% of the teachers. At the elementary level, males are used as science specialists to a greater extent than females, consistent with their typically more extensive science backgrounds.

3.2 Teacher Characteristics: Science Background

The science background of teachers in elementary schools is usually weak, particularly in the case of females. One-fourth of the elementary teachers have not taken as much as one 3-unit course in science at the university/college level. At the secondary level, the senior teachers have stronger backgrounds than the junior teachers. The typical junior secondary teacher is adequately prepared in the biological sciences but usually not in the physical or earth/space sciences.

Almost all senior secondary school teachers feel adequately prepared to teach science, but a small percentage of junior secondary science teachers feel unprepared, and 42% of elementary school teachers feel less than adequately prepared.

3.3 Coordination of the Science Programs

One of the strong recommendations from the 1978 Science Assessment was for increased coordination of science at the school and district levels. It appears that some progress has been made in secondary schools, but not enough has been done at the district level. Half of those responding to the questionnaire indicated no district coordination. In-school coordination at the elementary level remains inadequate.

3.4 Physical Facilities, Materials, and Equipment for Teaching Science

In 1982, there still seems to be a lack of storage and preparation facilities and suitable classrooms for teaching elementary science. At the secondary level, facilities are inadequate in many junior schools.

Provision and inspection of safety equipment are still unacceptable at both the elementary and secondary school levels. However, some improvement since 1978 is noted in secondary schools.

Elementary teachers are still experiencing difficulty with equipment and materials, particularly in terms of poor quality. The situation at the secondary level has improved somewhat since 1978, but problems remain in small junior secondary schools. Many teachers at both the elementary and junior secondary levels find that they have to adapt their teaching because of lack of equipment.

Compared to 1978, more teachers at all levels report that science reading materials are less than adequate, in both quality and quantity.

3.5 Worth of the British Columbia Science Program

While elementary and junior secondary teachers see some worth in the British Columbia science program, they fall below the senior secondary teachers in their estimations of worth, even though the senior secondary teachers have significantly lowered their ratings since 1978. The elementary and junior secondary teachers' feelings of inadequacy of preparation for teaching seem to be related to their perceptions of program worth.

3.6 Assignments in Science: Satisfaction in and Time Spent in Teaching Science

Elementary and senior secondary teachers seem to be satisfied teaching science at their present level, but the junior secondary teachers appear to be less content with their assignments, a situation similar to that in 1978. Many of the latter expressed a desire to teach at least some senior secondary courses.

Elementary teachers are generally not spending the recommended time in teaching science. This situation correlates highly with their lack of scientific background. At the secondary level, there is a strong trend toward increasing specialization in teaching science, but such a tendency is not evident at the elementary level.

3.7 The School Science Programs: Teachers' Suggestions for Improvement

Teachers at all levels expressed common suggestions for change. The three top ranked were:

- the provision of print materials other than textbooks
- background information for teachers
- provision to help exceptional pupils, both gifted and handicapped

Other highly rated suggestions included the need for more adequate reading resources, increased use of specialist science teachers in elementary schools, and the need for science programs to emphasize the impact of science on society.

3.8 Teacher Education: Pre-service

Most teachers felt that their initial preparation for teaching science was inadequate. Only 30% of the teachers believed their pre-service training was adequate or better. Even among senior secondary teachers (who rated their training more highly than other teachers), only 52% felt the initial training to have been adequate or better.

Given a list of teacher education topics, all teacher groups felt each component should receive greater emphasis than it actually did in their pre-service education. Tables 3.1 and 3.2 present teachers' ratings of what were, and what should be, major components of pre-service education for science teachers. Particular attention is called to the large discrepancy between the emphasis which should be and the time which was given to the topic of Laboratory Safety.

Table 3.1: Emphasis that Should Be and Emphasis that Was Placed on Elementary Teacher Education Components (Rank by Emphasis Component Should Receive)

Rank of Emphasis it Should Receive	Number of Question	Component	Median* Should	Median* Was
1	(15)	Practice in Teaching Science	3.65	2.22
2	(13)	Lesson Planning	3.44	2.81
3	(1)	Techniques of Teaching Science	3.41	2.19
4	(12)	How to Develop Curriculum Materials	3.36	1.90
5	(14)	Preparation of Science Materials	3.34	2.12
6	(5)	General Science	3.14	2.42
7	(4)	Subject Matter in Specific Areas of Science	3.05	2.16
9	(16)	Discussion of Problems of Science Teaching	3.01	1.47
9	(19)	Laboratory Safety	3.01	1.32
9	(22)	Use of Community Resources	3.01	1.45
11.5	(11)	Survey of Available Curriculum Materials	2.98	1.76
11.5	(23)	Use of Audio-Visual Materials	2.98	1.88
13	(21)	Integration With Other Subjects	2.92	1.68
14	(2)	Techniques for Developing Reading Skills in Science	2.84	1.25
15	(3)	Technique for Developing Writing Skills in Science	2.76	1.23
16	(8)	Testing/Evaluating/Grading in Science	2.74	1.71
17	(18)	Care and Maintenance of Equipment	2.55	1.30
18	(17)	Care and Observation of Animals in the Classroom	2.39	1.15
19	(7)	Psychology of Learning	2.30	1.77
20	(9)	Child Psychology	2.27	1.69
21	(20)	Special Education	2.25	1.11
22	(10)	Theories of Intellectual Development	2.07	1.48
23	(6)	History and Philosophy of Science	1.79	1.20

* Scale from 1 (Very Little Emphasis) to 4 (Very Heavy Emphasis)

Table 3.2: Emphasis that Should Be and Emphasis that Was Placed on Secondary Teacher Education Components (Medians)

Techniques and topics rated on a scale*	Junior Secondary		Senior Secondary	
	Should	Was	Should	Was
1. Techniques of teaching science	3.69	2.38	3.66	2.64
2. Techniques for developing reading skills in science	2.90	1.15	2.86	1.12
3. Techniques for developing writing skills in science	2.85	1.13	2.91	1.14
4. Subject matter in specific areas of science	3.08	2.58	3.52	2.85
5. General science	3.05	2.27	3.03	2.19
6. History & philosophy of science	1.96	1.30	2.20	1.38
7. Psychology of learning	2.41	2.26	2.63	2.55
8. Testing/evaluating/grading in science	2.93	2.13	3.04	2.29
9. Psychology of adolescence	2.47	1.93	2.43	2.21
10. Theories of intellectual development	2.05	1.79	2.09	1.79
11. Survey of available curriculum materials	2.81	1.70	2.90	1.86
12. How to develop curriculum materials	2.91	1.38	2.93	1.58
13. Lesson planning	3.18	2.72	3.32	2.82
14. Preparation of science materials	3.16	1.90	3.14	2.10
15. Practice in teaching science	3.85	2.87	3.85	2.99
16. Discussion of problems of science teaching	3.23	1.76	3.22	1.91
17. Care and maintenance of animals in the classroom	2.15	1.09	2.07	1.09
18. Care and maintenance of equipment	2.55	1.14	2.46	1.18
19. Laboratory safety	3.32	1.39	3.32	1.39
20. Special education	1.72	1.06	1.65	1.07
21. Integration with other subjects	1.79	1.12	2.34	1.11
22. Use of community resources	2.54	1.22	2.44	1.22
23. Use of audio-visual materials	2.79	2.04	2.82	1.93

* Scale is from 1 (Very Little Emphasis) to 4 (Heavy Emphasis)

3.9 Teacher Education: In-service

Nearly 50% of all teachers surveyed expressed the need for extensive in-service education. Almost all teachers were willing to participate in released-time in-service, and a large proportion indicated they would participate after school hours. The most preferred forms of in-service are also the easiest to plan, so it was disturbing to discover that one-third of the teachers had declared that such activities had not been planned in their districts. Teachers who had experienced in-service training found these activities to be more effective in 1982 than in 1978. In view of the findings of this Assessment, in-service requirements seem to command a very high priority.

3.10 Activities in Science Classrooms

Elementary science teachers reported using a wide variety of classroom activities, with verbal interaction activities and the consideration of observations on data activities outranking hands-on manipulative activities. At the secondary level, teachers reported that performing experiments from instructions and answering questions are more frequent pupil activities than are verbal interactions. Pupils designing their own experiments was the least frequent activity at all levels.

Among important elements of scientific procedure are such activities as generalizing information to new problem situations, making graphs from experimental data, and designing and doing experiments. Junior secondary teachers use these activities less often than the Contract Team views as desirable. The infrequency of these activities in the classroom may have led to some of the weaknesses in pupil performance which the results of the achievement forms and the subsequent Interpretation Panel ratings showed (see Chapter 2).

As in 1978, the Contract Team agrees that secondary schools should examine ways in which to obtain more time for science instruction.

3.11 Science at the Three Levels

Elementary

Since 1978, the textbook programs, STEM and Exploring Science, have become available to most British Columbia elementary teachers, while the Materials Based Program has become less available. Nearly three-fourths of the teachers used a combination of programs, with a higher proportion of primary than intermediate teachers doing so. The most commonly used materials were the Exploring Science texts, with STEM texts having second place. Forty percent of the elementary school teachers reported that they lacked sufficient materials to teach their program. Exploring Science was the program with which most teachers had greatest familiarity, while familiarity with the Materials Based Program has declined a great deal since 1978. Teachers preferred the programs in the following order:

Exploring Science, STEM and Materials Based. Most teachers preferred the program with which they were most familiar.

Teachers who were most familiar with, or who preferred, Exploring Science felt that it was easy to prepare for, easy to teach, had readable texts and was suitable to teacher backgrounds. Teachers who preferred STEM did so for a wide variety of reasons, none of which was selected by a preponderance of teachers. Teachers most familiar with the Materials Based Program rated it very highly for its interest and relevance to pupils, the amount of pupil activity and the content selection.

Junior Secondary

The Contract Team commends the Ministry of Education for work done so far on the Junior Secondary Program, particularly the successful introduction of a better Grade 9 program. The new Grade 9 textbook has received considerable approval from teachers. Further improvement is also anticipated with the introduction of the proposed new junior secondary curriculum.

One area of concern, however, is the lack of time spent in teaching earth science.

Senior Secondary

The Biology 11 and 12 courses are causing increasing problems. Because of out-of-date or inappropriate texts and because of course content in Biology 12 which may be too extensive for the time available, a revision of the biology curriculum may be indicated. Teachers reported that the new Physics 11 course is an improvement over the old course.

3.12 Impact of the British Columbia Science Assessment 1978

Of concern must be the lack of impact that the 1978 Science Assessment had on science education in British Columbia. Since teachers reported being unaware of the 1978 results, it is strongly suggested that districts make copies of both the Provincial Summary Report and the District Interpretation Report directly available to all science teachers.

CHAPTER 4

RECOMMENDATIONS ARISING FROM THE 1982 BRITISH COLUMBIA SCIENCE ASSESSMENT

This chapter presents a number of recommendations that have arisen from detailed studies of the data collected during the Assessment. Space limitations in this Summary Report prevent reporting a complete rationale for each recommendation. However, the interested reader is referred to the 1982 British Columbia Science Assessment: General Report for more specific information and analyses.

4.1 Recommendations: Of Highest Priority

The Advisory Committee held two extensive discussions with the Contract Team about the significance of the findings from this Assessment and it was agreed that the area of teacher education, both in-service and pre-service, should be singled out for special consideration and priority recommendations.

Factors such as facilities, materials and equipment, curriculum and teaching-learning conditions are important in the teaching of science. However, quality in these factors is secondary in importance to the quality of the teaching force. Dedicated, competent and confident teachers are needed if science is to be taught well. Confidence and competence are related to the training one has for the job.

The Assessment found that a large number of elementary school teachers have no academic or professional courses in science or the teaching of science and, therefore, must be considered inadequately prepared. There are even larger numbers who have minimal science backgrounds and who admit that they do not feel adequately prepared. In contrast, at the secondary level, most teachers feel adequately prepared, and the data suggest that the vast majority of them have taken course work in depth in at least one science area. There is evidence, however, that many junior secondary teachers lack depth of background in physical and in earth/space sciences, and a small percentage lack professional courses in science teaching.

The various groups involved with the Assessment are convinced that science is more than a unique body of knowledge. They believe that there are scientific ways of obtaining knowledge and of thinking about the natural world. Central to these beliefs are methods of systematic observation and experimentation, careful presentation and interpretation of data, and evaluations of the interpretations of others. Because of these convictions, the Advisory Committee and the Contract Team set specifications for the assessment exercises which stressed science processes and critical thinking. Review Panels accepted the items in these areas as valid reflections of the goals of the British Columbia science program. The Interpretation Panels expressed most of their concerns and made most of their recommendations in these areas.

The Contract Team and the Advisory Committee interpreted the data from the achievement forms, from the Interpretation Panels' deliberations, and from the teacher questionnaires to mean that the unique features of science are not well taught or well learned.

There was unanimous agreement among all groups involved with the Assessment that pupils must be taught in a safe environment, and must be taught safe procedures. The "Marginal" or "Weak" Interpretation Panel ratings given on the safety objective at all three levels cast doubts on the effectiveness of the teaching.

The teacher questionnaire data strongly indicate that the teachers of British Columbia are prepared to invest time and effort in improving their competence as science teachers.

When all the foregoing factors are considered, it seems necessary that there be an organized and concerted effort in British Columbia to improve the competence of those teachers now in the field and to ensure that future teachers are adequately prepared for the task which confronts them.

<u>It is therefore recommended</u>:

<u>Recommendation 1</u>.

that the Program Implementation Branch of the Ministry of Education coordinate the design, development and delivery of in-service programs for teachers which will focus on the following areas of need:

- **how to teach science processes and critical thinking skills**
- **the development of an adequate background of science knowledge in areas stressed in the curriculum, in areas of weakness for elementary teachers, and in the physical, and earth/space sciences for junior secondary teachers**
- **how to safely teach science**
- **how to teach safety to pupils**

The Contract Team suggests that the provincial Science Advisory Committee guide the design and development process. For junior secondary teachers, the program should be linked to the implementation of the new curriculum. It is further suggested that, as far as possible, the delivery of these in-service programs be in forms which teachers find most helpful--informal meetings with other science teachers, workshops conducted by teachers and visits to model classrooms. One of the priority needs expressed by teachers was for background information relating to the science curriculum. Such sources of information must be accessible to teachers.

Ways to prepare and provide background information for both elementary and junior secondary teachers must be developed. Various groups, such as the B.C. Science Teachers' Association and university personnel, should be consulted. The preparation of the source book for junior secondary science teachers might provide a model for this process.

* * *

Recommendation 2.

that the following actions be taken with respect to the pre-service training of teachers:

- the Faculties of Education should revise teacher education programs as needed to ensure that:

  (i) all pre-service elementary teachers experience science study to a minimum of a 3-unit course or equivalent at the university/college level, and

  (ii) all pre-service elementary teachers take a course in science teaching methodology

- the Faculties of Education should give greater emphasis to each of the techniques and topics identified by teachers to be most inadequately emphasized in their pre-service training (See Tables 3.1 and 3.2)

- the Ministry of Education should revise certification guidelines to reflect the above

4.2 Further Recommendations

Throughout this report, recommendations are made wherever the analysis of the data identifies a need. Sometimes, similar recommendations are made in different places. The following sections collect these recommendations and combine them. In addition, the text of the report often suggests or urges desirable courses of action. For brevity, these suggestions have not been reprinted in this chapter.

4.2.1 Recommendations to the Ministry of Education, Province of British Columbia

Not only must the science teachers be knowledgeable about safety in science teaching, but the conditions under which science is taught must be safe.

It is therefore recommended:

Recommendation 3.

that the Ministry of Education establish safety standards for school science classrooms, and provide funds for school districts not only to conduct surveys of the science safety equipment in schools where science is taught but also to correct deficiencies that may be discovered through such surveys. (This recommendation is repeated from the 1978 Assessment.)

* * *

A consistent theme in the secondary teachers' questionnaire was the need to re-examine the senior secondary biology program.

It is therefore recommended:

Recommendation 4.

that the Curriculum Development Branch of the Ministry of Education establish a Senior Secondary Biology Revision Committee to re-examine all aspects of the senior secondary biology curriculum.

4.2.2 Recommendations to the School Districts of British Columbia

The teacher questionnaires clearly demonstrate that science teachers feel a need for adequate science coordination at both school and district levels. Some progress has been made since 1978 but the Contract Team is of the opinion that more is necessary.

It is therefore recommended:

Recommendation 5.

that school districts:

- evaluate the form of science coordination within each school and establish some form of school-level coordination where none now exists
- not currently providing science coordination appoint or designate a qualified individual or individuals to be responsible for coordination and leadership of the science programs within the district

* * *

If science is to be well taught, there must be both adequate facilities and a good supply of necessary equipment and materials.

It is therefore recommended:

Recommendation 6.

that school districts:

- investigate the potential for converting some existing elementary general classrooms into rooms with adequate science facilities
- examine elementary schools for ways to utilize available space so that central storage and preparation space is available for science teaching
- attempt to provide for adequate ventilation, storage space for volatiles, increased general storage space for equipment and materials, increased preparation space and increased space for storage of pupil projects where these are needed in schools
- examine the quantity and quality of the materials and equipment used in their science programs, and make a determined effort to effect improvements where these are necessary, especially in elementary schools and small junior secondary schools
- encourage school libraries to purchase an adequate supply of science reading materials in both elementary and secondary schools

* * *

Questionnaire data show that there is a small but not insignificant proportion of junior secondary teachers who are teaching science without adequate preparation. This situation will further weaken the science program at a level where there are already serious weaknesses.

It is therefore recommended:

Recommendation 7.

- that wherever possible, school districts and administrators avoid assigning teachers with little science background to teach science in junior secondary grades. Where teachers must be reassigned outside their specialty, provisions should be made for retraining.

4.2.3 Recommendations to Schools and School Administrators in British Columbia

Attention is drawn to recommendations 5, 6 and 7.

* * *

Interpretation Panels' judgements of the achievement results clearly indicate that elementary school science programs are not as effective as they should be. Questionnaire data show that a substantial percentage of British Columbia elementary school pupils receive instruction in science for less time than the Ministry of Education recommends.

It is therefore recommended:

Recommendation 8.

- that school administrators and teachers follow the time allocations given for science instruction in the Administrative Handbook

4.2.4 Recommendations to Teachers of Science in British Columbia

Attention is drawn to recommendation 8.

* * *

Teachers at all levels showed concern about the lack of printed information other than textbooks available for pupils in science. This item was ranked highest by all groups of teachers on a list of suggested changes. The provision of such materials is a responsibility of school districts, but the choice must involve science teachers.

It is therefore recommended:

Recommendation 9.

- that teachers and school librarians cooperatively explore the upgrading of print materials in libraries and classrooms at both elementary and secondary levels

* * *

A finding from the Grade 12 Assessment was that pupil achievement in earth sciences was especially weak. A finding from the secondary questionnaire was that junior secondary teachers were spending less time in these areas than in any others.

It is therefore recommended:

Recommendation 10.

- that junior secondary teachers give greater time emphasis to earth science topics

*   *   *

The Interpretation Panels that examined the provincial data for pupil performance made a number of recommendations to teachers. All are stated in Chapters 3, 4 and 5 of the General Report, but some call for special emphasis in this section, and it is possible to combine certain of the recommendations.

It is therefore recommended:

Recommendation 11.

that science teachers:

- ensure that pupils understand safe procedures appropriate to their level
- give pupils more practice in presenting results in symbolic forms (especially graphs) and in interpreting such forms
- give extensive time (particularly in elementary school) and emphasis to measurement and quantification skills and to the use of the metric system
- give pupils in upper elementary grades and secondary schools adequate experience in analyzing variables and designing controlled experiments
- give more emphasis to teaching the practical applications of science knowledge and to using that knowledge in new situations

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APPENDIX A

MEMBERS OF REVIEW PANELS

Primary Panels

Richmond

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Lise MacDonald, Teacher, Richmond School District
Rosemary Meissner, Teacher, Coquitlam School District
Alfred Serfas, Teacher, West Vancouver School District
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Luanne Whiles, Teacher, Vancouver School District

Cranbrook

Jennifer Carter, Teacher, Castlegar School District
Heather DeWald, Teacher, Creston-Kaslo School District
Debbie Ewan, Teacher, Trail School District
David Humphrey, Teacher, Cranbrook School District
Brian Lutz, Teacher, Cranbrook School District
Mary Lyons, Supervisor, Creston-Kaslo School District
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Jill Shannon, Teacher, Castlegar School District

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Parksville

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Kathi Hogan, Teacher, Campbell River School District
Jackie Landon, Teacher, Campbell River School District
Jennifer Leary, Teacher, Qualicum School District
Norman Lindberg, Teacher, Qualicum School District
David Lowe, Teacher, Alberni School District
Ken Munslow, Teacher, Sooke School District
Robert Wall, Teacher, Victoria School District

Richmond

Robert Axford, Teacher, Coquitlam School District
Ken Fletcher, Teacher, Surrey School District

Vivian McConnell, Teacher, Vancouver School District
Russ McMath, Teacher, Richmond School District
Tony Rader, Teacher, North Vancouver School District
Gerry Sandberg, Teacher, North Vancouver School District
Eleanor Swan, Teacher, Sunshine Coast School District
Don Van Kleek, Teacher, Sunshine Coast School District
Stu Weir, Teacher, Delta School District
John Zappavigna, Coordinator, Vancouver School District

Secondary Panels

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Rick Dedora, Teacher, Vernon School District
Santosh Dey, Teacher, Shuswap School District
Bob Fisher, Teacher, Kamloops School District
Craig McLeish, Teacher, Central Okanagan School District
Don Pavlis, Teacher, Caribou-Chilcotin School District
Lee Venables, Teacher, Nanaimo School District

Richmond

Ross Apperley, Teacher, Richmond School District
Jim Ferguson, Teacher, Sunshine Coast School District
Jim Kettlewell, Teacher, Langley School District
Jim McKellar, Teacher, Coquitlam School District
Gary Spicer, Teacher, Surrey School District
Wayne Wood, Teacher, Prince Rupert School District

APPENDIX B

MEMBERS OF INTERPRETATION PANELS

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Lil Broadley, Teacher, Victoria School District
Louise Burgardt, Principal, Nechako School District
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Peter Hyde, Teacher, Stikine School District
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Kathy Ollila, Teacher, Sooke School District
Pat Rutherford, Teacher, Caribou-Chilcotin School District
Luisa Sessions, Teacher, Victoria School District
Sally Terakita, Teacher, Coquitlam School District

Grade 8

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Bill Costain, Principal, Nelson School District
Bart Deeter, Science Helping Teacher, Surrey
Peter Demchuk, Teacher, Saanich School District
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Scott Nicholson, Teacher, Burnaby School District
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Grade 12

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Queen's Printer for British Columbia ©
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