Results of the 1978 British Columbia Science Assessment*

E. D. Hobbs
Gaalen L. Erickson
university of british columbia

The 1978 British Columbia Science Assessment was part of the ongoing provincial learning assessment program. Science achievement tests were administered to almost all British Columbia public school students in Grades 4, 8, and 12. Questionnaires on various aspects of the teaching of science, including instructional practices, were completed by a sample of elementary teachers and secondary science teachers. An instrument designed to measure attitudes towards science and scientists was administered to a sample of Grades 7, 9, and 11 students. Results are reported for the following goals: (1) understanding concepts, (2) processes, (3) application, (4) safety, (5) scientific literacy, and (6) attitudes.

Dans le cadre de son programme permanent d'évaluation, la Colombie-Britannique a procédé en 1978 à l'évaluation de l'enseignement des sciences. Nous avons administré des tests à la quasi-totalité des élèves des 4è, 8è, et 12è années des écoles publiques. Nous avons également fait remplir à un échantillon d'enseignants de l'élémentaire et de professeurs de sciences du secondaire, des questionnaires sur divers aspects de l'enseignement des sciences, y compris sur leur façon d'enseigner. Nous avons enfin fait passer à un échantillon d'élèves des 7è, 9è, et 11è années, une épreuve destinée à mesurer leurs attitudes à l'égard des sciences et des hommes de science. Les conclusions dont nous faisons état dans notre article portent sur les objectifs suivants: (1) compréhension des notions, (2) processus, (3) application, (4) sécurité, (5) fréquentation des écrits scientifiques, et (6) attitudes.

The 1978 British Columbia Science assessment was part of the ongoing learning assessment program being carried out by the British Columbia Ministry of Education, Science and Technology. The assessment program is designed to indicate strengths and weaknesses within the public school system, to generate information for decision-making, and to provide direction for curriculum development and educational research.

PROCEDURES

Under terms of reference specified by the ministry of education, tests and questionnaires were to be developed by a group under contract to the ministry. This contract team was to operate with the guidance of a management committee consisting mainly of school science teachers and ministry of education officials.

*The B.C. Science Assessment was funded under contract by the British Columbia Ministry of Education.

The terms of reference specifically called for multiple-choice science achievement tests at the Grades 4, 8, and 12 levels, as well as questionnaires for teachers. The student tests were to measure science achievement at each of three levels: the end of primary education (K-3), the end of elementary education (4-7), and the end of secondary education (8-12). The tests were to be given to students enrolled in Grades 4, 8, and 12 regardless of whether they were taking science courses. The questions were to assess the kinds of understanding and skill which should develop over time in any good science program, rather than the specific knowledge which might be part of one particular science course.

The starting point for a framework of objectives for the tests was Klopfer's table of specifications (Bloom, Hastings, & Maduns, 1971). After extensive modification and revision, including review by special panels of professionals and members of the lay public, the following list of goals was adopted as the basis of the achievement tests:

1. Understanding Concepts, which includes:
   The knowledge and comprehension of important models, generalizations, theories, principles, ideas, and concepts of science, such as the principles of electrical circuits, the concept of biological variation, the structure of atoms, or the processes of mountain formation.
2. Skill in the Processes of Science, which includes:
   (a) observing (carefully noting the characteristics of properties of things or the sequence of events),
   (b) classifying (grouping things according to shared characteristics or properties),
   (c) communicating (reporting observations and conclusions in appropriate ways, interpreting information which has been communicated in a scientific way),
   (d) measuring (understanding units of measurement, choosing appropriate measuring instruments, using measuring instruments correctly),
   (e) combined skills (designing experiments, controlling variables, interpreting data).
3. Application, which includes:
   The ability to apply scientific knowledge to given problems and the knowledge of the way in which scientific principles are applied in the practical world.
4. Safety, which includes:
   The knowledge of safe procedures and precautions in the use of hazardous materials and equipment in the laboratory, the classroom, or the home.
5. Scientific Literacy, which includes:
   Understanding and appreciation of the nature of science and its methods, and the ability to interpret discussion of science-related issues.
6. Favorable Attitudes to Science and Scientists, such as:
   Favorable attitudes to scientists as people, and towards science as a school subject, as a career, and as an interest.

The first five goals formed one dimension of tables of specifications for the science achievement tests, with broad categories of science content as the other dimension. These tables encompassed a potentially enormous number of possible learning objectives — far too many at any one level for a single test. Obviously, the tests would be able to cover only a small sample of all the possible objectives. Faced with the problem of selecting this sample of objectives, and with the concern to select good test items, the contract team established a bank of multiple-choice test items. These items were drawn from a number of sources, such as the National Assessment of Educational Progress, the International Association for the Evaluation of Educational Achievement, and a number of published science tests.

Each item in the bank was classified according to goal, content area, and grade level. Where there were insufficient items for a grade in a given goal-content category, items were constructed by the contract team to fill the gap.

Items were then selected from the bank to form three sub-banks, one for each of Grades 4, 8, and 12. Selection was made on the basis of apparent quality of items and suitability to the British Columbia situation within the constraint of maintaining balance among goals and content areas. In effect each sub-bank represented a sampling of objectives from the large number of possible objectives encompassed by the goals.

According to specifications agreed upon by the management committee, a set of pilot tests was prepared and administered to a sample of British Columbia public school students in the fall of 1977. On the basis of the item analysis, and in consultation with the management committee, the contract team prepared final versions of the science achievement tests in the spring of 1978. These achievement tests were distributed to all public schools in the province to be administered to every pupil in Grades 4, 8, and 12 who was at school on the day of testing. School principals, at their discretion, were permitted to excuse students with severe handicaps.

A few weeks after the achievement testing, four other instruments were administered. One instrument consisted of two parts: (a) a survey of students' attitudes towards science and scientists, and (b) a set of questions dealing with students' perceptions of the science teaching practices to which they had been exposed. This instrument was administered to a sample of Grades 7, 9, and 11 students throughout the province.

The other three instruments were versions of a teaching/learning survey, with separate versions being directed to elementary school teachers, junior secondary school science teachers, and senior secondary school science teachers respectively. The three questionnaires covered such aspects of science teaching and learning as curriculum, textbooks and other printed materials, apparatus and science equipment, physical facilities for teaching, teacher education, leadership, and instructional practices.

Selection of all samples, distribution of instruments, collection of results, and computer analysis of data were carried out by the B.C. Research Corporation.

The results of the achievement tests were interpreted by panels nominated by the ministry of education. The panels included teachers, school administrators, school trustees, university and college instructors, and representatives of industry and other members of the public.

In procedures designed to achieve consensus, the panels were asked to rate performance on each test item as weak, marginal, satisfactory, very satisfactory, or strong. They also commented on the overall achievement for each of the five goals tested.

ACHIEVEMENT RESULTS

Grade 4

On the basis of the recommendations made by the management committee and the review panel, the main emphasis on the Grade 4 test was on (a) understanding concepts, and (b) basic processes (classifying, observing, communicating, and measuring). Lesser emphasis was placed on combined process skills, application, and safety. Four items on scientific literacy were also included.

Concern was expressed by members of the review panel that poor readers would have excessive difficulty with the written multiple-choice test in Grade 4, causing systematic attenuation of the scores. Experimental work was undertaken by the contract team, as part of the pilot testing program, to investigate this potential problem. The results showed that performance on most items increased when the questions, but not the answer choices, were read aloud to the children by their teacher. Accordingly, teachers were instructed to read the question stems but not the response choices to their Grade 4 classes as they took the test.

In general, the performance of the Grade 4 students on understanding concepts, application, and safety could be considered as very acceptable. Performance on the basic processes — observing, classifying, communicating, and measuring — was consistently high. Results for the other goals were judged to be satisfactory.

The results on combined process skills were particularly interesting. Pupil performance was consistently beyond the expectations of the contract team, management committee, review panel, and interpretation panel. The following item illustrates the type of reasoning often thought to be beyond the ability of the average Grade 4 child:

Tom wanted to find out whether plants can grow better in the dark or in the light. He put a pot with 6 radish seeds in a dark room and a pot with 6 bean seeds on the window sill.

He added the same amount of water to both pots. The bean seeds grew better than the radish seeds. So Tom said his plants grow best in the light. To be able to say this, he should have:

	p-values Gr. 4	Gr. 8
(a) watered both pots	7	2
(b) watered the radish seeds more	15	5
*(c) put the same kind of seeds in both pots	60	78
(d) grown the seeds in water instead of soil	8	7
(e) I don't know	9	7

This item required pupils to identify the important variables in the experiment and decide which one should have been controlled. More than 60% chose the correct response. Results of this type suggest that many children in the elementary grades are capable of more advanced and abstract science work than is usually offered at that level.

The goal of scientific literacy was not accorded a high priority at Grade 4, but four items were included. The panel judged performance on three items to be satisfactory, but considered 24% correct on the following item as "marginal." (Sixty-four percent of the Grade 8 students chose the correct response to the same item.)

About what topic do scientists know everything?

	p-values
(a) Clouds	9
(b) Stars	29
(c) Trees	32
*(d) No topic	24
(e) I don't know	5

With a few exceptions, the differences between boys' and girls' results on process items were small — 1 or 2 percentage points. For the seven measurement items, however, boys' results were usually 5 or more percentage points higher than girls'. For understanding concepts and application, boys' results were often much higher than girls'. On more than half of the items, boys' scores exceeded girls' by 4 percentage points or more. The differences were small for items dealing with observation of everyday phenomena such as weather, familiar animals and plants, or familiar substances and materials. Boys seemed to achieve higher scores than girls on the more conceptual items such as those dealing with the Earth's revolution, gravitation, action of germs, function of lungs, and concept of speed. The results taken as a whole seem to indicate that a divergence in the interests of boys and girls is evident as early as Grade 4.

Generally, the Grade 4 results were pleasing. Many students at this age level seemed to have the knowledge and skills to solve fairly complex scientific problems. The contract team formed the strong impression that elementary school teachers were underestimating the thinking abilities of many students. Repeatedly, in the review and pilot testing processes, teachers expressed the opinion that most of the items would be too difficult for Grade 4 students. The results, however, showed that students performed beyond the interpretation panel's expectations on 70% of the items, and most of the teachers on the panel were surprised at how well the children had done.

Grade 8

By comparison with the Grade 4 test, more emphasis in the Grade 8 test was placed on combined process skills and application. Also, sufficient items were included under the heading, "Understanding Concepts," to allow results to be reported in each of the four content areas — biology, chemistry, physics, earth/space science.

Of the 92 items on the Grade 8 test, the interpretation panel rated the performance to be weak on 12 items, marginal on 16 items, satisfactory on 29 items, very satisfactory on 28 items, and strong on 7 items. Performance was rated as satisfactory or better for 70% of the items.

Overall, the performance on understanding concepts was satisfactory, although weaknesses were found on some items. The interpretation panel rated performance on 5 of the 31 items as weak. For example, fewer than one-third of the students recognized that the main function of "sweating" is to help cool the body, or identified burning wood as an example of chemical change. About one-third of the students added the temperatures of two containers of water to find the temperature of a mixture of the two.

Some items judged as marginal by the interpretation panel indicated important areas which may warrant more emphasis in the school. Fewer than half of the students recognized a charged battery as a source of energy, green plants as the only producers of food, or the spinning of the Earth as the cause of night and day. On the other hand, performance on other items indicated that many Grade 8 students had a good grasp of such concepts as the life cycle of the butterfly, the working of a flashlight, the constituents of the Earth's surface, evolutionary succession, conditions for evaporation, and speed.

The students did very well on most of the process items. In particular, the interpretation panel was very satisfied with performance on the skills of classifying and communicating. For combined skills only two results were interpreted as less than satisfactory. The need for controlling variables seemed to be well understood by the majority of students, while performance on items requiring the interpretation of experimental data was very acceptable.

The interpretation panel judged overall performance on the application goal as "satisfactory in general." Very few students (6%) knew that paper, disinfectants, and alcohol can all be made from wood, and just over one-third recognized our ultimate dependence for food on green plants. On the other hand, about 80% could correctly identify thermal expansion as one method to open a tight lid on a jam jar, or knew why fanning helps a campfire burn and why refrigeration helps keep milk fresh.

The interpretation panel rated overall performance on safety items as satisfactory, but called for more emphasis on safety in teacher education and in-service workshops.

Ten items were included under the heading scientific literacy. Most dealt with the nature of statements in science and of scientific procedures. The interpretation panel was a little concerned about performance on this goal, as 5 of the 10 items were rated lower than satisfactory. The ability to distinguish among fact, hypothesis, and opinion was difficult for many, but the students experienced little difficulty recognizing the kinds of claims which could be empirically tested, and were able to identify with some success the most appropriate procedures for testing a statement.

The differences between boys' and girls' results on the Grade 8 test were similar to those found on the Grade 4 test, but were slightly larger. On the process, safety, and scientific literacy goals, boys and girls generally performed equally well. On the application items, the mean percent correct for boys was 57 compared to 52 for girls. On understanding concepts, the mean percent correct for boys was 7 percentage points higher than for girls, although no mean difference was found for the biology items in that goal.

Taken as a whole, the results of the Grade 8 test were considered to be very encouraging. The evidence indicated that students were entering secondary school with well-developed skills in basic processes and a satisfactory level of science concepts.

Grade 12

Generally, the performance of the Grade 12 students gave cause for concern. Of the 120 items on the Grade 12 test, the panel rated performance on 39 as weak, 45 as marginal, 22 as satisfactory, 10 as very satisfactory, and 4 as strong. Performance was rated as satisfactory or better on only 30% of the items.

Table 1 shows the results for understanding concepts in the area of biology.

Obviously, the interpretation panel felt that 50 to 60% correct was not a satisfactory level for these basic biology concepts. The single clear weakness was identified in an item which required students to recognize the uterus as the place where the human embryo normally develops. In particular, the interpretation panel noted that understanding of "life process concepts" was marginal.

With respect to understanding concepts in chemistry, the interpretation panel felt that the results indicated "no depth of understanding" and

TABLE 1

Results for Biology Concepts: Grade 12

Item Number	*Panel Rating*	*Percent Correct* *Male*	*Female*	*Total*	*Description of Items*
A-12	Strength	92	96	94	Nutrition
A-14	Marginal	55	51	53	Function of white blood cells
A-31	Satisfactory	62	64	63	Iodine test for starch
A-34	Weakness	44	66	56	Embroyo develops in uterus
A-44	Marginal	50	45	48	Water and CO_2 used in photosynthesis
A-52	Marginal	53	54	53	Natural selection
B-3	Marginal	66	57	61	Function of perspiration
B-15	Marginal	68	54	61	Function of kidney
B-33	Satisfactory	60	69	65	Genes determine heredity
B-35	Marginal	72	59	65	Green plants produce food
B-60	Satisfactory	50	49	49	Sequence of mitosis

"superficial learning." Many students knew that atoms consist of electrons, protons, and neutrons, but fewer knew that electrons are involved in forming chemical bonds or forming ions, and even fewer knew the presence of ions in solution can be detected by finding out if the solution conducts electricity. The performance on this last mentioned item was especially disappointing in view of the emphasis on electro-chemistry in the British Columbia Grade 10 science curriculum (which is compulsory for all students).

Performance on understanding concepts in physics was judged as marginal to weak. Metallic conduction and the kinetic molecular theory seemed well understood, but the performance on other items, such as the following, left much to be desired:

> The advantage of using a lever such as that shown in the diagram to raise a weight W instead of lifting it directly is that

	p-values Grade 12
(a) less energy is required	28
(b) it is quicker	3
*(c) less force is needed	44
(d) less movement is needed	5
(e) less work has to be done	14
(f) I don't know	5

The results for understanding earth/space science concepts indicated that earth and space science topics were not getting their due share of attention in the secondary school years. Data from the junior-secondary teacher questionnaire supported this claim. As in the case of physics concepts, males' performance was clearly superior to females' on most of the earth/space items, the discrepancy being, on the average, 11 percentage points.

The 21 process items in the Grade 12 test consisted exclusively of combined skills questions, including aspects of experimental design, interpretation of data, and evaluation of conclusions from given data. The interpretation panel judged performance on 6 of these items as weak, 10 as marginal, and only 5 as satisfactory or very satisfactory. Overall performance on these items was rated by the interpretation panel as marginal. These were generally quite difficult items, however, and often required students to study an extensive amount of information before answering the questions. Girls' performance on the process items was virtually the same as boys' in contrast to the items on understanding concepts.

With respect to applications, the panel members were reasonably satisfied with the performance in the area of biology, but identified weaknesses in applications of photosynthesis, human physiology, and ecology. They suggested that lack of ability to apply was related to a weak conceptual base. Notably, four of the five items for which performance was rated as satisfactory or better dealt with aspects of reproduction. The three weaknesses were items related to ecology concepts, while the two marginal items dealt with human physiology.

On chemistry application, the panel rated performance as "deplorably weak" and recommended greater attention to the practical application of theoretical concepts in school.

For application in physics, the overall rating was "marginal at best," and disappointment with the results led some panelists to question the physics background of junior secondary science teachers. Like physics concepts, males' results were much better than females'.

The panel rated the results on earth/space science application as very poor, and concluded that earth/space science is "the poor country cousin" in the junior secondary science curriculum in British Columbia schools.

With respect to the five safety items, the panel commented that their expectations were high, but felt student performance was satisfactory.

Twenty items were included under the heading scientific literacy. In addition to items of the type used in the Grades 4 and 8 tests, two sets of items were included to assess students' ability to read and comprehend passages dealing with scientific matters. The results for scientific literacy are shown in Table 2.

The panel rated performance on scientific literacy as marginal, and called for more attention to be given in schools to developing "interpretive skills." In fact, the ratings were satisfactory or better for more than half of the items, and the four weaknesses were recorded for the reading items. Interestingly, for the reading items alone, the boys' results were slightly

TABLE 2

Results for Scientific Literacy: Grade 12

Item Number	Panel Rating	Percent Correct Male	Female	Total	Description of Items
A-8	Satisfactory	84	83	84	What topic do scientists know everything about?
A-19	Satisfactory	66	54	59	Scientific status of astrology
A-20	Marginal	55	46	50	Connection between science and technology
A-21	Marginal	57	59	58	Relation between separate science disciplines
A-24	Satisfactory	60	58	59	Evaluation of statements based on reading of article on research in pulp and paper
A-25	Weak	26	18	22	
A-26	Very Satisfactory	79	76	77	
A-27	Weak	43	36	39	
A-46	Marginal	46	42	44	Identification of statement as hypothesis
A-56	Marginal	59	55	57	Evaluation of scientists' statements
B-19	Satisfactory	61	63	62	Verifiability of scientific reports
B-20	Weak	25	19	22	Meaning of scientific model
B-21	Strength	86	88	87	Willingness to consider evidence
B-24	Weak	43	36	40	Evaluation of statements based on reading of article on recombinant DNA
B-25	Very Satisfactory	72	75	74	
B-26	Satisfactory	62	62	62	
B-27	Weak	39	37	38	
B-28	Satisfactory	71	76	74	
B-48	Satisfactory	47	54	50	Stereotypes of scientists
B-49	Satisfactory	54	51	52	Relation between facts and theory

higher than the girls' (55% compared to 53%), although generally there was very little difference between boys' and girls' scores on the scientific literacy items. Notable exceptions were on items dealing with the scientific view of astrology and the relation between science and technology. On both items boys scored 9 percentage points higher than girls.

Considered as a whole, the Grade 12 results must be considered as disappointing to say the least, especially in light of the encouraging results of the Grade 8 test. Apparently many students were leaving school with limited understanding of some very fundamental concepts. Also, the evidence indicated that during the secondary grades, the abilities to design and interpret experiments were not developing much beyond the level attained at Grade 8. Perhaps this may relate to a finding from the teacher survey that secondary students spend most of their science classes doing experiments from instructions, and seldom design their own experiments. Another area of poor performance was knowledge of practical applications of science, possibly indicating an over-emphasis on the formal theoretical aspects of science in the secondary grades. Finally, the very weak results obtained by girls in the areas of physics and earth/space science should give cause for concern.

SEX DIFFERENCES

On the Grades 4 and 8 achievement tests, clear differences were found between the results of male and female students. Differences on the Grade 12 test were also found, and were even more pronounced.

On goals 1, 3, and 4 (concepts, applications, safety), males scored consistently higher than females except for those items dealing with reproduction and nutrition. On the other hand, for process skills and scientific literacy items, there was virtually no difference between males and females, which seems to indicate that the difference in achievement is not due to differences in science ability between boys and girls. Table 3 summarizes the differences for each goal at each grade level.

TABLE 3

Comparison Between Results of Males and Females: Grades 4, 8, and 12

	Mean Percent Correct					
	Grade 4		*Grade 8*		*Grade 12*	
Goal	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Concepts	64	59	60	54	55	47
Process	76	76	63	63	47	47
Application	50	43	57	52	48	38
Safety	79	78	65	63	71	61
Scientific Literacy	46	44	60	62	57	55

Differences in achievement between male and female students are most clearly evident in the Grade 12 results, particularly for the separate subject areas as shown in Table 4.

Sex differences were apparent also in the choice of science courses in Grades 11 and 12. The proportions of Grade 12 male and female students who elected not to study science beyond Grade 10 did not differ greatly

TABLE 4

Comparison Between Results of Males and Females: Grade 12

	Mean Percent Correct			
	Goal 1 — Concepts		Goal 3 — Application	
Subject	Male	Female	Male	Female
Biology	61	60	59	58
Chemistry	48	42	35	26
Physics	60	46	49	32
Earth/Space	50	39	42	27

(34% of males versus 37% of females), but there was a clear tendency for girls to avoid physics — 17% of the girls had studied physics in Grade 11 or 12, compared to 38% of the boys. Of the girls who had studied science in Grade 11 or 12, only 28% had studied physics; the corresponding figure for boys was 49%.

The absence of sex differences on the process and scientific literacy goals was surprising, and warrants further investigation. Sex differences on science achievement tests in favor of boys have been well known for some time, but in this assessment, the sex difference was found to disappear for these two sets of items.

In the understanding concepts and application goals, the girls achieved results superior to boys on items dealing with nutrition, reproduction, and heredity, but the boys achieved results superior to girls on all other concept and application items. The difference was especially marked in physics. Possibly the semantic content of the items contributed to sex differences. This is an empirical question and warrants further study.

FUTURE PLANS

For all goals except safety, a spread of more than 20 percentage points was found in the mean percent correct scores according to students' plans. For example, students planning to enter university averaged 64% correct on understanding concepts, while students planning to look for a job after leaving secondary school averaged 42%. The provincial average for this goal was 51%. Students planning to enter a technical institute or community college university transfer program averaged 57%.

Special interpretations using separate criteria were undertaken by the contract team in order to estimate the level of acceptability of the results for two of the groups: those students planning to enter university, and those students planning to look for a job. The performance of the university-bound group was judged to be far more satisfactory than that of the work-bound group, even though higher criteria were set for the university group. For the university-bound group, performance on half of the items was judged as weak or marginal, while for the work-bound group, performance on almost three-quarters of the items was judged as weak or marginal. In the judgment of the contract team the school system in British Columbia seemed to be failing badly to provide a satisfactory education in science for those students who plan to complete their schooling at the end of Grade 12.

ATTITUDES

An instrument to measure certain aspects of students' attitudes was designed by the contract team to be administered by teachers to a provincially representative sample of Grade 7, 9, and 11 classes. The instrument consisted of:

1. Semantic differential scales to measure attitudes towards science, scientists, and school science (Part A);

2. Personal action and hypothetical action scales to measure interests in science (Parts B and C);

3. Likert scales to measure students' attitudes towards science as a career, scientists, and scientific ideas (Parts D, E, and F).

As a rule, differences according to sex or grade level were small, so the results are reported below for the sample as a whole.

On the semantic differential scales (Part A), the means were at least one standard deviation above the midpoint for all attitude objects except "industrialist." Although "school" and "scientists" shared similar ratings, "reading science books," "doing science experiments," and "science I have taken in school" all had ratings about one-third of a standard deviation lower than "school." Means for Grade 9 students were generally about one-third of a standard deviation below the means for Grade 7 students and Grade 11 students.

Part B of the attitude instrument consisted of 10 statements of a number of science-related activities. Students were required to indicate on a five-point scale the extent of their willingness to try each of the activities. In spite of the generally favorable attitude towards science indicated in Part A of the instrument, only a quarter to a third of the students indicate interest in doing science experiments at home, buying books about science, or taking more science in school. On the other hand, more than half indicated interest in movies, television programs, and newspaper or magazine articles about science.

Two findings of interest emerged:

1. On any given item, from about one-quarter to one-half the students indicated lack of interest by responding in categories 1 or 2. About one-quarter responded in category 1 (definitely unwilling) for items which could be classed as school-type activities.

2. The three items for which interest levels were highest all related to media presentations of science.

Part C of the instrument consisted of statements of science-related activities of the kind which might be expected to be part of science class activities. Subjects were asked to indicate how frequently they had engaged in these activities during the current year, voluntarily, "just because (they) wanted to." On most of the items, 40 to 50% of the respondents indicated a level of interest in science high enough to voluntarily engage in the activity at least a few times in the year. Almost half had frequently tried to find out how mechanical things around the house work, and 60% had frequently thought about the origins of the universe or of life. On the other hand, most students had never, or rarely, designed and carried out an experiment for themselves, or tried to find out how major industries in the province apply scientific ideas.

Chi-square analysis showed that the following differences were significant ($p<.01$):

1. About twice as many boys (60%) as girls (29%) reported trying to find out how mechanical things around the house work, quite frequently or very frequently.

2. More boys (35%) than girls (20%) reported trying to find out, at least a few times, how industries apply science.

3. More girls (73%) than boys (51%) indicated they had never successfully designed and carried out their own experiment.

4. More girls (43%) than boys (30%) indicated they had never voluntarily carried out experiments from sets of instructions.

5. The higher the grade level, the less likely students were to have carried out experiments for themselves during the year.

Part D was designed to measure interest in science as a career, and consisted of 13 Likert items. The means on the five-point scale for the three grade levels were:

Grade 7 = 3.3	(*S.D.* = 0.58)
Grade 9 = 3.1	(*S.D.* = 0.58)
Grade 11 = 3.2	(*S.D.* = 0.56)

This gives evidence for a certain amount of equivocation among students about careers in science. The results indicated that this scale could readily be developed for use as a measure of individual students' interest in science as a career.

On Part E, students were asked to indicate their level of agreement with a number of statements about scientists and scientific ideas. With respect to beliefs about scientists, students generally subscribed to the notion that scientists are somehow different or odd, but agreed that scientists put a high value on human life, have done more good than harm, and know much more about the world today than in past years. Students disagree that scientists practice a kind of magic, but were equivocal about whether scientists have the answers to society's problems, and disagreed that scientists should govern our country. Many students would neither agree nor disagree with scientists that human life comes from simpler forms, or that the planets do not determine success or failure in our daily lives.

With respect to beliefs about scientific ideas, responses generally seemed to display a fairly high level of faith in modern science. Students tended to feel that scientific ideas are very difficult, but that studying them makes people more broadminded. Even though many (55%) were not prepared to agree that science has a monopoly on valid knowledge, students were generally undecided about the relative merits of science and common sense.

TEACHING/LEARNING SURVEY RESULTS

Much of the information obtained from the teacher questionnaires was of particular interest to the current situation in British Columbia. The following represents a selection of some findings which may be of more general interest.

The Teachers of Science

Clear differences among the teachers at the three levels can be seen in Table 5. About two-thirds of the elementary school teachers responding were women while more of the junior secondary science teachers were younger men. Senior secondary science teachers were predominantly men with many years of teaching experience.

TABLE 5

Characteristics of Science Teachers at Three School Levels by Sex, Age, and Years of Teaching Experience

	Percent of Respondents		
School Teachers	*Elementary*	*Junior Secondary*	*Senior Secondary*
Males	34	88	94
Females	66	12	6
Age over 30 years (males & females)	66	43	88
10 or more years of teaching experience (males & females)	44	40	63

Teachers were asked to express the degree of satisfaction they felt for the level at which they were currently teaching. Their responses indicated a high degree of dissatisfaction with science teaching at the junior secondary level. While more than 90% of the elementary and senior secondary science teachers preferred to teach at their present level, only 43% of the junior secondary science teachers preferred to teach at the junior secondary level. About two-thirds of the junior secondary science teachers either were not comfortable teaching science, would have preferred to avoid teaching science altogether, or would have rather taught science at another level.

Instructional Practices

According to the teachers' reports, the teaching of secondary school science seemed to rely heavily on one method — students carry out laboratory work from sets of instructions, write up reports of the labs in their own words (often as homework), and submit the reports to the teacher for marking. Most teachers said they mark every lab report for every student, and base a proportion of students' evaluation on these reports. About half of the teachers said they base 20 to 60% of students' grades on lab reports.

Senior secondary teachers reported using lecturing and note-taking more frequently than did junior secondary teachers. Both junior and senior secondary teachers reported that they never or rarely required students to make up their own experiments, or do investigations at home. These activities were done more frequently by elementary students, along with classifying, observing, and reporting observations in their own words.

The secondary teachers reported using teacher-made tests and laboratory reports for most student evaluation. By comparison, the elementary teachers reported making more frequent use of general attitude in class, work habits, projects, and anecdotal records.

At the end of the attitude questionnaire given to the Grades 7, 9, and 11 students, there were questions about science instructional practices. Their answers confirmed the pattern described above, although the students reported a greater frequency of such activities as listening to teachers talk and copying notes than did the teachers. The students in Grades 7 and 11 reported a wider variety of learning activities than did the students in Grade 9. Fifty-six percent of the Grade 9 students reported that more than half the time (28% said almost every class) they were required to carry out experiments from sets of printed instructions. Many of the students reported that they:

— never make up their own experiments in class (53%),

— never have guest speakers in science (66%),

— never go on field trips (58%),

— never do investigations at home (40%),

— never discuss newspaper or magazine articles in class (38%), and
— never do projects or reports (30%).

As for homework, responses of both students and teachers indicated that the most common forms were writing lab reports, reading, preparing for tests, and completing work unfinished in class. Respondents indicated that this required one or two hours per week for most junior secondary students and three to four hours or more per week for most senior secondary students.

Working Conditions

When asked how certain changes might affect the quality of learning in their classrooms, the teachers most often gave the highest likelihood of improvement to better working conditions such as smaller class size, more time to prepare and mark, and fewer subjects and classes to teach. Many teachers commented in writing that they spent far more than six hours every week preparing and marking. Sixty-three percent of the full time junior and senior secondary science teachers reported their marking load to be "barely manageable" or "unmanageable." Compared to the elementary and senior secondary teachers, a significantly larger number of junior secondary teachers called for reduction in class size.

RECOMMENDATIONS

The 21 recommendations listed in the Summary Report of the assessment may be summarized as follows:

1. Major revision of the junior secondary science curriculum and changes in science offerings at the senior secondary level in order to meet the needs of more students;

2. Establishment by the ministry of education of a special committee to investigate the tendency of girls to avoid physical science courses in Grades 11 and 12, the preponderance of males among secondary science teachers, and the gap between boys' and girls' achievement in science;

3. Measures to increase the desirability and satisfaction of junior secondary science teaching;

4. Measures to support and encourage elementary school teachers of science through improved leadership, in-service, and supply of materials;

5. Suggestions for teachers to widen their repertoires of instructional practices, to make efforts to encourage girls in science, and to take account of the full range of students' abilities;

6. Establishment of a ministry of education sponsored bulletin for science teachers, containing up-to-date background information related to science and suggestions for teaching.

REFERENCES

Bloom, B. S., Hastings, J. T., & Madnus, G. F. *Handbook on formative and summative evaluation of student learning.* New York: McGraw-Hill, 1971.

Comber, L. C., & Keeves, J. P. *Science education in nineteen countries.* New York: Wiley, 1973.

Conry, R., Muir, W., Mussio, J., Rogers, T., & Wideen, M. *Assessment planning: B.C. assessment program.* Victoria: British Columbia Department of Education, 1975.

Hobbs, E. D., Boldt, W. B., Erickson, G. L., Quelch, T. P., & Sieben, G. A. *British Columbia science assessment 1978 summary report.* Victoria: British Columbia Ministry of Education, 1978.

Hobbs, E. D., Boldt, W. B., Erickson, G. L., Quelch, T. R., & Sieben, G. A. *British Columbia science assessment 1978 general report* (Vol. 1). Victoria: British Columbia Ministry of Education, Science and Technology, 1979.

Maccoby, E. A., & Jacklin, C. N. *The psychology of sex differences.* Stanford: Stan-University Press, 1974.

Sieben, G. A., & Hobbs, E. D. *British Columbia science assessment 1978 general report* (Vol. 2). Victoria: British Columbia Ministry of Education, Science and Technology, 1979.

E. D. Hobbs and Gaalen L. Erickson are both Assistant Professors in the Department of Science Education at the University of British Columbia, Vancouver, British Columbia V6T 1Z5.