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Background Study 52

Science Education in Canadian Schools

Volume II
Statistical Database for Canadian Science Education

Graham W.F. Orpwood
Isme Alam

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Science Education in Canadian Schools

Volume II

Statistical Database for Canadian Science Education

Graham W.F. Orpwood
Isme Alam
with the collaboration of
Jean-Pascal Souque

Graham W.F. Orpwood

Graham Orpwood studied chemistry at Oxford University where he received bachelor's and master's degrees. In 1966, following a year at the University of London, he began a teaching career that included appointments at a secondary school in England and at the St. Lawrence College of Applied Arts and Technology in Kingston, Ontario. He returned to post-graduate studies in 1975, this time at the Ontario Institute for Studies in Education. He received an MA and a PhD from the University of Toronto, and served as a research officer at OISE for a further two years.

In 1980, Dr. Orpwood was appointed as science adviser at the Science Council, where he has acted as project officer of the Science and Education Study. He has coauthored a book, *Seeing Curriculum in a New Light*, and several articles in the field of science education and curriculum theory. His current interests are the methodology of policy research, federal-provincial relations in education and public attitudes to science.

Isme Alam

Isme Alam earned her honours degree in Biology from Carleton University in 1978. She joined the Science Council of Canada in 1979, contributing to a study of innovation in Canadian industry and later to the Science and Education Study. On both studies, she was primarily engaged in developing surveys for the collection of data relevant to policy formation. Her interest in science policy research and statistical analysis has led her to the Science and Technology Division of Statistics Canada, where she is developing techniques for measuring the extent of scientific and technological activity in Canada.

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Foreword

Excellence in science and technology is essential for Canada's successful participation in the information age. Canada's youth, therefore, must have a science education of the highest possible quality. This was among the main conclusions of the Science Council's recently published report, *Science for Every Student: Educating Canadians for Tomorrow's World*.

Science for Every Student is the product of a comprehensive study of science education in Canadian schools begun by Council in 1980. The research program, designed by Council's Science Education Committee in cooperation with every ministry of education and science teachers' association in Canada, was carried out in each province and territory by some 15 researchers. Interim research reports, discussion papers and workshop proceedings formed the basis for a series of nationwide conferences during which parents and students, teachers and administrators, scientists and engineers, and representatives of business and labour discussed future directions for science education. Results from the conferences were then used to develop the conclusions and recommendations of the final report.

To stimulate continuing discussion leading to concrete changes in Canadian science education, and to provide a factual basis for such discussion, the Science Council is now publishing the results of the research as a background study, *Science Education in Canadian Schools*. Background Study 52 concludes, not with its own recommendations, but with questions for further deliberation.

The background study is in three volumes, coordinated by the study's project officers, Dr. Graham Orpwood and Mr. Jean-Pascal Souque. Volume I, *Introduction and Curriculum Analyses*, describes the philosophy and methodology of the study. Volume I also includes an analysis of science textbooks used in Canadian schools. Volume II, *Statistical Database for Canadian Science Education*, comprises the results of a national survey of science teachers. Volume III, *Case Studies of Science Teaching*, has been prepared by professors John Olson and Thomas Russell of Queen's University, Kingston, Ontario, in collaboration with the project officers and a team of researchers from across Canada. This volume reports eight case studies of science teaching in action in Canadian schools. To retain the anonymity of the teachers who allowed their work to be observed, the names of schools and individuals have been changed throughout this volume.

As with all background studies published by the Science Council, this study represents the views of the authors and not necessarily those of Council.

James M. Gilmour
Director of Research
Science Council of Canada

Acknowledgements

This project could not have been undertaken without the help and cooperation of a large number of people. At every stage of the planning and analysis activities, Vicki Rutledge, Allen Gower and Ruth Dibbs of the Federal Statistical Activities Secretariat, Statistics Canada, have been especially helpful and encouraging. Jim Seidle and Michele Vigder of the Education, Science and Culture Division, Statistics Canada, have provided us with key information, often at short notice. The questionnaire was developed with advice from Dr. Robert Kenzie (Department of Measurement, Evaluation and Computer Applications at the Ontario Institute for Studies in Education) and from teachers at the Ottawa Board of Education, the Carleton Board of Education, and the region of Québec City. The conduct of the survey depended in large measure on the cooperation of many individuals at ministries of education, school boards and schools, and on the interest and enthusiasm of the responding teachers. To all of these we are grateful, but particularly to Dr. David Bateson of the Learning Assessment Branch, British Columbia Ministry of Education. Finally, our colleagues at the Science Council have been of continuing support and help, especially Herman Yeh (computing), Jerry Zenchuk (editorial), Leo Fahey (graphics), Nancy Weese and Lise Parks (secretarial).

I. Survey Objectives and Methodology

Objectives of the Survey

A study of science education would scarcely be complete without serious consideration of the views of those most intimately involved in the day-to-day business of science education, namely the teachers of science at elementary and secondary levels. Their perspective is not the only relevant view, of course (as other sections of this report show), but an appreciation of that perspective was crucial to the achievement of two of the overall aims of the study. Both the documentation of the present purposes of science education and the stimulation of deliberation concerning the future required not only that teachers be consulted and their views sought, but also that they become actively involved in the discussion of issues that arose during the study.

This consultation process took several forms; but the most systematic and comprehensive of them was the survey of science teachers, undertaken as one component of the research program and described in detail in this volume. Data from this survey can be combined with data from other components of the research program (analysis of ministry policies, analysis of textbooks and case studies of science teaching) to provide a composite picture of science education in Canada today and to inform the process of deliberating its future directions.

The survey was designed to determine:

- science teachers' beliefs concerning the relative importance of various aims of science education;
- science teachers' perceptions of the effectiveness of their teaching in enabling students to achieve the various aims of science education;
- obstacles to the achievement of the various aims of science education.

Design of the survey involved developing an instrument (a questionnaire), devising an appropriate sampling technique, planning data collection procedures and developing a strategy for processing and analyzing the data.

Instrument Development

Instrument development began in early December 1980 with the construction of a questionnaire item bank based on recent surveys relating to science education in Canada and the United States. Many items were dropped, others were modified, and still others were constructed to meet the information needs suggested by our objectives and by the issues raised in other parts of the study. All potential items were then sorted into topical areas of interest to the study:

- general information (age, sex, etc.)
- aims of science education
- teachers' backgrounds and experience (preservice and inservice)
- curriculum resources (ministry/department guidelines, textbooks, etc.)
- physical facilities and equipment
- institutional arrangements (time allocation, teaching load, etc.)
- students' abilities and interests
- community and professional support

From each topical group, particular items were selected and arranged in a sequence that would appear logical to the prospective respondent. A preliminary version of the questionnaire was drafted, using this process, by May 1981.

Instrument Review and Pretest

A meeting was held with several expert consultants to assess the instrument on the basis of its substance and technical adequacy. As a result of this meeting, the questionnaire was revised as both objectives and items were refined and clarified. Revisions in the questionnaire involved changes in wording, sequence and layout of questions. Some questions that appeared to be obsolete were dropped entirely and others were added as required. In early June 1981, the revised version was circulated to a wider selection of reviewers, including ministry of education science officials and study committee members.

In the June-July period, both English and French versions of the questionnaire were field tested. The English version was tested by 22 elementary and secondary school science teachers employed by the Ottawa and Carleton Boards of Education. The French version was field tested by six elementary and secondary school science teachers in the Québec City area. In both instances teachers were asked to fill out the questionnaire and complete an evaluation form in which they reported the time taken to answer the questions, identified various problems and commented on the questionnaire generally and on specific items. The French field test was followed by a discussion with teachers about the questionnaire.

On the basis of the pretest analysis and comments by the various reviewers, the instrument underwent another round of revision. By mid-August 1981, the final draft of the instrument was completed. (See Appendix A.) A rationale for the questions was included in an introductory letter on the inside cover of the questionnaire, and each section was further explained in a preamble. The questionnaire was designed to be self-administered. Respondents were directed to circle the appropriate answers on a separate response sheet (also included in Appendix A). In this way, 162 separate pieces of information were collected.

The questionnaires and accompanying materials were printed and organized in packages, which were mailed out in October 1981.

Sample Design and Selection

The sample design and selection procedures were developed in collaboration with survey experts at Statistics Canada. Three important aspects of the sample design were:

1. target population (sampled population);
2. frame (list of all members of the population);
3. sampling procedure (unit sampled, sample size and sample selection methods).

Target Population

The survey was designed for "teachers of science in Canadian schools." The definitions below, which are based on the terms of reference of the overall study, identify this population more precisely.

1. "Science" in the context of the survey is taken to cover those areas of the school curriculum defined by ministries of education as science. This definition usually includes the physical, biological and earth sciences but excludes mathematics, computer science, social sciences, economics and vocational or trade subjects. While this definition may appear to be very vague, operationally it is less so because professional educators have, within any given jurisdiction, a clear sense of what is and is not "science."
2. "Teachers" in this context refers to all who taught science as part, or all, of their teaching assignment during the 1981-1982 school year. Included, therefore, are teachers who teach science as part of an integrated curriculum, those who teach science and other subjects, and science specialists.
3. "Canadian schools" refers to publicly supported elementary and secondary schools under the jurisdiction of provincial and

territorial governments. Excluded are private schools and federally administered schools (such as Indian schools).

4. For the purpose of this survey, teachers were divided into three groups according to the grade level at which they taught. These three levels, called "early," "middle" and "senior" years, correspond to the divisions of science curriculum policies in each province and territory; the complete distribution of grades by teaching level is shown in Table I.1.

Table I.1 – Distribution of Grades by Province[a]

Province/Territory	Early Years	Middle Years	Senior Years
Newfoundland	K-6	7-9	10-11[a]
Prince Edward Island	1-6	7-9	10-12
Nova Scotia	K-6	7-9	10-12
New Brunswick	1-6	7-9	10-12
Québec	K-6	7-9	10-11
Ontario	K-6	7-10	11-13
Manitoba	K-6	7-9	10-12
Saskatchewan	K-6	7-9	10-12
Alberta	K-6	7-9	10-12
British Columbia	K-7	8-10	11-12
Northwest Territories	K-6	7-9	10-12
Yukon Territory	K-7	8-10	11-12

[a] At the time of data collection, Newfoundland had not yet implemented its grade 12 program.

Frame

Having defined the population, we were concerned next to find a sampling frame from which teachers of science could be drawn. Such a complete listing of teachers is not available, and we therefore sampled schools for which complete lists were available. The school lists were obtained from the Education Division of Statistics Canada and from the Ministère de l'Éducation, Gouvernement du Québec. They were found to be complete and to include very few extra schools (private schools, for example).

Table I.2 shows the number of schools and science teachers in each province. The figures for schools have been obtained directly from our sampling lists while those for science teachers have been estimated from the responses. (See Appendix B for calculations.)

Table I.2 – School and Science Teacher Populations by Province

Province	Number of Schools	Number of Science Teachers
Newfoundland	671	5 432
Prince Edward Island	67	465
Nova Scotia	599	4 167
New Brunswick	465	2 766
Québec	2 340	17 840
Ontario	4 530	34 074
Manitoba	715	4 369
Saskatchewan	951	4 682
Alberta	1 391	8 527
British Columbia	1 821	15 504
Northwest Territories	70	434
Yukon Territory	24	144
Canada	13 644	98 404

Sampling Procedure

The following procedure was used to select as representative a sample of science teachers as possible:

1. The country was stratified by region[1] and by province (or territory).
2. Within each region, science teacher sample sizes were calculated separately for each teaching level (early, middle and senior) on the basis of estimated population sizes for each level,[2] the desired degree of regional data reliability,[3] the anticipated response rate,[4] design effects[5] and considerations of cost.[6] (See Appendix B.)
3. The regional samples were proportionally allocated to each province or territory within that region while adjusting provincial sample sizes to ensure the desired provincial data reliability.[7]
4. The lists of schools were stratified as follows: (i) by province and territory; (ii) by school level (elementary/secondary);[8] (iii) by type of school location (urban/rural).[9] Using this figure, the number of science teachers was estimated for every school in a given province.[10]
5. Schools were selected systematically from the list until the appropriate number of science teachers for each sample (as calculated in steps 2 and 3) was obtained.
6. All teachers of science in selected schools were potential respondents to the survey.

The sampling procedure described above was used in the case of all provinces except British Columbia, where the Learning Assessment Branch of the Ministry of Education conducted the sample selection (according to our specifications of sample sizes by teaching level, while ensuring adequate regional representation within the province). In the Yukon and Northwest Territories, and at the secondary school level in Prince Edward Island, a *census* of schools was conducted because the number of science teachers in those jurisdictions was too small to warrant sampling. Table I.3 shows the sizes of the resulting samples.

Table I.3 – School and Science Teacher Samples by Province

Province	Number of Schools	Number of Science Teachers
Newfoundland	135	725
Prince Edward Island	31	186
Nova Scotia	79	504
New Brunswick	69	418
Québec	128	774
Ontario	140	887
Manitoba	70	416
Saskatchewan	118	522
Alberta	153	799
British Columbia	210	1 056
Northwest Territories	70	434
Yukon Territory	24	144
Canada	1 227	6 865

Data Collection

Packages of questionnaires and related materials were mailed to principals of selected schools in October 1981. Each package contained a letter from an official of the provincial ministry of education, a letter from the Science Council of Canada, a control form, an instruction sheet, a postage-paid postcard and envelope, and several questionnaires in unsealed envelopes for teachers. The letter from the ministry of education, which was also included in the teachers' envelopes, indicated the ministry's support for the Science Council's study and encouraged both teachers and principals to participate. The letter addressed to the school principal described the survey and the principal's role in it, stressing that participating schools and teachers would not be identified. The instruction sheet outlined the role of the principal in greater detail. Principals were requested: to return the postcard in order to acknowledge receipt of the materials and to inform us if additional questionnaires were required; to forward questionnaires in unsealed envelopes to teachers teaching science; to collect response sheets sealed in envelopes from teachers; to record the number of questionnaires distributed and returned on the control form; and to enclose and return the control form and sealed teacher envelopes in the larger postage-paid envelope provided. Principals were requested to return the response forms by 31 October.

A week after mailing, we began to receive responses from schools. As each package arrived, the date it was received, the school code and the data on the control form were keypunched onto a computer file and also recorded on a hard-copy listing of sample schools. By the end of October, the school response rate was roughly 33 per cent; this figure almost doubled by mid-November. On 26 November, a thank-you/ reminder postcard was mailed out to all sample schools in order to increase response rates further. This procedure had little impact, and we decided in January to conduct a follow-up by phone. Approximately 350 schools across the country were phoned, boosting response rates a further 5 to 10 percentage points.

Table I.4 shows the final number of responding schools and teachers in each province. These responses represent an overall response rate for the national sample of 72 per cent (schools) and 61 per cent (teachers). The teacher response rate was computed by multiplying the average teacher response rate within responding schools (approximately 85

Table I.4 – Number of Schools and Science Teachers Responding in Each Province

Province	Number of Schools	Number of Science Teachers
Newfoundland	84	401
Prince Edward Island	22	117
Nova Scotia	63	364
New Brunswick	54	310
Québec	69	320
Ontario	105	567
Manitoba	54	263
Saskatchewan	87	356
Alberta	105	455
British Columbia	182	798
Northwest Territories	44	206
Yukon Territory	10	49
Canada	879 (72%)	4 206 (61%)

per cent as estimated from control form data) by the overall school response rate (72 per cent).

Response rates of various subgroups in the population were examined in order to determine whether or not there is variation among these subgroups. For example, we analyzed response rates for each province by school level (elementary/secondary) and type of school location (urban/rural). Had we found different response rates for the various subgroups, it would have suggested that certain segments of the population were either over or underrepresented in the sample. However, we found few differences in response rates in either case, indicating that the sample is fairly representative in these respects.

Data Processing and Analysis

Upon receipt, each response form was given a two-digit identifying code (in addition to the four-digit school code already on the school package) so that each responding teacher would have a unique identifier for keypunchers and, subsequently, for computer files.

Editing and Coding

Response sheets, consisting mainly of self-coded answers, were inspected for various problems and then edited manually. For instance, it was necessary to resolve multiple responses to items for which only one response was allowed. In such cases, we had to decide whether there was actually adequate information from other questions to assign a particular answer, or whether to consider the multiple response as missing data. Generally, questions with multiple responses were treated as missing information. One question, which concerned the textbook used by students, was coded from a precoded list of textbooks developed from a list of provincially approved texts.

Edited and coded response forms were then ready to be keyed to magnetic tape. Keypunching errors were checked (by a process called "verification") to reduce errors to less than five per cent. In order to correct for several types of errors resulting from keypunching and from problems in response, a thorough machine cleaning of the data was initiated.

Researchers used a computer to scan the data for illegitimate codes that might have been created by keypunching errors. Next, they identified logical inconsistencies and improbabilities (for example, a teacher says he is not currently teaching science and then, in a subsequent question, says he teaches biology). To resolve these problems, researchers scanned the original response forms. This entire process allowed researchers to acquire high quality data by minimizing errors other than sampling errors.

Weighting

The probability that any given teacher would be selected was not uniform across the country. To ensure high quality samples, we sampled a greater *proportion* of teachers from smaller provinces than from larger provinces; we also sampled a greater proportion of secondary school teachers than elementary school teachers. To counteract this imbalance and to adjust for nonresponse, every teacher's responses were weighted to ensure that the resulting national estimates would reflect the true balance of opinions in the population. The method of calculating weights is described in Appendix B.

Sampling Error and Data Reliability

Sampling error is the error resulting from studying a portion, rather than all members, of a population. It is the difference between the population estimates obtained from repeated samples and the true population value, and depends on the size of both population and sample, the variability of the particular characteristic in the population, the design of the sample and the method of estimation. Generally speaking, as the sample size increases the sampling error decreases. The sampling error is usually expressed as the standard error of an estimate. Details of the method used to estimate standard errors can be found in Appendix B.

Our sampling procedure, as outlined in the previous section, attempted to minimize errors due to sampling by selecting the most feasible and efficient design, taking into account the extent of sampling errors anticipated in the data. These errors have been calculated for estimates on the basis of actual data.

Table I.5 presents (as a general guide) the range of standard errors for national estimates by teaching level. In general, errors appear to be quite small. This implies a fairly narrow confidence interval and therefore a relatively high degree of reliability of our national estimates.

Table I.5 – Range of Standard Errors by Teaching Level[a]

	Early	Middle	Senior
Range of Errors	0.01-3.08	0.01-5.30	0.02-2.43

[a] Figures shown are percentages.

Overview of the Report

In general, this report is restricted to national data. Estimates for each province are available in separate provincial supplements to the report. In subsequent chapters, we report the estimates by teaching level (early, middle and senior years). For most chapters, a written text summarizing the highlights of the data is provided, followed by the tables to which the summaries refer. In Chapter III, however, the tables appear in the text for the convenience of the reader. The text of each chapter is divided into various topical sections in which data about a particular subject is discussed. Tables follow a similar pattern; a comment is usually provided to summarize the data in each table.

The major tabulating variables used for data in this report are teaching level, school location, sex, age and length of teaching experience. We have reported all estimates as percentages of science teachers responding to various choices for particular questionnaire items.

Population size (as estimated from data) and number of respondents for each teaching level are compared in Table I.6. In general, estimates are based on the number of respondents to the survey as a whole, and the number of teachers responding to each question is therefore not reported in the data tables in subsequent chapters. Figures do not exactly add up to 100 per cent for such tables, as the proportion of teachers not responding, or responding improperly, to individual questions is not reported. However, in tables where two variables are cross-tabulated, numbers of respondents are shown, and figures for such tables do add up to approximately 100 per cent.

Table I.6 – Population Size and Number of Respondents by Teaching Level

	Early	Middle	Senior	Total
Population	78 699	12 132	7 573	98 404
Sample (Respondents)	1 703	1 346	1 157	4 206

Chapter II presents the demographic characteristics of science teachers such as age, sex and length of teaching experience. Chapter II also presents data relating to the professional and academic background of teachers – degrees, number of courses in mathematics, science and education, and time elapsed since a course was taken in those subjects. Data concerning employment in science-related jobs is described in this chapter as well. Finally, data relating to teachers' attitudes towards science teaching and teacher education is presented.

Chapter III is concerned with teachers' views about the aims of science teaching and with their achievement or nonachievement of those aims.

Chapter IV describes the instructional contexts of science teaching – obstacles to the achievement of aims, textbooks and other curriculum resources used, types of inservice experiences and their value to teachers, and students' abilities and interest in science.

Chapter V presents information concerning the physical, institutional and social contexts of science teaching. "Physical context" refers to the availability and quality of physical facilities and equipment. "Institutional context" refers to the time allotted for teaching science, class size and teaching load. The "social context" includes the attitudes of peers, principals, parents and school trustees to science teaching and teachers. The involvement of industry in science education is also examined here.

Chapter VI contains comments about information in previous chapters. It focusses particularly on questions raised by the data.

Finally, the report contains two appendices. Appendix A provides a copy of the instrument and response sheet, and Appendix B contains technical information concerning estimation procedures, standard errors and the reliability of data.

II. Science Teachers

One of the most important parts of the database for those deliberating over curriculum change is that which describes the teachers of science – who they are, the type of background they bring to their work, their attitudes towards teaching, and so on. Since the respondents to this survey questionnaire were all teachers, all the data reported here can contribute to this information. However, some questions were particularly intended to elicit information about the respondents themselves, and Tables II.1 to II.17 summarize these results. The information given here is of three kinds:

- Demographic information (sex, age, length of teaching experience) (Tables II.1-II.6)
- Educational background (including employment other than teaching) (Tables II.7-II.13)
- Attitudes towards teaching and teacher education (Tables II.14-II.17)

With each table of data is a "comment" which highlights the information contained in the table. In addition, some general observations about the results of each section are given below.

Demographic Information

The results of the survey show that science is taught by a teaching force that (above the early-years level) is predominantly male, is largely in the 26 to 45 age range, and is relatively experienced (10 years or more) in teaching.

The early years are dominated by female teachers in a ratio of 3:1. But a comparison of the ages or years of experience of early-years teachers by sex (Tables II.3 and II.5) shows that a change is taking place. Specifically, 47.2 per cent of female early-years teachers have 14 years of experience or more, compared with 34.7 per cent of male early -years teachers. Thirty-one per cent of female teachers have less than 10 years of experience compared with 38.3 per cent of male teachers. These figures suggest that, at this level, a small but definite shift in the balance between sexes is taking place. A corresponding trend in the other direction can be detected at the senior-years level. There, only 10 per cent of male teachers have fewer than five years of experience, compared with 28.1 per cent of female teachers. These figures suggest that the current balance of males to females (8:1) may be changing, albeit slowly. As noted in the comment on Table II.1, there is considerable provincial variation in these particular figures.

A comparison of Tables II.2 and II.4 shows that the ages and lengths of teaching experience of teachers are related. However, Québec teachers tend to be older, on average, than those in other provinces, especially at the early-years level, where 60.8 per cent of Québec teachers are over 35. By contrast, teachers in Newfoundland and in Alberta are relatively younger, especially at the middle years, where 71.1 per cent (in Newfoundland) and 68.0 per cent (in Alberta) are 35 or younger. Male teachers, in general, are slightly older and significantly more experienced than female teachers. Teachers in urban areas also appear to be relatively more experienced than those in rural areas.

Table II.1 – Sex of Teachers[a]

Sex	Early	Middle	Senior
Male	22.1	69.4	88.0
Female	77.1	30.2	11.9

[a] Figures shown are percentages.

Comment:

These results will probably surprise no one, but it should be noted that provincial data vary significantly. For example, at the early-years level, 10 per cent of Québec teachers are male, compared with 35 per cent of Manitoba teachers.

Table II.2 – Ages of Teachers[a]

Age (years)	Early	Middle	Senior
Under 26	8.7	7.6	3.6
26-35	42.4	48.7	34.9
36-45	32.6	32.1	40.9
46-55	11.5	8.6	15.7
Over 55	3.8	2.5	4.6
Average Age	36	35	39

[a] Figures shown are percentages.

Comment:

Teachers at the senior-years level are older than those at the early-years level; those at the middle-years level are the youngest of all.

Figure II.1 – Ages of Teachers

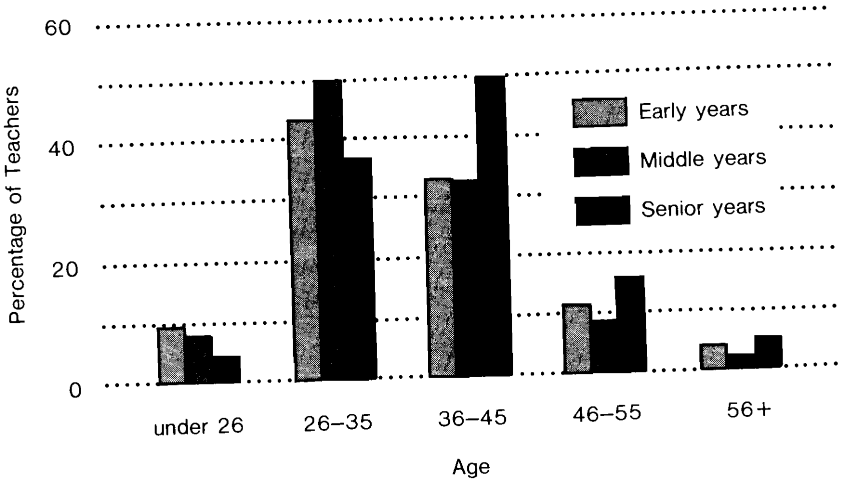


Table II.3 – Ages of Teachers by Sex[a]

Age	Early		Middle		Senior	
	M	F	M	F	M	F
Under 26	3.3	10.3	3.7	16.6	3.4	11.6
26-35	51.6	40.2	53.5	38.1	33.2	41.5
36-45	30.8	33.4	32.2	32.2	43.3	26.8
46-55	9.0	12.3	7.8	10.3	15.3	16.5
Over 55	5.1	3.5	2.6	2.5	4.6	3.3
(N)	(414)	(1 272)	(1 066)	(275)	(1 018)	(139)

[a] Figures shown are percentages.

Comment:

Male teachers are somewhat older than female teachers.

Table II.4 – Length of Teaching Experience[a]

Years of Experience	Early	Middle	Senior
1 year	3.1	6.5	2.1
2-5 years	15.2	16.5	9.4
6-9 years	14.4	21.6	15.0
10-13 years	22.7	17.0	22.9
14 years or more	44.0	37.9	50.2

[a] Figures shown are percentages.

Comment:

More than half of the science teachers have more than 10 years' experience. Teachers at the senior-years level are somewhat more experienced.

Figure II.2 – Length of Teaching Experience

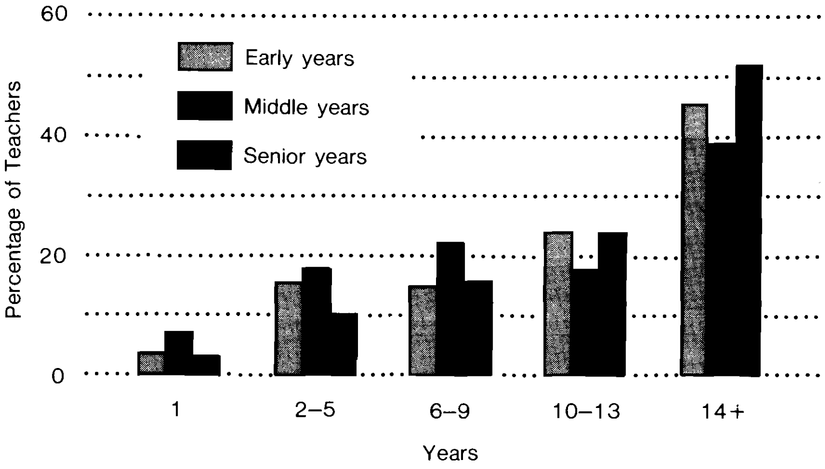


Table II.5 – Length of Teaching Experience by Sex[a]

	Early		Middle		Senior	
Experience	M	F	M	F	M	F
1-5 years	21.1	17.7	17.6	35.9	10.0	28.1
6-9 years	17.2	13.3	23.4	17.4	14.4	17.8
10-13 years	26.8	21.6	16.8	17.9	24.4	13.2
14 years or more	34.7	47.2	42.1	28.6	51.1	40.8
(N)	(411)	(1 272)	(1 065)	(274)	(1 017)	(138)

[a] Figures shown are percentages.

Comment:

At the middle- and senior-years levels, male teachers are more experienced than female teachers. At the early-years level, female teachers are slightly more experienced.

Table II.6 – Length of Teaching Experience by School Location[a]

	Early		Middle		Senior	
Experience	Urban	Rural	Urban	Rural	Urban	Rural
1-5 years	7.2	18.9	10.9	25.6	9.2	12.9
6-9 years	10.5	13.9	17.8	24.9	13.0	16.0
10-13 years	30.8	20.6	18.2	16.0	22.5	23.7
14 years or more	50.9	46.0	52.3	33.2	55.2	46.7
(N)	(434)	(1 026)	(350)	(617)	(351)	(606)

[a] Figures shown are percentages. No data are included for British Columbia because the urban/rural indicator was unavailable for that province.

Comment:

Teachers in urban areas are somewhat more experienced than those in rural areas.

Educational Background

Tables II.7 to II.13 show evidence of an increasingly highly qualified teaching force (the vast majority of science teachers have university degrees); but, on the other hand, over half the teachers (at all levels) have not taken a university-level course in mathematics or science for over 10 years, if at all.

The trend towards higher academic qualifications for teachers during the past 20 years is demonstrated graphically in Table II.9. At the early-years level, 57.8 per cent of teachers with 14 or more years of experience have university degrees; this proportion increases to 82.8 per cent for teachers with 1 to 5 years of experience (i.e., the younger teachers). However, when teachers' education in specific subjects is examined (Tables II.10, II.11 and II.12), the trend becomes less clearly defined. Over one-third of all middle-years teachers have taken no university-level mathematics or science; over one-half of all early-years teachers have taken no mathematics, and nearly three-quarters of them have taken no science at university level. Even at the senior-years level, where 83.3 per cent of teachers have studied university mathematics and 94.5 per cent have studied university science, it is frequently a long time since those courses were taken. For two-thirds of senior-years teachers, it is more than five years and, for one-third of them, more than 10 years since they last took a university science course. However, a significant number of teachers at all levels appears to have been in touch with the university in the last five years. Over 60 per cent of early-years teachers have taken an education course; one-quarter of these courses have been taken at the graduate level.

But teachers learn about science in more ways than by taking university courses. One of these ways is through employment in areas other than science teaching. Researchers asked about what science-related employment teachers had experienced; the results are reported in Table II.13. It appears that a significant number of teachers, especially in the senior years, have had some science-related experience outside the academic world. Such experience could be important if a teacher is called upon to demonstrate the relationship between scientific knowledge and the practical business of research, development or agriculture.

Table II.7 – Teachers' Level of Education[a]

Level of Education	Early	Middle	Senior
Teacher's college diploma	33.2	10.3	4.1
Bachelor's degree	58.0	70.9	69.1
Postgraduate degree	7.4	18.0	26.0

[a] Figures shown are percentages.

Comment:

At the middle- and senior-years levels, about 9 out of 10 teachers have a university degree; at the early-years level, two out of three teachers have a university degree.

Table II.8 – Teachers' Level of Education by Sex[a]

	Early		Middle		Senior	
Level of Education	M	F	M	F	M	F
Teacher's college diploma	7.9	41.3	7.0	19.8	4.2	3.7
Bachelor's degree	70.3	55.0	73.7	64.6	68.9	74.0
Postgraduate degree	21.6	3.5	19.1	15.4	26.8	22.1
(N)	(411)	(1 267)	(1 065)	(275)	(1 011)	(139)

[a] Figures shown are percentages.

Comment:

At the early- and middle-years levels, male teachers tend to be better educated than female teachers, but there is no difference at the senior-years level.

Figure II.3 – Teachers' Level of Education by Sex

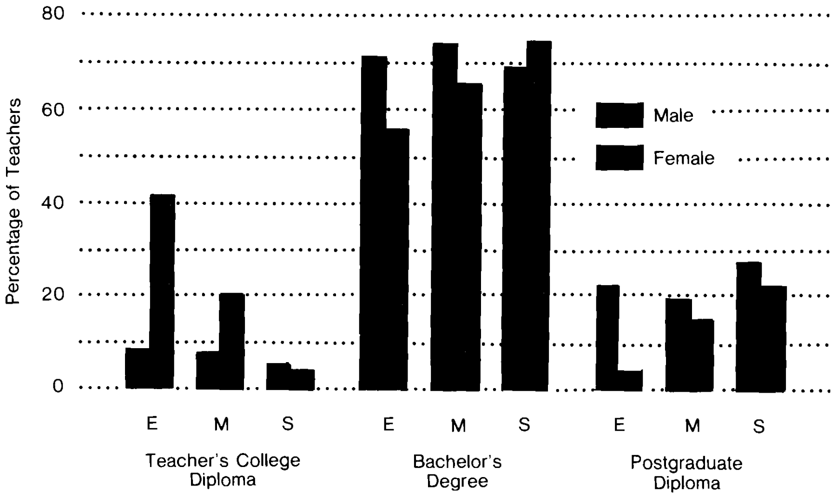


Table II.9 – Teachers' Level of Education by Length of Teaching Experience[a]

Level of Education	1-5 years	6-9 years	10-13 years	14+ years
Early Years				
-Teacher's college diploma	19.1	25.3	35.8	42.0
-Bachelor's degree	75.7	64.9	57.1	49.7
-Postgraduate degree	5.1	9.6	6.9	8.1
-(N)	(435)	(286)	(336)	(618)
Middle Years				
-Teacher's college diploma	2.0	9.6	4.3	20.1
-Bachelor's degree	81.4	82.6	81.5	53.1
-Postgraduate degree	16.5	7.7	14.0	26.7
-(N)	(290)	(296)	(293)	(460)
Senior Years				
-Teacher's college diploma	1.1	1.1	6.2	4.8
-Bachelor's degree	86.9	78.5	59.8	67.1
-Postgraduate degree	11.8	20.2	33.9	27.9
-(N)	(152)	(189)	(258)	(549)

[a] Figures shown are percentages.

Comment:

Less experienced (i.e., younger) teachers tend to have more education than more experienced teachers.

Table II.10 – Teachers' Level of Education[a]

Level of Education	Mathematics	Pure Science	Applied Science	Education
Early Years				
-No university study	55.2	72.7	85.9	20.5
-Undergraduate level	39.6	23.0	8.5	68.1
-Postgraduate level	1.5	0.4	0.3	7.6
Middle Years				
-No university study	40.4	35.8	65.1	10.0
-Undergraduate level	54.5	59.6	28.8	71.2
-Postgraduate level	1.7	3.6	3.5	17.2
Senior Years				
-No university study	13.7	4.6	61.6	5.3
-Undergraduate level	79.4	78.0	28.7	72.4
-Postgraduate level	3.9	16.5	3.6	20.0

[a] Figures shown are percentages.

Comments:

1. More than half the early-years teachers have no university-level mathematics.
2. Nearly three-quarters of the early-years teachers have no university-level science.
3. One-third of the teachers at the middle-years level have had no university-level mathematics or science.

Table II.11 – Teachers' Level of Education in Specific Subjects by Sex[a]

	Early		Middle		Senior	
Level of Education	M	F	M	F	M	F
Mathematics						
-No university study	45.8	60.7	32.8	63.0	12.4	24.0
-Undergraduate level	49.6	38.4	64.9	35.8	83.4	73.2
-Postgraduate level	4.4	0.7	2.1	1.0	4.0	2.6
-(N)	(405)	(1 216)	(1 041)	(267)	(995)	(134)
Pure Science						
-No university study	59.7	80.5	27.3	56.4	4.4	5.1
-Undergraduate level	39.5	19.1	68.3	41.4	79.3	77.2
-Postgraduate level	0.6	0.2	4.3	2.1	16.1	17.5
-(N)	(407)	(1 218)	(1 051)	(270)	(1 008)	(139)

[a] Figures shown are percentages.

Comments:

1. Female teachers tend to be less qualified than male teachers in mathematics and science.
2. There is an 80 per cent chance that a female teacher at the early-years level has not had any science since high school and a 60 per cent chance that she has not had any mathematics since high school.

Table II.12 - Time Since Last Postsecondary Course in Specific Subjects[a]

Time Since Last Course	Mathematics	Pure Science	Applied Science	Education
Early Years				
-Never taken	32.2	45.9	57.2	6.6
-More than 10 years	26.7	26.0	18.4	14.7
-6-10 years	18.1	14.1	11.3	16.1
-1-5 years	19.0	11.2	9.1	46.2
-Currently enrolled	1.8	0.0	0.7	14.6
Middle Years				
-Never taken	31.4	22.9	42.1	5.3
-More than 10 years	26.1	28.1	18.2	15.4
-6-10 years	25.0	28.4	23.3	20.2
-1-5 years	13.6	18.2	13.3	44.6
-Currently enrolled	3.0	1.5	1.3	13.6
Senior Years				
-Never taken	12.6	4.4	46.8	4.5
-More than 10 years	42.3	34.0	23.4	24.3
-6-10 years	24.5	31.7	14.8	28.1
-1-5 years	16.9	27.3	10.8	33.8
-Currently enrolled	1.7	1.6	1.8	7.9

[a] Figures shown are percentages.

Comment:
Most teachers have not taken a college course in a subject other than education in the last 10 years.

Table II.13 – Types of Science-Related Employment Experienced by Teachers[a]

Type of Employment[b]	Early	Middle	Senior
None	77.2	44.3	37.3
Work in a science library	1.1	1.5	2.1
Routine work in a testing or analysis laboratory	5.1	13.7	24.0
Research or development on methods, products or processes	2.7	10.1	16.0
Basic research in physical, medical, biological or earth sciences	3.8	13.2	19.5
Work in farming, mining or fishing	14.5	26.0	26.1
Other industrial work including engineering	4.2	14.4	20.3

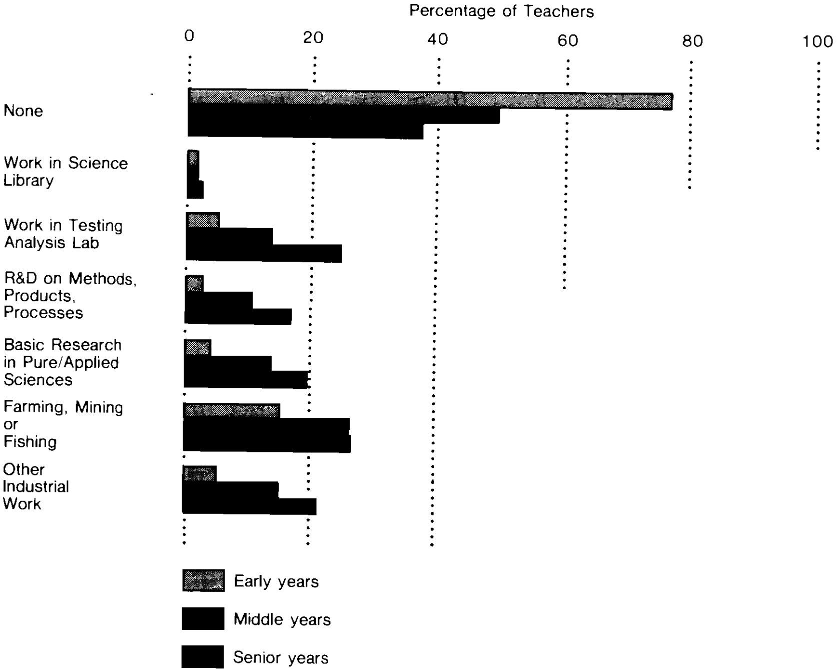
[a] Figures shown are percentages.

[b] Respondents were requested to indicate all categories that applied. The columns do not, therefore, total 100 per cent.

Comment:

More than half of the teachers at middle- and senior-years levels have had some experience of science other than through their school or university courses.

Figure II.4 – Types of Science-Related Employment Experienced by Teachers



Attitudes Towards Teaching and Teacher Education

Teachers' assessments of their education, both in science and as teachers, were sought; Table II.14 presents the results of this inquiry. In general, it appears that teachers' degree of satisfaction with their education in science is roughly proportional to the amount of it they have had. The least satisfied were the early-years teachers and the most satisfied, the senior-years teachers.

Teachers' attitudes to their work were also sought with a question that asked if they would prefer to avoid teaching science altogether. Predictably, the senior-years teachers answered strongly in the negative, but an encouraging number of early-years teachers (63 per cent) did also. It appears that science teachers at all levels are enthusiastic about teaching science. Teachers who wished to avoid teaching science most often cited an inadequate background as the major reason; for example, of early-years teachers giving this as a reason, 83 per cent had had no university science courses.

Table II.14 – Teachers' Assessments of Their Education[a]

Assessment	Early	Middle	Senior
Science Education			
-Very unsatisfactory	17.4	7.4	1.6
-Fairly unsatisfactory	29.2	25.7	7.3
-Fairly satisfactory	43.0	45.4	45.3
-Very satisfactory	8.6	21.1	45.1
Teacher Education			
-Very unsatisfactory	13.1	9.1	8.3
-Fairly unsatisfactory	23.5	21.9	22.2
-Fairly satisfactory	38.4	50.3	45.4
-Very satisfactory	23.1	17.9	23.3

[a] Figures shown are percentages.

Comments:

1. Senior-years teachers are more satisfied with their education in science than middle- or early-years teachers. Teachers' satisfaction with teacher training is about equal to their satisfaction with the education in science they received.
2. Analysis by level of education shows that teachers who took more science at university are more satisfied with the quality of their education in science than are those who took no university science.
3. Teachers who took more courses in education are not more satisfied with their teacher training than are those who took fewer education courses.

Table II.15 – Teachers' Responses to the Question, "If you had a choice, would you avoid teaching science altogether?"[a]

Response	Early	Middle	Senior
Yes	18.6	9.5	4.5
No	63.1	77.2	87.5
Undecided	9.7	9.6	3.2

[a] Figures shown are percentages.

Comment:

The majority of science teachers want to teach science; however, at the early-years level, more than 1 in 4 does not, or is undecided.

Figure II.5 – Teachers' Responses to the Question, "If you had a choice, would you avoid teaching science altogether?"

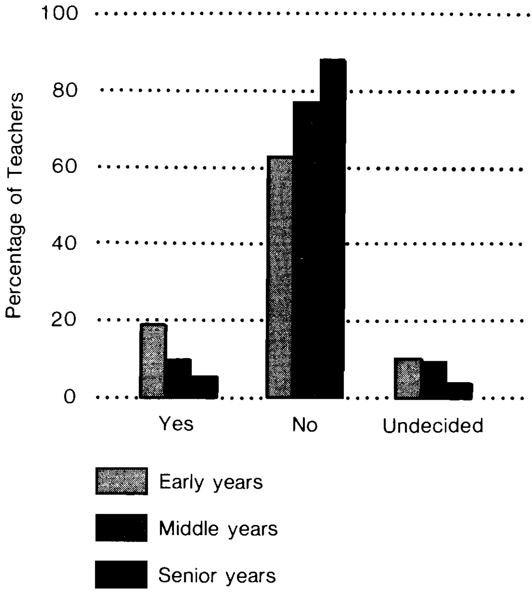


Table II.16 – Teachers' Responses to the Question, "If you had a choice, would you avoid teaching science altogether?" by Sex[a]

	Early		Middle		Senior	
Response	M	F	M	F	M	F
Yes	14.5	21.9	7.6	14.6	5.8	3.8
No	76.8	66.7	84.8	69.5	90.8	92.8
Undecided	8.6	11.2	7.5	15.8	3.3	3.2
(N)	(384)	(1 171)	(1 015)	(257)	(961)	(133)

[a] Figures shown are percentages.

Comment:

At the early- and middle-years levels, nearly one-third of female teachers would rather not teach science or are undecided.

Table II.17 – Reasons for Avoiding Science Teaching[a]

Reason(s)	Early	Middle	Senior
Lack of Resources	34.7	34.4	25.8
Inadequate Background	54.6	54.8	29.7
Dislike of Science	20.7	27.0	0.0
Working Conditions	23.1	43.4	59.5
Student Attitudes	4.3	17.0	39.4
Other	16.5	21.7	33.4
(N)	(346)	(160)	(53)

[a] Figures shown are percentages. The figures are based only on those respondents who indicated that they would prefer to avoid teaching science. In addition, respondents were requested to indicate all categories that applied; the columns do not therefore total 100 per cent.

Comments:

1. Inadequate background is the reason most often cited by teachers for not wanting to teach science.
2. Of those early-years teachers citing inadequate background as a reason for avoiding science teaching, 83 per cent had not studied pure science at university.

III. Objectives of Science Teaching

The focus of the study (see volume I, chapter I) is on the aims and objectives of science education in Canadian schools. All of the components of the research program were designed to clarify the educational objectives found in the rhetoric and practice of science teaching. Specifically, the survey of science teachers was designed to discover: (1) which objectives teachers consider to be important for the level at which they teach, and (2) which objectives teachers think they are most successful in achieving through their present teaching. This information complements the information obtained about the aims and objectives mandated by ministries of education (volume I, chapter V) and about the educational objectives contained in science textbooks (volume I, chapter VII). It also sheds light, implicitly, on teachers' views of the criticisms of science education expressed in the discussion papers and workshop proceedings, where alternative aims for science education are proposed by the authors.

These three sources – ministry policy documents, textbooks and Council's discussion papers – provided a basis for constructing a list of educational objectives to which teachers were asked to respond. The final instrument (see Appendix A) contained 14 objectives representing all eight categories of aims contained in ministry guidelines and the major themes of the discussion papers (the need for a Canadian context, the need to teach the practical skills of an engineer, the need to take special account of the science education of women, etc.). Respondents were asked to indicate their assessments of the importance of each objective for the level at which they themselves taught. The results therefore correspond to early-years teachers' opinions concerning early-years objectives, middle-years teachers' opinions concerning middle-years objectives and so on.

Respondents were asked to rate each objective as either "of no importance"; "of little importance"; "fairly important"; or "very important." Rather than present a large mass of data corresponding to all of these responses, we have developed, for each level, a rank ordering of objectives based on the sum of those responding "fairly important" and "very important." Consequently, results expressed in this way are less a measure of the importance of each objective (as assessed by teachers), and more a measure of the degree of consensus among teachers that an objective is important. For discussion purposes, however, these two measures can be regarded as identical. The results are analyzed in two ways. First, the assessments are examined by teaching level – early, middle and senior years – to show which objectives are rated as most important for each level. Second, the various assessments of each objective are discussed in order to facilitate comparisons with the analysis of ministry policies and with the claims made by the authors of the discussion papers. The chapter concludes with the results of teachers' assessments of the effectiveness of their teaching in relation to each of the 14 objectives.

Importance of Objectives: Analysis by Teaching Level

Early Years

Table III.1 shows how early-years teachers assess the importance of educational objectives. Examination of these data reveals three distinct clusters with clear discontinuities at 80 per cent and 50 per cent. The first cluster contains three objectives about whose importance there appears to be a very high degree of consensus. These objectives are those involving attitudes, process skills and social skills. The second cluster comprises six objectives about which there is a moderate consensus that they are important. The remaining five objectives are those about which there is least consensus (below 50 per cent) regarding their importance.

In order to probe this notion of consensus somewhat further, we analyzed the assessments of objectives by province, by sex, by length of teaching experience and by school location. In all of these analyses, a significant degree of consensus was found, but with certain interesting differences. The differences in the data presented in Table III.1 are:

1. At the early-years level, significantly more male teachers (76.5 per cent) than female teachers (59.6 per cent) rated the "science content" objective as fairly or very important. Also, the objective "understanding the way that scientific knowledge is developed" was rated as fairly or very important by 62.0 per cent of male teachers; only 34.1 per cent of female teachers gave it a similar rating.
2. There is a striking difference in the value attached to "science content" as an objective by teachers having different amounts

of teaching experience. At the early-years level, 59.5 per cent of those with more than 10 years' teaching experience rated "science content" as a fairly or very important objective; only 71.7 per cent of those with less than 10 years' experience so rated it.

3. No significant differences were detected between teachers in urban and rural schools.

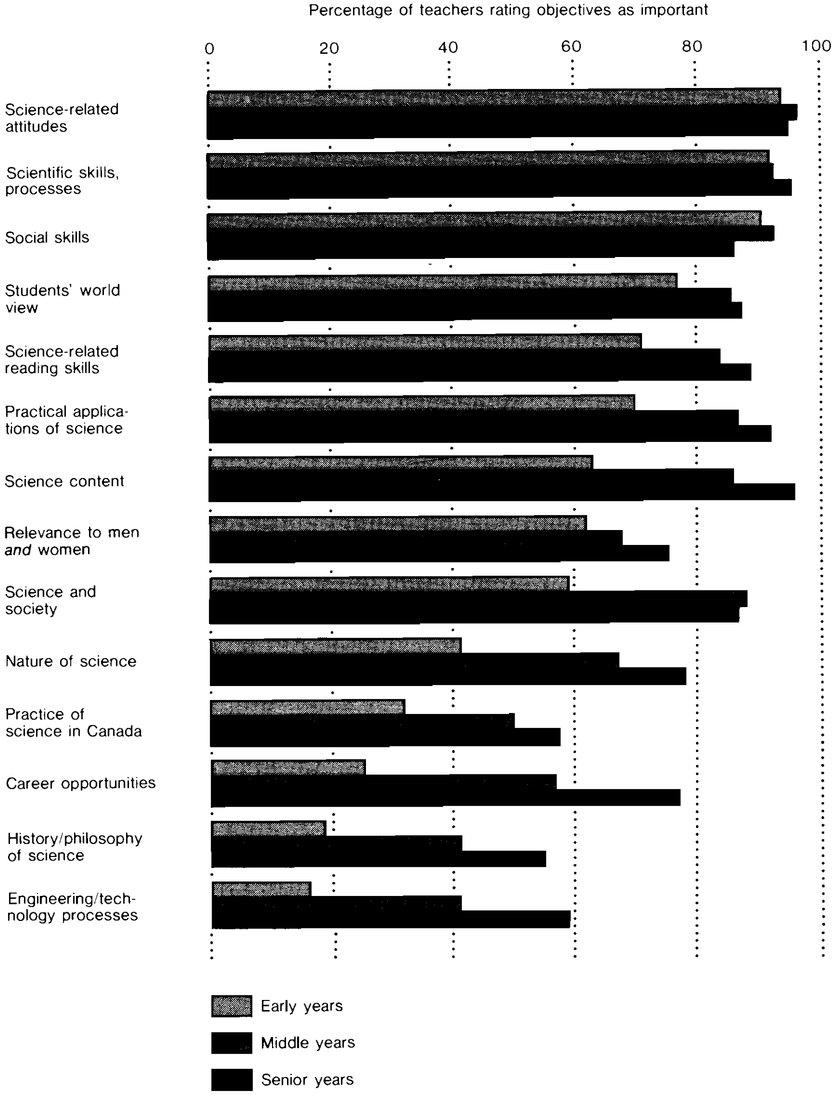
Table III.1 – Importance of Objectives: Early Years[a]

Rank[b]	Objective	Assessment
1.	Developing attitudes appropriate to scientific endeavour	94.3
2.	Developing skills and processes of investigation	92.8
3.	Developing social skills	92.2
4.	Relating scientific explanation to the student's conception of the world	77.8
5.	Developing the skills of reading and understanding science-related materials	70.9
6.	Understanding the practical applications of science	70.4
7.	Understanding scientific facts, concepts and laws	63.6
8.	Understanding the relevance of science to the needs and interests of both men and women	62.5
9.	Understanding the role and significance of science in modern society	59.6
10.	Understanding the way that scientific knowledge is developed	40.7
11.	Developing an awareness of the practice of science in Canada	32.6
12.	Relating science to career opportunities	25.2
13.	Understanding the history and philosophy of science	19.3
14.	Understanding the nature and process of technological or engineering activity	17.9

[a] Figures shown are percentages.

[b] Objectives are ranked according to the percentage of teachers assessing them to be fairly or very important.

Figure III.1 – Teachers' Assessments of the Importance of Objectives



Middle Years

At the middle-years level, many more objectives are regarded by teachers as important. Again, using the 80 per cent and 50 per cent dividing lines, the 14 objectives can be grouped into three clusters. But in this case the proportions of objectives in each cluster are quite different, as the results in Table III.2 show. In the first group, there are eight objectives about whose importance there is strong agreement. The second group (80 per cent to 50 per cent) contains four objectives, and the third group (below 50 per cent) contains only two. The sequence of objectives in the overall list (with a few exceptions) approximates the order of objectives established by early-years teachers, but what is particularly different is the increased importance attached to every objective.

Table III.2 – Importance of Objectives: Middle Years[a]

Rank[b]	Objective	Assessment
1.	Developing attitudes appropriate to scientific endeavour	96.0
2.	Developing skills and processes of investigation	93.4
3.	Developing social skills	92.9
4.	Understanding the role and significance of science in modern society	88.4
5.	Understanding the practical applications of science	87.8
6.	Understanding scientific facts, concepts and laws	86.6
7.	Relating scientific explanation to the student's conception of the world	86.3
8.	Developing the skills of reading and understanding science-related materials	84.2
9.	Understanding the relevance of science to the needs and interests of both men and women	68.6
10.	Understanding the way that scientific knowledge is developed	66.1
11.	Relating science to career opportunities	56.1
12.	Developing an awareness of the practice of science in Canada	51.4
13.	Understanding the nature and process of technological or engineering activity	40.8
14.	Understanding the history and philosophy of science	40.7

[a] Figures shown are percentages.

[b] Objectives are ranked according to the percentage of teachers assessing them to be fairly or very important.

The objectives in the first cluster include the three identified by most early-years teachers as important – attitudes, process skills and social skills – but to them are added five more: science and society; practical applications of science; science content; relating science to the student's world view; and the skills of reading and understanding science materials. This broader array of objectives in the first cluster reflects the broader variety of purposes for which science is taught at the middle years. The analysis of ministry guidelines reveals a similar effect. It is interesting to note, moreover, that despite the large array of objectives, there is a high degree of consensus (over 80 per cent of the teachers) concerning the importance of as many as eight objectives.

The shift in importance of specific objectives is discussed in the second part of the analysis. Further analysis of the middle-years consensus by sex, length of teaching experience and school location yields several results of note:

1. There are two objectives which tend to be rated as important more often by female teachers than by male teachers. The objective, "to impart an understanding of the relevance of science to the needs and interests of both men and women" (which implies that these "needs and interests" might be different and that any differences should be taken into account) was assessed as fairly or very important by 78.7 per cent of female teachers but by only 64.3 per cent of male teachers. Also, the objective, "to develop an awareness of the practice of science in Canada" was regarded as important by 67.9 per cent of female teachers but by only 44.3 per cent of male teachers. Concerning other objectives, there was less than a 10 per cent difference between the sexes.
2. Analysis of these results on the basis of the length of respondents' teaching experience shows a number of objectives about whose importance more experienced teachers have opinions which differ from those of teachers with less experience. Again, using a spread of more than 10 per cent as the basis for selection, significantly more teachers with over 10 years' experience rated the following objectives as important than did teachers with less than 10 years' experience:
   - understanding scientific facts, concepts and laws;
   - relating science to career opportunities;
   - understanding the nature and process of technological or engineering activity;
   - relating science to the student's conception of the world;
   - understanding the way that scientific knowledge is developed.

   Of course, because this group of teachers rated no objectives lower than did teachers with less experience, it could be argued that these results indicate a different degree of discrimination on the part of less-experienced teachers. However, the differences exist. They are presented here for discussion purposes.

3. At the middle years, two objectives show a spread greater than 10 per cent when the results are analyzed on the basis of the location of the respondents' school. Urban teachers tend to favour the following two objectives more than do rural teachers:
   - understanding the relevance of science to the needs and interests of both men and women (urban – 71.8 per cent; rural – 61.8 per cent);
   - developing an awareness of the practice of science in Canada (urban – 55.5 per cent; rural – 44.5 per cent).

Table III.3 – Importance of Objectives: Senior Years[a]

Rank[b]	Objective	Assessment
1.	Understanding scientific facts, concepts and laws	96.1
2.	Developing skills and processes of investigation	96.1
3.	Developing attitudes appropriate to scientific endeavour	95.7
4.	Understanding the practical applications of science	92.2
5.	Developing the skills of reading and understanding science-related materials	89.2
6.	Understanding the role and significance of science in modern society	87.9
7.	Relating scientific explanation to the student's conception of the world	86.9
8.	Developing social skills	86.1
9.	Understanding the way that scientific knowledge is developed	78.0
10.	Relating science to career opportunities	77.3
11.	Understanding the relevance of science to the needs and interests of both men and women	72.8
12.	Understanding the nature and process of technological or engineering activity	58.9
13.	Developing an awareness of the practice of science in Canada	58.6
14.	Understanding the history and philosophy of science	54.6

[a] Figures shown are percentages.

[b] Objectives are ranked according to the percentage of teachers assessing them to be fairly or very important.

Senior Years

Table III.3 shows the results of the senior-years teachers' assessments of the importance of objectives. If the two points of division (80 per cent and 50 per cent) are retained, all 14 objectives now fall into the top two clusters. The consensus appears to be that all the objectives are fairly or very important. The consensus is strongest (over 80 per cent) in regard to eight particular objectives, the same set of eight, in fact, that were in the highest cluster at the middle-years level.

1. When these results are analyzed on the basis of the sex of the respondents, female teachers again appear to favour two objectives more than do male teachers:
    - understanding the relevance of science to the needs and interests of men and women (M - 71.6 per cent; F - 82.3 per cent)
    - developing an awareness of the practice of science in Canada (M - 56.8 per cent; F - 72.0 per cent)
2. When analyzed on the basis of length of respondents' teaching experience, only one objective shows a difference greater than 10 per cent:
    - developing an awareness of the practice of science in Canada (1 to 5 years' experience – 67.0 per cent; over 14 years' experience – 56.7 per cent)
3. No significant differences could be detected between responses of teachers in urban and rural schools.

In general, there appears to be a uniformly high degree of consensus among senior-years teachers that all the objectives – but particularly the eight in the first cluster – are important. Of course, as was noted earlier, this result can mean two things. On the one hand, teachers may, at the senior years, be striving to reach a very broad array of objectives. On the other hand, senior-years teachers may not be as discriminating as are, for example, early-years teachers concerning what are, in fact, their most important objectives. Consequently, senior-years teachers rate all the objectives as important. In either case, the question is raised as to how many objectives can realistically be pursued. This same question arises from the analysis of ministry of education policy documents (volume I, chapter V). Likewise the trend (noted in volume I, chapter V) towards more objectives as one progresses from early- through middle- to senior-years levels is evident here also. This is hardly surprising in view of the fact that the guidelines documents are usually drafted by committees of teachers (see volume I, chapter IV).

Importance of Objectives: Analysis by Objective

In order to facilitate comparison with the analyses of aims contained in ministry guidelines, the same categories of aims used in that section of the report are used as the basis for the present discussion. Table III.4 compares the 14 objectives used in the survey questionnaire to the eight categories of educational objectives listed by ministries of education (as defined in general terms in volume I, chapter V). The groupings found in Table III.4 may be open to question; they are used here merely as a means of organizing the discussion. No revision of the original set of categories is implied or intended. The results of the teachers' assessments can, however, be compared with the aims endorsed by ministries.

Table III.4 – Categories of Aims and Objectives

Category of Aims	Survey Objective(s)
Science Content	Understanding scientific facts, concepts and laws
Scientific Skills/Processes	Developing skills and processes of investigation
Science and Society	Understanding the role and significance of science in modern society
	Developing an awareness of the practice of science in Canada
Nature of Science	Understanding the way that scientific knowledge is developed
	Understanding the history and philosophy of science
Personal Growth	Developing social skills
	Developing the skills of reading and understanding science-related materials
	Understanding the relevance of science to the needs and interests of both men and women
	Relating scientific explanation to the student's conception of the world
Science-Related Attitudes	Developing attitudes appropriate to scientific endeavour
Applied Science/Technology	Understanding the practical applications of science
	Understanding the nature and process of technological or engineering activity
Career Opportunities	Relating science to career opportunities

Science Content

The learning of science content is of central importance as an educational objective at the senior-years level, both in the guidelines and in teachers' assessments. At the middle-years level, it is one of the three aims found in every guideline, and it is endorsed by 86.6 per cent of teachers as being of major importance. As was mentioned earlier, all early-years guidelines specify "learning of content" as an aim, but they also point out that this is not the central aim of the program. Teachers clearly share this view; only 63.6 per cent of early-years teachers assessed this objective as fairly or very important. Overall, this objective is evidently not controversial, although the question concerning the desirable balance between teaching content and achieving other aims remains unresolved.

Scientific Skills/Processes

The development of scientific skills is endorsed as an objective by all ministry documents at early- and middle-years levels (as well as by most documents at the senior-years level) and by teachers at all three levels. Aims of this type are uncontroversial, although questions about which skills should be taught at which levels continue to be asked.

Science and Society

One of these objectives – understanding the role and significance of science in modern society – is regarded as very important at both middle-years (88.4 per cent) and senior-years (87.9 per cent) levels. However, the other – developing an awareness of the practice of science in Canada – is rated uniformly low at all three levels, ranking 11/14 at the early-years level, 12/14 at the middle-years level, and 13/14 at the senior-years level. These ratings parallel those made implicitly in ministry guidelines. There appears to be an increasing awareness among science educators (especially at the middle years) of the need to teach students about the relationship between science and society, but there is no great concern that this relationship be discussed with reference to Canadian society in particular. The concerns of Thomas Symons and James Page, that science is not portrayed as part of the cultural fabric of Canadian society, would appear to be well founded. The analysis of textbooks (see volume I, chapter VII) tends to confirm this observation.

Nature of Science

These objectives were amongst those regarded as very important during the curriculum reform movement of the 1960s. However, teachers found that only the brightest students could achieve them. The relatively low ratings given to them in this survey attest to their declining popularity. At the senior years, where most guidelines still contain objectives of this type, teachers ranked them 9/14 and 14/14. At other levels, these objectives were assigned even less importance, both in the guidelines and by teachers.

Personal Growth

As explained earlier, this category of objectives is rather broad and diffuse. It involves the development of characteristics or qualities – such as creativity, a sense of responsibility, cooperation – whose relevance or application goes beyond the field of science, being more closely related to the broader goals of education. As Table III.4 shows, this category includes four rather diverse objectives that do not readily fit elsewhere. At the early level, the development of social skills and reading skills is (predictably) important to both ministries of education and to teachers. These objectives become progressively less important at higher levels. (Although the reading and understanding of science-related materials is stressed by senior-years teachers, we assume that their emphasis is less on basic reading skills and more on the need for understanding science-related materials.) The objective implying possible differences among girls and boys in relation to science education has already been discussed in connection with the analysis of responses on the basis of sex. Its relatively low ranking at all levels perhaps reflects a relatively low level of awareness among teachers about the need to encourage girls to study science. Its total absence from ministry guidelines, as noted earlier, tends to confirm this hypothesis. Finally, the objective, "to relate scientific explanation to the student's conception of the world," touches on students' readiness to accept science as a way of understanding the world. Implicit in the objective is the basis for dealing with controversial moral or religious issues such as creation and evolution. Teachers at the early-years level rank this objective high (4/14); at the other levels also there is agreement (86.3 per cent at middle years and 86.9 per cent at senior years) concerning its importance.

Science-Related Attitudes

This objective is uniformly important in both guidelines and teacher assessments at all three levels.

Applied Science/Technology

Objectives in this category are of two types: those having to do with teaching about the practical applications of science (the products of engineering and technology) and those having to do with teaching the "process skills" of the engineer or technologist. The former type of objective is highly rated at all levels, especially at the senior-years level; the latter is rated low at all levels (14/14 at early years, 13/14 at middle years and 12/14 at senior years). As was evident from the analysis of guidelines, ministries of education appear ambivalent concerning these objectives. Teachers' assessments of the importance of these objectives also indicate a certain ambivalence concerning the importance of teaching about technology in "science" education.

Career Opportunities

Predictably, this objective is rated highly only by senior-years teachers, 77.3 per cent of whom consider it to be important – not a very high proportion, given the current recession.

Effectiveness of Teaching: Analysis by Teaching Level

In this question, teachers were presented with the same list of objectives as before and asked, "How effective do you feel that your teaching is at enabling students to achieve each of the following objectives?" Teachers were asked to respond using a four-point scale, ranging from "very ineffective" through "very effective." They were also given the option of indicating that they had not attempted a given objective. In Tables III.5, III.6 and III.7, the total number of teachers responding 3 (fairly effective) and 4 (very effective) to each objective is reported as a percentage of the total number of respondents. The sequence of objectives used in Tables III.1, III.2 and III.3, respectively, is retained.

Early Years

In general, teachers feel that those objectives they consider to be the most important are also those that their teaching is most effective in achieving. The only objective in the first two clusters (objectives 1 to 9) that the majority of teachers considered themselves to have been unsuccessful in achieving is the one involving the needs and interests of both men and women. Most of the objectives in the third cluster have not been attempted by a significant proportion of teachers.

Middle Years

At the middle-years level, teachers' assessments of effectiveness are, again, very similar to their assessments of importance. The most notable exception concerns the "science and society" objective: 88.4 per cent of teachers rate it as an important objective, but only 64.9 per cent of them consider their teaching to be effective in achieving it. By contrast, the objective "understanding scientific facts, concepts and laws" is rated highly on the effectiveness scale.

Senior Years

The close relationship between assessments of importance and effectiveness can be seen at the senior-years level also. Again, the "science and society" objective is thought to be important by a high proportion of science teachers (87.9 per cent), but considered to be effectively achieved by a significantly smaller proportion (69.3 per cent). The same is true for the objective, "developing the skills of reading and understanding science-related materials" (importance – 89.2 per cent; teaching effectiveness – 67.6 per cent) and for the objective "relating scientific explanation to the student's conception of the world" (importance – 86.9 per cent; teaching effectiveness – 71.2 per cent). These assessments underscore our concern for the number of objectives which a science program can realistically be expected to attain.

Finally, it should be asked whether teachers can make an accurate assessment of the effectiveness of their own teaching. As more sophisticated systems of learning assessment are introduced by several provinces, it may be possible to "assess" the teachers' assessments. For the present, these assessments are reported here as they were recorded.

There are many reasons why objectives considered by teachers to be important are nevertheless difficult to achieve in practice. The remaining chapters in this part of the report explore some of the obstacles that may keep teachers from attaining educational objectives.

Table III.5 – Effectiveness of Teaching: Early Years

Objective[a]		Assessment[b]
1.	Developing attitudes appropriate to scientific endeavour	90.7
2.	Developing skills and processes of investigation	90.2
3.	Developing social skills	92.4
4.	Relating scientific explanation to the student's conception of the world	66.3
5.	Developing the skills of reading and understanding science-related materials	67.9
6.	Understanding the practical applications of science	66.3
7.	Understanding scientific facts, concepts and laws	64.6
8.	Understanding the relevance of science to the needs and interests of both men and women	45.0
9.	Understanding the role and significance of science in modern society	49.5
10.	Understanding the way that scientific knowledge is developed	31.4
11.	Developing an awareness of the practice of science in Canada	19.6
12.	Relating science to career opportunities	18.6
13.	Understanding the history and philosophy of science	16.6
14.	Understanding the nature and process of technological or engineering activity	14.1

[a] The order of objectives is the same as in Table III.1.

[b] Percentage of teachers assessing their teaching as fairly or very effective in achieving their objectives.

Table III.6 – Effectiveness of Teaching: Middle Years

Objective[a]		Assessment[b]
1.	Developing attitudes appropriate to scientific endeavour	86.0
2.	Developing skills and processes of investigation	88.7
3.	Developing social skills	64.9
4.	Understanding the role and significance of science in modern society	64.9
5.	Understanding the practical applications of science	79.0
6.	Understanding scientific facts, concepts and laws	87.9
7.	Relating scientific explanation to the student's conception of the world	76.8
8.	Developing the skills of reading and understanding science-related materials	71.0
9.	Understanding the relevance of science to the needs and interests of both men and women	51.5
10.	Understanding the way that scientific knowledge is developed	52.2
11.	Relating science to career opportunities	38.8
12.	Developing an awareness of the practice of science in Canada	28.2
13.	Understanding the nature and process of technological or engineering activity	26.5
14.	Understanding the history and philosophy of science	35.8

[a] The order of objectives is the same as in Table III.2.

[b] Percentage of teachers assessing their teaching as fairly or very effective in achieving their objectives.

Table III.7 – Effectiveness of Teaching: Senior Years

Objective[a]		Assessment[b]
1.	Understanding scientific facts, concepts and laws	96.1
2.	Developing skills and processes of investigation	89.3
3.	Developing attitudes appropriate to scientific endeavour	83.7
4.	Understanding the practical applications of science	79.7
5.	Developing the skills of reading and understanding science-related materials	67.6
6.	Understanding the role and significance of science in modern society	69.3
7.	Relating scientific explanation to the student's conception of the world	71.2
8.	Developing social skills	77.5
9.	Understanding the way that scientific knowledge is developed	66.3
10.	Relating science to career opportunities	47.7
11.	Understanding the relevance of science to the needs and interests of both men and women	46.2
12.	Understanding the nature and process of technological or engineering activity	39.2
13.	Developing an awareness of the practice of science in Canada	27.9
14.	Understanding the history and philosophy of science	46.0

[a] The order of objectives is the same as in Table III.3.

[b] Percentage of teachers assessing their teaching as fairly or very effective in achieving their objectives.

IV. Instructional Contexts of Science Teaching

The achievement of objectives for science education depends in large measure on the importance accorded those objectives by teachers. But other factors are also involved, including the availability (to both teacher and students) of appropriate curriculum resources (textbooks, software, magazines, etc.), the adequacy of the teacher's background for the specific pedagogical tasks required, the interests and abilities of the students, the physical facilities and equipment provided, the institutional arrangements (such as teaching schedule and class size) and the degree of professional (e.g., school principal) and community (e.g., parental) support for science teaching. Any one of these factors can make the achievement of any objectives, however desirable in principle, impossible in practice. Given this fact, well established by educational research, one may wonder how *any* objectives can be met successfully. But some are; schools do result in students' learning. However, it is naive to expect real change in the combination or balance of objectives of science education while ignoring factors such as those listed above. Likewise, it is necessary for a study such as the present one to determine as much information as possible about those contextual factors if it is to inform a deliberative process that may contemplate changes in the direction of science education.

Information concerning six such factors was collected in the survey of science teachers. Three of these are discussed in this chapter:

- Curriculum resources (Tables IV.2 to IV.6);
- Teacher's background and experience (especially inservice education) (Tables IV.7 to IV.10);
- Students' abilities and interests (Tables IV.11 to IV.15).

These factors directly affect the substance of a teacher's instructional interaction with his or her students.

In chapter V, three other factors, one step removed from the instructional process but none the less important, are examined: the physical facilities and equipment available; institutional arrangements (such as class size and time allocation); and the extent of community and professional support for science teaching. First, however, we needed to be sure that these six factors were all, in the opinion of teachers, relevant to the problem of achieving objectives. Table IV.1 reports teachers' responses to this question; it shows that all six factors are, to different degrees at different levels, important to teachers. At the early- and middle-years levels, physical facilities and institutional factors are of concern to most teachers. At the senior years, students' abilities and interests are cited most often as being important. However, further investigation of each of these six areas is clearly warranted.

Table IV.1 – Obstacles to the Achievement of Objectives

	Percentage of teachers assessing various areas as containing fairly or very important obstacles to the achievement of their objectives		
Areas Containing Potential Obstacles	Early	Middle	Senior
Curriculum resources	58.5	61.8	57.4
Teacher's background and experience	62.8	50.0	41.8
Students' abilities and interests	67.2	74.4	77.0
Physical facilities and equipment	75.3	73.2	61.1
Institutional arrangements (e.g., class size)	78.1	77.3	74.6
Community and professional support	47.0	50.9	46.1

Comment:
To some extent all areas contain obstacles to the achievement of objectives. Of most importance to teachers are institutional arrangements; of least concern is community and professional support.

Curriculum Resources

Five questions on the survey focussed on curriculum resources and curriculum development. The results of these inquiries are reported in Tables IV.2 to IV.6.

Teachers use curriculum resources to plan their lessons. Table IV.2 shows the degree to which teachers value various resources for this purpose. It is interesting to note that textbooks – both those approved for student use and others – are a major resource for three out of four teachers. School libraries are noted by over 80 per cent of early-years teachers as being important. Surprisingly perhaps, the ministry guidelines themselves, although they form the policy basis for the science curriculum, are not used as a primary resource for planning by a large proportion of teachers. It is also worth noting that teachers make little use of materials not produced specifically for educators. Science magazines, journals and newsletters are cited as important resources by 72.4 per cent of senior-years teachers, but respondents probably interpreted this category of resources as including science *education* magazines and journals as well as scientific periodicals.

A series of questions focussed on the textbooks used by students. At the senior- and middle-years levels, a large number of respondents reported that their students use textbooks (Table IV.3) and that, in general, these texts are satisfactory (Table IV.4). These assessments were based on a number of specific criteria and referred to texts named by respondents.*

Two final questions in this section concern the processes used for developing curricula. Tables IV.5 and IV.6 suggest that teachers believe that development work is best done either by ministries of education or by committees of teachers at school-board level. This distribution of responsibility reflects essentially the present situation in which school boards have formal responsibility for the implementation of ministry policies. However, only a few teachers think that the selection of textbooks is a task best accomplished by ministries of education. Finally, most teachers report that they have not had an opportunity to participate in curriculum development activities beyond the school level.

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* Only teachers' general assessments of textbooks are reported in this volume. Detailed assessments are reported in volume I.

Table IV.2 – Resources for Planning Instruction

	Percentage of teachers assessing various resources as fairly or very important in the planning of their instruction (with ranking)		
Resources	Early	Middle	Senior
Ministry policy statements	50.4 (8)	56.1 (8)	48.0 (7)
Supplementary material from the ministry of education	48.0 (9)	43.3 (9)	31.0 (11)
Provincially approved textbooks	61.6 (4)	73.4 (3)	78.0 (2)
Other science textbooks	56.7 (6)	74.8 (1)	81.5 (1)
Commercially published curriculum materials	65.4 (3)	59.4 (6)	50.4 (6)
Curriculum materials developed locally	67.8 (2)	60.5 (5)	50.7 (5)
Materials from teachers' association	40.7 (11)	31.3 (11)	37.0 (9)
Materials from the school library	82.5 (1)	74.5 (2)	62.8 (4)
Publications from government departments	33.4 (12)	29.8 (12)	26.9 (12)
Science magazines, journals, newsletters	53.2 (7)	69.1 (4)	72.4 (3)
Industrially sponsored free materials	42.6 (10)	40.4 (10)	32.4 (10)
TV or radio programs or tapes	56.8 (5)	58.1 (7)	44.0 (8)
Computer software	9.8 (13)	11.6 (13)	14.1 (13)

Comment:

Textbooks, both provincially approved and others, are important – especially at senior and middle years. School libraries provide important resources, especially at the early years.

Table IV.3 – Use of Textbooks by Students

Percentage of teachers whose students use a science textbook		
Early	Middle	Senior
37.6	70.9	89.6

Comment:

At middle and senior levels, the textbook continues to be of great importance. There is great variation among provinces in the early years (low: 7.1 per cent; high: 95.0 per cent).

Table IV.4 – Teachers' Assessments of Textbooks[a]

Criteria	Percentage of teachers assessing the text most often used by students as fairly or completely adequate with respect to various criteria		
	Early	Middle	Senior
Appropriateness of the science content for the grade level you teach	84.4	78.8	83.3
The relationship of the text's objectives with your own priorities	78.0	73.5	75.8
Readability for students	72.7	75.1	73.7
Illustrations, photographs, etc.	85.2	79.6	77.4
Suggested activities	76.9	69.6	55.7
Canadian examples	56.1	49.8	28.8
Accounts of the applications of science	65.3	56.7	45.0
Appropriateness for slow students	46.0	30.5	25.7
Appropriateness for bright students	78.5	72.4	79.5
References for further reading	49.4	38.7	46.3
Overall impression	76.0	75.1	74.9
(N)[b]	(722)	(890)	(882)

[a] These assessments were made of specific textbooks named by the respondents. This table provides a general view of the degree of teachers' satisfaction with the textbooks their students use; see volume I, chapter 6 for assessments of individual textbooks.

[b] This question was only answered by those naming a textbook in a previous question. In addition, there was a typographical error in the questionnaire. As a result, there was a larger number of nonrespondents than usual.

Comment:

Textbooks are generally regarded as adequate except for slow learners.

Table IV.5 – Responsibilities for Curriculum Development[a]

Opinions of teachers (at early, middle and senior levels) concerning which agencies are the most appropriate to take responsibility for various curriculum development tasks

	Defining overall aims			Selecting textbooks			Preparing courses of study		
Agency	E	M	S	E	M	S	E	M	S
Ministry of education	38.1	48.8	47.9	8.5	8.3	14.5	11.1	10.6	18.8
School-board officials	7.1	2.0	1.8	5.9	8.5	1.3	6.7	1.4	1.6
Committee of teachers at school-board level	37.0	35.0	35.8	51.1	43.5	44.2	50.0	49.9	41.9
Families of schools	10.0	5.7	5.9	11.3	8.8	7.8	12.5	5.6	6.2
Individual schools	1.6	1.9	2.0	10.4	13.9	13.2	5.2	7.6	10.2
Individual teachers	3.9	3.2	5.1	9.3	13.5	17.3	11.2	21.1	19.3

[a] Figures shown are percentages.

Comment:

Few teachers believe that ministries of education should select textbooks.

Table IV.6 – Teachers' Participation in Curriculum Development[a]

	Extent to which teachers at early-, middle- and senior-years levels have participated in curriculum planning and development activities at various levels during the past few years								
	No opportunity			Occasionally			Frequently		
Level of activity	E	M	S	E	M	S	E	M	S
School	51.0	28.6	27.9	26.2	24.1	26.2	20.7	44.7	44.6
School board	79.5	67.7	59.2	15.1	23.7	30.6	2.5	6.0	8.3
Provincial ministry	92.7	88.8	79.7	2.7	6.3	13.8	1.2	2.3	4.6
Teachers' association	87.1	79.7	77.2	8.8	15.7	17.3	1.3	2.0	3.6
Other	83.8	82.2	80.0	6.4	7.5	8.9	2.7	3.5	3.8

[a] Figures shown are percentages.

Comment:

Most teachers do not participate in curriculum development activities beyond their own school.

Teachers' Backgrounds and Experiences: Inservice Education

In chapter II, aspects of teachers' backgrounds and experiences were discussed. Here, the focus is on inservice education, an area of particular importance when curriculum changes are planned. Tables IV.7 to IV.10 report on teachers' assessments of the effectiveness of existing inservice programs, teachers' willingness to participate in inservice workshops, teachers' assessments of the amount of inservice education they need, and teachers' opinions concerning the value of various inservice experiences.

The ability of the science education system to be reoriented towards new objectives depends in large measure on its ability to provide useful and effective inservice training to a teaching force that, as was noted in chapter 2, is mature and experienced. Yet, as Table IV.7 shows, teachers do not feel that present inservice programs are very effective. Most teachers are prepared to participate in inservice workshops (Table IV.8) and feel that the present quantity of inservice education is about right (Table IV.9), although different amounts are clearly needed for teachers at different stages of their careers. Table IV.10 reports teachers' opinions concerning the usefulness of specific inservice experiences. Interactions with other science teachers rate highly at all levels. Many senior-years teachers claim that university courses in science are most useful. A large number of teachers, particularly at the early years, report having had no experience of many inservice training alternatives. For example, 71.1 per cent of early-years teachers report never having attended a conference or meeting organized by a science teachers' association. This situation is perhaps the result of a traditional focus on secondary schools by such associations, and also of the need for early-years teachers to keep informed in several subject areas at the same time.

Table IV.7 – Effectiveness of Inservice Education[a]

Teachers' assessments of the inservice program provided in their school or district

Assessment	Early	Middle	Senior
Nonexistent	34.7	29.0	38.7
Completely or fairly ineffective	32.4	34.3	39.5
Fairly or very effective	27.9	33.5	19.6

[a] Figures shown are percentages.

Comment:

At least two out of three teachers find their inservice education program nonexistent or ineffective.

Table IV.8 – Teachers' Participation in Inservice Education

	Percentage of teachers indicating that they would (probably or definitely) participate in an inservice workshop in two specified circumstances		
Circumstances	Early	Middle	Senior
During school hours if release time was given	90.8	96.2	95.7
At a convenient time outside of school hours	63.9	77.9	77.8

Comment:
Three out of four teachers are prepared to participate in inservice workshops in or out of school hours.

Table IV.9 – Teachers' Requirements for Inservice Education[a]

Teachers' assessments of the amounts of inservice education they require per year in order to maintain the quality of their science teaching

Amount	Early	Middle	Senior
None	4.6	7.3	9.8
3-5 hours	30.6	12.3	17.1
5-20 hours	49.3	64.0	52.0
An intensive refresher course	10.8	12.0	10.4
A full year away from the classroom	2.4	3.7	9.5

[a] Figures shown are percentages.

Comment:
Present amounts of inservice education (5-20 hours per year for most teachers) are appropriate.

Table IV.10 – Value of Inservice Education Experiences[a]

	Opinions of teachers (at early, middle and senior levels) regarding various inservice experiences in terms of the contribution to their work as science teachers								
	Completely or fairly useless			Fairly or very useful			No experience		
Inservice Experience	E	M	S	E	M	S	E	M	S
Informal meetings with other science teachers	7.5	2.8	4.8	60.9	90.1	91.8	29.4	6.5	2.7
Informal meetings with university science education personnel	8.9	15.7	17.6	22.9	42.1	58.5	65.9	41.4	22.9
Informal meetings with scientists	6.9	13.0	10.3	9.0	35.5	44.6	81.8	50.5	44.2
Workshops presented by other teachers	5.3	5.1	12.7	61.2	76.3	75.0	31.5	17.9	11.5
Workshops presented by school board	8.8	16.1	31.2	52.6	54.6	41.5	36.5	28.4	26.3
Workshops presented by university science education personnel	7.0	17.6	13.3	16.4	36.3	51.0	74.2	45.2	34.8
Workshops presented by scientists	5.5	6.7	8.4	6.3	24.9	35.8	86.0	67.5	54.7
Workshops presented by ministry of education officials	5.3	15.7	19.1	18.9	28.7	31.4	72.7	54.1	18.2
University courses in science	13.2	13.5	5.8	28.3	59.2	82.0	54.5	25.6	11.1
University courses in science education	12.5	18.9	20.8	34.6	50.8	56.7	49.5	28.7	21.0
Visits to other teachers' classrooms or other schools	4.3	5.6	12.7	53.3	66.1	60.0	38.9	26.4	26.0
Conferences or meetings arranged by science teachers' association	3.7	9.5	9.3	21.6	54.9	72.9	71.1	32.4	16.5
Visits to industry	4.5	14.0	13.1	32.5	45.9	56.7	59.5	36.8	28.9
Visits from industrial personnel	5.1	14.1	16.2	12.0	19.5	28.9	79.1	63.1	53.7

[a] Figures shown are percentages.

Comment:

Teachers believe they learn most from other teachers.

Students' Abilities and Interests

If students are unable or unwilling to learn what is taught to them, then nothing in the world can make an otherwise successfully planned and implemented curriculum effective. As we had agreed with ministries of education at the outset that we would conduct no direct assessment of students' abilities or attitudes, it was necessary to rely on indirect evidence, namely, teachers' assessments of these factors. Tables IV.11 to IV.14 analyze results of these inquiries and Table IV.15 reports teachers' estimates of students' extracurricular activities related to science.

According to the vast majority of teachers, students are both able and well motivated to undertake science courses. Girls and boys have equal ability, according to teachers, but their motivation varies somewhat: boys in the early years and girls in the senior years appear to some teachers to be more motivated. These perceptions tend to be related to the sex of the respondent, though not in a systematic way (Table IV.14). Students also learn about science from extracurricular activities. According to teachers, visits to museums appear to be a good way for early-years students to learn about science; for middle-years students, museums and science fairs are important sources of information.

Table IV.11 – Students' Attitudes Toward Learning Science[a]

Teachers' perceptions of the attitudes of the majority of their students

Student attitude	Early	Middle	Senior
Ready to drop science	0.1	0.8	0.1
Indifferent	9.6	15.1	15.4
Fairly motivated	67.1	68.8	75.1
Highly motivated	21.6	13.0	8.7

[a] Figures shown are percentages.

Comment:
Four out of five teachers find students to be well motivated towards learning science.

Table IV.12 – Students' Backgrounds and Abilities[a]

Teachers' perceptions of their students' backgrounds and abilities to undertake present science courses

Student's background and ability	Early	Middle	Senior
Completely inadequate	2.0	4.7	2.0
Fairly inadequate	23.2	26.5	19.1
Fairly adequate	62.1	60.9	70.9
Completely adequate	8.6	5.5	6.7

[a] Figures shown are percentages.

Comment:
Two out of three teachers find their students able to undertake science courses.

Table IV.13 – Attitudes and Abilities of Boys and Girls[a]

Teachers' perceptions of differences in attitudes and abilities (relating to science courses) between boys and girls

Teachers' perceptions	Early	Middle	Senior
Attitudes			
-Girls more motivated than boys	3.1	12.2	21.6
-No difference	83.6	70.4	68.1
-Boys more motivated than girls	11.3	14.1	8.1
Abilities			
-Girls more able than boys	4.9	6.0	6.6
-No difference	87.2	85.6	82.4
-Boys more able than girls	4.2	2.9	7.3

[a] Figures shown are percentages.

Comment:

1. Most teachers see no difference in attitude or ability between boys and girls.
2. Where there is a perceived difference in attitude, teachers claim that boys are more motivated at the early years, while girls are more motivated at the senior years.

Table IV.14 – Attitudes and Abilities of Boys and Girls by Sex of Respondent[a]

Male and female teachers' perceptions of attitudes and abilities of girls and boys

	Early		Middle		Senior	
Teachers' perceptions	M	F	M	F	M	F
Attitudes						
-Girls more motivated than boys	4.1	2.9	12.1	13.7	22.5	14.1
-No difference	77.1	87.3	75.8	65.9	66.4	80.3
-Boys more motivated than girls	18.6	9.6	12.0	20.2	10.9	5.4
-(N)	(410)	(1 256)	(1 047)	(271)	(996)	(135)
Abilities						
-Girls more able than boys	5.6	4.9	7.1	4.5	6.3	10.1
-No difference	84.6	92.2	89.4	93.1	85.2	84.1
-Boys more able than girls	9.6	2.8	3.4	2.2	8.4	5.7
-(N)	(403)	(1 227)	(1 014)	(264)	(980)	(135)

[a] Figures shown are percentages.

Comment:

The perception of attitudes and abilities in boys and girls tends to be influenced by the sex of the respondent, but not in a consistent pattern.

Table IV.15 – Students' Science-Related Extracurricular Activities[a]

	Early-, middle- and senior-years teachers' estimates of the proportion of their students participating in various extracurricular activities											
	Very few			About half			Very many			I don't know		
Activities	E	M	S	E	M	S	E	M	S	E	M	S
A science fair project	44.4	56.6	78.9	4.0	2.1	2.4	8.8	22.3	4.3	36.4	17.9	12.7
Membership in a science-related club	45.5	60.7	79.5	0.7	3.8	1.2	0.2	0.6	0.3	46.4	31.8	17.4
A visit to a museum or science centre during the past year	33.2	35.7	43.5	13.7	11.8	16.5	17.9	21.8	10.3	30.4	27.8	28.0
Regularly read a science-related book or magazine	43.9	50.9	48.3	11.0	14.7	17.1	5.2	5.5	5.0	34.4	26.1	28.4
Regularly watch a science TV show (or listen to a radio show)	32.1	30.6	32.6	17.0	27.3	26.2	9.6	15.7	10.3	36.3	23.5	29.1
Pursue actively a scientific hobby	43.1	57.2	61.5	6.1	7.8	5.5	0.4	0.8	0.8	44.9	31.2	31.0

[a] Figures shown are percentages.

Comment:
A surprisingly high proportion of early-years teachers (about one in three) do not know what their students' interests are.

V. Physical, Institutional and Social Contexts of Science Teaching

Effective science teaching depends not only on the purposes of teachers, students and curricula being in harmony, but also on other factors, which are usually beyond teachers' control. This chapter focusses on three such factors:

- Physical facilities (Tables V.1 to V.3);
- Institutional arrangements (Tables V.4 to V.8);
- Support for science teaching (Tables V.9 to V.13).

Physical Facilities

Effective science teaching requires special facilities and equipment. The exact requirements will vary, of course, depending on the course content and the teaching level. To learn about the facilities and equipment presently available to teachers and about teachers' views of their adequacy, several questions on this subject were included in the questionnaire. Tables V.1, V.2 and V.3 report the results of this inquiry.

These data show that, not surprisingly, most science in the early years is taught in a regular classroom, that there is not usually enough equipment for students to participate actively and that over 50 per cent of the teachers regard the situation as being poor or very poor. By contrast, three out of four senior-years science teachers have a regular laboratory equipped for experiments by students, and the quality of both laboratory and equipment are regarded as good or excellent. The situation in the middle years is much more varied, although teachers' assessments of quality are almost as high as are those of senior-years teachers.

Table V.1 – Facilities for Science Teaching[a]

Facility	Early	Middle	Senior
A laboratory or specially designed science room	1.3	41.9	74.2
A classroom with occasional access to a laboratory	7.4	18.0	21.5
A classroom with facilities for demonstrations only	11.2	15.3	1.8
A classroom with no special facilities for science	78.9	24.1	1.9

[a] Figures shown are percentages.

Figure V.1 – Facilities for Science Teaching

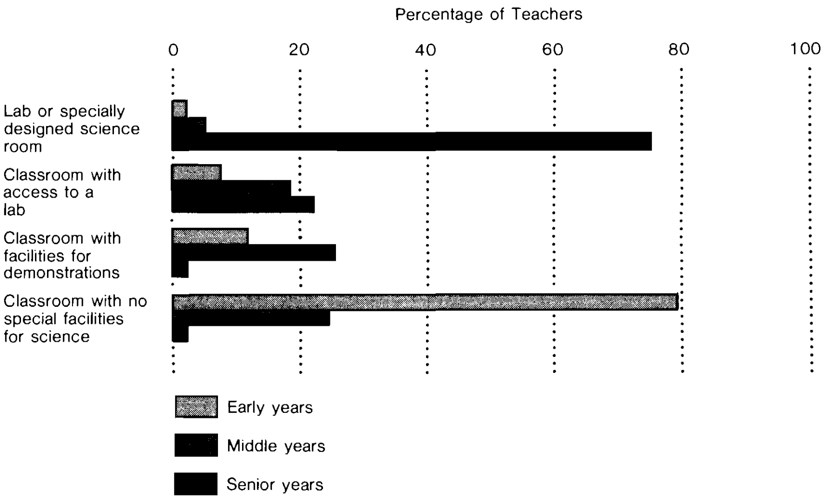


Table V.2 – Equipment and Supplies for Science Teaching[a]

Conditions[b]	Early	Middle	Senior
Ample equipment for student use	15.4	51.4	68.5
Inexpensive, outdated, or donated equipment for student use	16.9	22.9	14.3
Virtually no equipment for demonstration purposes	29.9	10.0	1.8
Adequate equipment for demonstration purposes	41.5	49.0	50.4
Virtually no science equipment at all	18.7	7.0	2.0
Sufficient consumable materials	16.3	49.9	61.8
Access to computing facilities	2.9	16.4	26.8
Adequate audio-visual equipment	34.6	52.9	58.6

[a] Figures shown are percentages.

[b] Respondents were requested to indicate all categories that applied; consequently, the columns do not total 100 per cent.

Table V.3 – Quality of Facilities and Equipment[a]

Teachers' assessment	Early	Middle	Senior
Very poor	18.2	10.3	3.0
Poor	40.5	21.9	14.9
Good	37.1	54.1	58.8
Excellent	2.3	12.7	22.3

[a] Figures shown are percentages.

Comment:

Most early-years science teachers feel that the quality of the facilities and equipment available to them is inadequate. The same opinion is held by one in three middle-years teachers.

Institutional Arrangements

Teachers of science operate in schools where schedules and classes are arranged not only to accommodate the teaching of science, but many other subjects and considerations as well. Nevertheless, in terms of available time, science seems to fare as well or better than other subjects in the curriculum (Tables V.4 to V.8).

Tables V.4 and V.5 show the range of subjects taught by teachers. For early-years teachers, science is only one of a variety of subjects that they teach, while senior-year teachers tend to specialize in science subjects. Table V.5 shows the *proportions* of male and female teachers teaching each of the science subjects. While a greater proportion of female teachers teach biology than, say, physics, it should be noted that the overall 7:1 balance of male teachers to female teachers means that, in absolute terms, there are many more male than female biology teachers.

Table V.6 reports the number of different grades and classes each teacher is responsible for. Early-years teachers tend to have one class at one grade while senior-years teachers teach several different classes at several grade levels. Class sizes, according to the data in Table V.7, are fairly uniform at 20 to 30, and the time allocated to science appears to be adequate (Table V.8).

Table V.4 – Subjects Taught: (1) All teachers[a]

Subjects	Early	Middle	Senior
Science only	0.7	32.6	65.7
Science and Mathematics	2.4	14.8	21.9
A variety of subjects	95.2	51.8	10.9

[a] Figures shown are percentages.

Table V.5 – Subjects Taught: (2) Senior-years teachers compared by sex[a]

Major subject	Male	Female	Overall
Biology	25.8	39.5	27.4
Chemistry	32.7	34.0	32.9
Physics	26.0	14.1	24.6
Earth Science	0.9	0.7	0.9
Other science subjects	5.3	2.9	5.0
Nonscience subjects	8.9	8.4	8.8
(N)	(987)	(135)	(1 122)

[a] Figures shown are percentages.

Table V.6 – Number of Different Grades and Classes Taught[a]

	Early	Middle	Senior
Number of Grades			
-1 only	64.8	25.7	8.8
-2	23.2	30.3	32.6
-3	4.1	28.0	38.9
-More than 3	6.2	15.0	19.1
Number of classes			
-1 only	64.7	13.8	1.5
-2-3	21.1	28.1	19.0
-More than 3	11.6	57.2	78.3

[a] Figures shown are percentages.

Table V.7 – Class Size[a]

Average number of students per class	Early	Middle	Senior
20 or less	16.4	7.9	12.1
21-25	36.2	23.9	23.3
26-30	36.8	39.9	47.2
31-35	6.2	26.7	15.8
Over 35	1.4	0.4	0.6
Average size	25	27	27

[a] Figures shown are percentages.

Table V.8 – Early-, Middle- and Senior-Years Teachers' Assessments of the Adequacy of Time Allocated to Science at Their Level[a]

	In relation to other subjects			In terms of course content		
Teachers' Assessments	E	M	S	E	M	S
Inadequate amount of time	17.8	19.6	19.0	31.2	32.0	31.9
Just enough time	53.4	48.9	52.3	58.9	61.2	62.1
Very adequate amount of time	26.9	30.6	27.3	7.0	5.0	4.5

[a] Figures shown are percentages.

Supports for Science Teaching

Science teachers are not always in the best position to assess the degree of support for science education that exists in other parts of the educational system. However, we sought their opinions on this matter and on the existence of leadership in science education at school and school-board levels. Tables V.9 and V.10 convey the results of these inquiries. A final area of interest for the study was the interaction between science education and industry. Many teachers have never experienced any interaction between industry and schools (Table V.11). Few of those who have think that industry's objective is primarily to support schools (Table V.12). Yet, despite this, an overwhelming majority of science teachers believe that there is a role for industry to play in science education (Table V.13). It is a challenge for deliberators to find what the role should be.

Table V.9 – Leadership and Coordination of Science at School and School-Board Levels[a]

	School level			School-board level		
Form of leadership	E	M	S	E	M	S
Specially designated person	5.5	35.3	66.5	38.8	42.0	42.8
A group of teachers	10.9	9.9	7.2	8.4	11.1	7.9
Administrators	9.2	13.0	4.7	5.5	8.6	6.9
No particular leadership	63.4	35.9	20.2	24.2	23.3	35.2
Don't know	8.7	5.1	0.7	20.5	14.0	6.1

[a] Figures shown are percentages.

Comment:

There is great variation in the data for school-board level when these data are compared by province.

Table V.10 – Views of the Importance of Science[a]

	Early-, middle- and senior-years teachers' assessments of the views of various administrators and members of the community towards science, relative to the other subjects in the school curriculum											
	Less important			Equally important			More important			Don't know		
	E	M	S	E	M	S	E	M	S	E	M	S
School principal	19.3	10.6	9.6	53.1	64.5	68.2	3.5	12.6	8.5	22.5	9.7	12.7
School-board administrators	18.4	12.7	12.3	41.1	51.5	54.2	3.4	1.5	2.7	35.1	31.4	29.8
Parents	31.4	18.9	9.7	29.8	46.8	47.8	2.2	9.2	13.1	34.7	22.2	28.4
Trustees	18.0	12.7	10.4	24.6	34.6	38.8	2.1	0.7	1.6	52.7	48.8	47.4

[a] Figures shown are percentages.

Table V.11 – Experience of Industrial Involvement in Science Education[a]

Teachers' experiences[b]	Early	Middle	Senior
Provisions of curriculum materials	19.8	29.4	35.6
Financial support of activities such as science fairs	2.7	8.5	15.8
Visits to industry	23.0	35.1	44.0
Visits by industrial personnel to school	7.1	11.7	21.1
Provisions of career information	6.1	25.1	41.2
Other experiences	8.2	11.8	9.0
No particular experience	60.8	40.9	31.1

[a] Figures shown are percentages.

[b] Respondents were requested to indicate all categories that applied; the columns do not therefore total 100 per cent.

Table V.12 - Benefits of Industrial Involvement in Science Education[a]

Teachers' opinions of industry's contributions to science teaching

Opinion concerning the contributions	Early	Middle	Senior
Exclusively in the interests of industry	3.0	7.9	5.3
Mostly in the interests of industry	16.7	26.6	28.9
Equally helpful to both industry and school	19.1	26.8	31.7
Designed primarily to assist schools	7.2	8.9	6.1
No opinion	50.4	26.0	26.4

[a] Figures shown are percentages.

Table V.13 – The Role of Industry in Relation to Science Education[a]

Teachers' responses to the question, "Do you believe it is appropriate for industry to be involved in science education at all?"

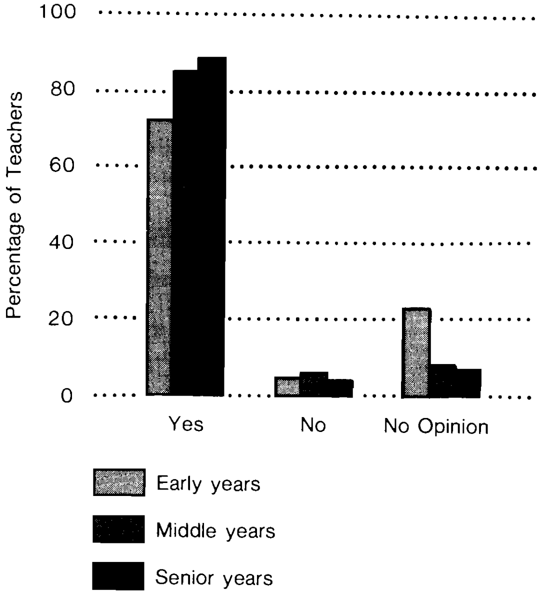
Response	Early	Middle	Senior
Yes	71.4	84.5	88.8
No	3.7	5.6	3.9
No opinion	22.2	7.4	6.6

[a] Figures shown are percentages.

Comment:

Four out of five teachers support industry's involvement in science education.

Figure V.2 – **The Role of Industry in Relation to Science Education (Teachers' Responses to the Question, "Do you believe it is appropriate for industry to be involved in science education at all?")**



VI. Concluding Comments: Questions Raised by the Data

As did other parts of the research program, the survey of science teachers raised as many questions as it answered. These questions, together with the data produced by the research, stimulated and informed a series of deliberative conferences held across Canada during 1982-1983. Those who participated in these conferences raised a number of issues that were particularly important to individual provinces and territories, but they also discussed questions based on the national data included in this report. These questions, which are relevant to all provinces and territories, are listed in the pages that follow. They are arranged to correspond with the order of the preceding chapters.

Science Teachers

Trends In the Age of Science Teachers

In many provinces, schools are experiencing the phenomenon of declining enrolments resulting from the passage of the population "bulge" through its school years. A direct result of this is that school systems have, in many places, not only stopped recruiting new teachers, but have been forced to lay off those already employed. Usually, the youngest (or least senior) teachers have been laid off. This is one reason for the relative absence of young teachers (Table II.2) and for the relatively experienced teaching force noted in Table II.4. However, several disturbing consequences of this trend should be noted. The younger teachers are among the best qualified (Table II.9); there is also a more even balance between the sexes in this group (Table II.5). If policies concerning teacher layoffs are continued, what will be the consequences for the teaching of science, especially at the elementary level?

Preservice Teacher Education

Assuming that it is inappropriate to expect science to be taught at any level by a person who has not had any college-level courses in either science or mathematics, the data presented in Tables II.10 and II.11 are cause for concern. The data show that more than half of all early-years teachers, and more than a third of all middle-years teachers, have never taken mathematics or science at the university level. In view of these statistics, what changes should be made in preservice teacher education and certification requirements? Of course, in view of declining student enrolment, any changes made will only affect the very small number of new teachers entering the profession. Changes in the backgrounds of those currently teaching science are a matter for inservice education (see below).

Work Experience Outside of Teaching

As Table II.13 suggests, many science teachers have had science-related jobs. If the present trend towards greater concern with the applications of science, the relationship between science and society and the use of technology continues, these experiences could prove invaluable. How can this type of experience be recognized and encouraged for those who are, or plan to be, teachers of science? Also, how can teachers use this experience as a pedagogical resource for students' benefit?

Objectives of Science Teaching

The Number, Variety and Balance of Objectives

The analysis of provincial science curriculum policies (volume I, chapter V) prompted the question, "How many different objectives can a science program realistically be expected to reach?" The question is equally apt here. As Tables III.1, III.2 and III.3 show, teachers appear to be as enthusiastic as ministries of education in aiming at a long and varied list of objectives. In volume I, we suggested that to test whether real commitment to a particular objective exists, we should ask, "What practical difference to the day-by-day teaching of science would it make if each objective were separately dropped?" Teachers, as well as ministries, might do well to ask themselves such a question.

Changes in the Objectives of Science Teaching

The survey made no direct inquiry into teachers' readiness to accept change in the balance of objectives in their science programs. However, the fact that those objectives that were thought to be the most important are also those most frequently encountered in present science programs suggests a certain resistance to change on the part of most teachers. The authors of Council's discussion papers have, explicitly or implicitly, suggested alternative objectives, but these have received little support from science teachers. This can mean several things. Perhaps, teachers know best what is achievable in schools, and present programs are a reflection of their judgement. On the other hand, the critics may be right, but the teaching profession has not yet been persuaded. There is little doubt that what teachers believe to be important is a major influence – perhaps *the* major influence – on what actually takes place in classrooms. Clearly, dialogue and deliberation is called for between both those inside and those outside the education system on this most urgent of all questions: What should be the priority among objectives for science education?

Assessing the Effectiveness of Science Teaching

Discussion of the effectiveness of teaching with respect to various objectives tends to be contentious and political. The measurement of learning is, of course, fraught with all kinds of technical difficulties. Yet most teachers, administrators and parents recognize that certain objectives can be and are being met in schools. In recent years, some provinces (notably BC, Alberta and Manitoba) have instituted assessment programs aimed at determining how effectively various objectives of science programs are being met. Despite the controversy surrounding such assessment programs, they may help clarify the debate about new (and old) objectives by telling us what schools can do, and do, well or poorly. Having such information, educators could better assess the feasibility of introducing new objectives or, at least, the strategies required to do so. Until such data are available, we must rely on teachers' assessments of their own effectiveness. At the same time, we should question the reliability of such self-assessment. At issue, for provincial deliberation, is the matter of extending, introducing and improving systematic approaches to the evaluation of students' learning.

Instructional Contexts of Science Teaching

Factors Affecting the Effectiveness of Science Teaching

If assessing the effectiveness of teaching is difficult, determining which factors most strongly influence effectiveness may be more difficult still. Some factors, such as class size, may affect the pleasantness of the working atmosphere significantly and thus lead a teacher to suppose that he or she is being more effective. Factors that may increase teachers' enjoyment of teaching may make little or no difference to the degree to which students achieve objectives. This situation makes it difficult to know which factors are most crucial to teachers' effectiveness and students' learning when a change in objectives is contemplated. Lacking any further evidence, we must assume that all of the six factors identified in Table IV.1 are (more or less equally) important. Are there, however, other factors that influence teaching effectiveness significantly, about which data are needed before the costs of a change in educational objectives can be estimated?

Curriculum Resources

Are teaching resources – particularly textbooks – sufficiently adequate to allow desired objectives to be met? Or, to put the matter in slightly different terms: What new curriculum resources are required to enable teachers to achieve objectives that cannot be met with existing materials? How can materials that contain useful resources (such as government publications) be made more accessible to teachers? How can computer technology be developed to increase curriculum resources for teachers? There is ample material to satisfy all resource needs in existence. The problem is to make it available in the right form at the right time (and at the right price). How can these problems be solved?

Processes of Curriculum Development

Will existing procedures, which are supported by teachers, allow science curricula with different objectives to be developed, or will new procedures and the participation of different people in the making of policy decisions be needed if change is to occur?

Inservice Education

How can inservice education be made more effective so that teachers can continue to enjoy teaching science, and can maintain and develop their abilities to do so? Data presented in this report suggest that inservice education in its present form is not very effective (Table IV.7). Are too many different groups responsible for it? Does it have too many objectives? Does it lack adequate resources?

Students' Interests and Abilities

Does science teaching adequately capitalize on the interests and abilities of all students? A significant number of teachers do not know what science-related extracurricular activities interest their students. How can science activities outside school, which students find interesting, be better related to the science that they learn inside the school?

Science Teaching for Boys and Girls

What can teachers do to ensure that girls take an active interest in science? Most teachers see no difference in attitude or ability between boys and girls (Table IV.13). Yet girls continue to drop out of science at a much higher rate than do boys. What can be done to change this pattern?

Physical, Institutional and Social Contexts of Science Teaching

Physical Facilities and Equipment

What different facilities are required for the achievement of the various objectives of science education? Laboratories are clearly required if students are to develop all the skills of the experimental scientist. Since these objectives have been regarded as important, there has been a corresponding move to ensure that laboratory facilities were available. But are "science-and-society" objectives best achieved through laboratory work? If not, what type of facility is required? To put the matter another way, if we were to design a new school with facilities and equipment appropriate to the objectives of science education in the 1980s and 1990s, what might such a school contain?

Institutional Arrangements

What relative importance should be given to science at each stage of a student's education?

Leadership in Science Education

What kinds of leadership are required, especially in elementary science? How can the resources (especially the human resources) of secondary science teaching be extended to assist and improve science education in the middle and early years?

Views of the Importance of Science

Are educators and politicians sufficiently convinced of the importance of science in the education of students? If not, how can their views be changed?

Industrial Involvement in Science Education

How can industry become more involved in science education without diminishing the integrity of teachers and their responsibility towards students?

Appendix A

Questionnaire and Response Sheet

SCIENCE COUNCIL OF CANADA

SCIENCE EDUCATION STUDY

A Questionnaire for Teachers of Science

1 October 1981

To each teacher:

The Science Council of Canada is currently undertaking a major study into the directions of science education in Canadian schools and invites you to participate by completing this questionnaire.

First, however, some background information. For several years now, science education has been the object of growing criticism and this has become a matter of concern to the Science Council of Canada. So, with the cooperation of the Council of Ministers of Education, the Science Council decided that a better understanding of science teaching, its problems and difficulties, was needed before any useful recommendations for change could be considered.

To this end, the comments of teachers of science — *your* comments — are of vital importance. By responding to this questionnaire, you will be providing us with information that will help us to answer three questions:

1. What are the aims and objectives of science teaching in Canada today, as perceived by teachers?
2. What problems are encountered by teachers when they try to achieve these objectives in practice?
3. What changes are required if science education is to continue to meet the needs of Canadians in the years to come?

Your school has been randomly selected to participate in this study and all teachers who teach science (whether full or part time) are being asked individually to respond to the questionnaire.

Science programs and administrative terminology vary greatly from one province or territory to another. Inevitably, therefore, some questions will not seem to be worded in an exactly appropriate manner. We hope, nevertheless, that you will respond as completely as possible. Thank you in advance for your cooperation.

You can be assured that your responses will be treated in complete confidence. Our reports will not identify participating teachers or schools. When you have completed the questionnaire, place the response sheet in the envelope provided, seal it, and return it to the person who gave it to you — within a week, if possible.

Thank you again for your participation. If you would like to have more information about Science Council or the Science Education Study, you can obtain our publications free of charge from the Council's Publications Office, 100 Metcalfe Street, Ottawa.

Yours truly,

Graham Orpwood
Graham W.F. Orpwood

Jean P. Souque
Jean-P. Souque

Project Officers
Science Education Study

A Questionnaire for Teachers of Science

IMPORTANT: We ask that you respond to each item in this questionnaire by circling the appropriate number *on the separate response sheet provided.*

I GENERAL INFORMATION

In this section, we are interested in learning something about you. This will enable us to understand better your opinions concerning the objectives and difficulties of science teaching.

1. Are you currently teaching some science?

(Circle one on the response sheet)

a. Yes	1
b. No	2

If your answer is "No", please do not proceed further. Kindly return this questionnaire to the individual who gave it to you. Thank you for your cooperation.

If your answer is "Yes", please go on to the next question.

2. For the purpose of our study, we have defined three levels of teaching. At which level is *most* of your science teaching currently taking place? Please select only one of a, b, or c.

(Circle one)

a. Early Years	(grades K-6 for all provinces except K-7 in B.C. and the Yukon)	1
b. Middle Years	(grades 7-9 for all provinces except secondary 1-3 in Quebec, grades 7-10 in Ontario, and 8-10 in B.C. and the Yukon)	2
c. Senior Years	(grades 10-12 for all provinces except 10-11 in Newfoundland, secondary 4-5 in Quebec, grades 11-13 in Ontario, and 11-12 in B.C. and the Yukon)	3

Note: Although you may teach (or have taught) at more than one of those levels, we would ask you to complete the rest of this questionnaire *as though you only taught at the level you have marked.*

3. What is your age?

(Circle one)

a. Under 26	1
b. 26-35	2
c. 36-45	3
d. 46-55	4
e. over 55	5

4. What is your sex?

(Circle one)

a. Male	1
b. Female	2

5. How many years of overall teaching experience do you have, including the present year?

(Circle one)

a. 1 year (i.e., new to teaching this year) 1
b. 2-5 years 2
c. 6-9 years 3
d. 10-13 years 4
e. 14 years or more 5

II CURRICULUM & INSTRUCTION

In this section, the questions have to do with the overall aims and objectives for a student's learning science and with the degree to which these aims can be successfully achieved through present science programs.

There are many reasons why objectives, considered by teachers to be important, are nevertheless difficult to achieve in practice. Questions 6 and 7 contain a list of possible objectives for science teaching. Question 6 asks you to rate the importance of each objective *for the level you teach*. Question 7 asks you to estimate the effectiveness of your own teaching with respect to each objective. Question 8 then explores some of the potential obstacles to achieving objectives.

6. Importance of objectives

Please indicate your assessment of the importance of each of the following objectives *for the level which you identified* in Question 2.

Scale: 1 — No importance
2 — Of little importance
3 — Fairly important
4 — Very important

(Circle one on each line on the response sheet)

a. Understanding scientific facts, concepts, laws, etc. . .	1	2	3	4
b. Developing social skills (e.g., cooperation, communication, sense of responsibility)	1	2	3	4
c. Relating science to career opportunities	1	2	3	4
d. Developing the skills of reading and understanding science-related materials	1	2	3	4
e. Understanding the nature and process of technological or engineering activity	1	2	3	4
f. Developing attitudes appropriate to scientific endeavour (e.g., curiosity, creativity, skepticism) ...	1	2	3	4
g. Understanding the history and philosophy of science .	1	2	3	4
h. Understanding the practical applications of science . .	1	2	3	4
i. Developing skills and processes of investigation (e.g., observing, classifying, conducting experiments)	1	2	3	4
j. Understanding the relevance of science to the needs and interests of both men *and* women	1	2	3	4
k. Relating scientific explanation to the student's conception of the world	1	2	3	4
l. Understanding the way that scientific knowledge is developed	1	2	3	4
m. Developing an awareness of the practice of science in Canada	1	2	3	4
n. Understanding the role and significance of science in modern society	1	2	3	4

7. Achievement of objectives

How effective do you feel your teaching is at providing for students to achieve each of the following objectives? If you do not attempt an objective, circle 0.

Scale: 1 — Very ineffective
2 — Fairly ineffective
3 — Fairly effective
4 — Very effective
0 — Not attempted

(Circle one on each line)

a. Understanding scientific facts, concepts, laws, etc.	1	2	3	4	0
b. Developing social skills (e.g., cooperation, communication, sense of responsibility)	1	2	3	4	0
c. Relating science to career opportunities	1	2	3	4	0
d. Developing the skills of reading and understanding science-related materials	1	2	3	4	0
e. Understanding the nature and processes of technological or engineering activity	1	2	3	4	0
f. Developing attitudes appropriate to scientific endeavour (e.g., curiosity, creativity, skepticism)	1	2	3	4	0
g. Understanding the history and philosophy of science	1	2	3	4	0
h. Understanding the practical applications of science	1	2	3	4	0
i. Developing skills and processes of investigation (e.g., observing, classifying, conducting experiments)	1	2	3	4	0
j. Understanding the relevance of science to the needs and interests of both men *and* women	1	2	3	4	0
k. Relating scientific explanation to the student's conception of the world	1	2	3	4	0
l. Understanding the way that scientific knowledge is developed	1	2	3	4	0
m. Developing an awareness of the practice of science in Canada	1	2	3	4	0
n. Understanding the role and significance of science in modern society	1	2	3	4	0

8. Obstacles to achieving objectives

We have listed six areas which may contain obstacles to the achievement of objectives. Please rate the importance of these areas as representing obstacles to the achievement of *your* objectives.

Scale: 1 — No importance
2 — Of little importance
3 — Fairly important
4 — Very important

(Circle one on each line)

a. Curriculum resources (including Ministry/ Department guidelines, textbooks, etc.)	1	2	3	4
b. My background and experience (pre-service and in-service)	1	2	3	4
c. Physical facilities and equipment	1	2	3	4
d. Students' abilities and interests	1	2	3	4
e. Institutional arrangements (e.g., class size, time allocation)	1	2	3	4
f. Community and professional support (e.g., parents, principals, superintendents, trustees)	1	2	3	4

PARTS III-VIII

In the remainder of the questionnaire, we are interested in exploring further those six areas identified in Question 8 which influence, in various ways, the effectiveness of science teaching.

III CURRICULUM RESOURCES

9. Teachers use a variety of materials when planning instruction. How useful have you found the following types of material to be in *your* planning? If, for any reason, you do not have an opinion, please circle 0.

Scale: 1 — No importance
2 — Of little importance
3 — Fairly important
4 — Very important
0 — No opinion

(Circle one on each line)

a. Ministry/Department policy statements	1	2	3	4	0
b. Provincially/Territorially approved texts	1	2	3	4	0
c. Other science texts	1	2	3	4	0
d. Supplementary material from the Ministry/ Department of Education	1	2	3	4	0
e. Curriculum material developed in your school or school board	1	2	3	4	0
f. Commercially published curriculum materials other than textbooks such as kits of printed materials etc....	1	2	3	4	0
g. Publications from government departments (other than education)	1	2	3	4	0
h. Materials from teachers' associations	1	2	3	4	0
i. Science magazines, journals, newsletters etc.	1	2	3	4	0
j. Industrially sponsored free materials	1	2	3	4	0
k. TV or radio programs or tapes	1	2	3	4	0
l. Materials from the school library	1	2	3	4	0
m. Computer software	1	2	3	4	0

10. Student textbooks

(a) Please identify the grade that you teach science to most often this year.

(Circle only one)

K 1 2 3 4 5 6 7 8 9 10 11 12 13

(b) Do the students in this grade use a science textbook?

Yes .... 1 .... Please go on to part (c) of this question.
No .... 2 .... Please go directly to Question 12.

(c) Which textbook is used most often by students in this grade? Provide as much information as you can. If a series of books is used, give the series title only.

a. Author(s) ....
b. Title ....
c. Publisher ....
d. Year of edition ....

(Provide this information in the appropriate space on the response sheet)

11. This question concerns the textbook you identified in Question 10. Please assess the quality of the text in respect of each of the following criteria.

(Circle one on each line)

	Completely inadequate 1	Fairly inadequate 2	Fairly adequate 3	Completely adequate 4
a. Appropriateness of the science content for the grade level you teach	1	2	3	4
b. The relationship of the text's objectives with your own priorities	1	2	3	4
c. Readability for students	1	2	3	4
d. Illustrations, photographs, etc.	1	2	3	4
e. Suggested activities	1	2	3	4
f. Canadian examples	1	2	3	4
g. Accounts of the applications of science	1	2	3	4
h. Appropriateness for slow students	1	2	3	4
i. Appropriateness for bright students	1	2	3	4
j. References for further reading	1	2	3	4
k. Overall impression	1	2	3	4

12. Suppose a new science program is to be developed for your grade level. This must involve (a) defining overall aims and objectives, (b) selecting textbooks, and (c) preparing detailed courses of study. Which of the following agencies (numbered 1-6) do you consider to be most appropriate *to take responsibility* for each of these tasks?

1. Department/Ministry of Education
2. School board officials
3. Committee of teachers at school board level
4. Families of schools
5. Individual schools
6. Individual teachers

(Circle one on each line)

a. Defining overall aims and objectives	1	2	3	4	5	6
b. Selecting textbooks	1	2	3	4	5	6
c. Preparing detailed courses of study	1	2	3	4	5	6

13. To what extent have you participated in curriculum planning and development activities at each of the following levels during the past few years?

(Circle one on each line)

	No opportunity to participate 1	Participated occasionally 2	Participated frequently 3
a. School	1	2	3
b. School board	1	2	3
c. Provincial/Territorial Department/Ministry	1	2	3
d. Teachers' association	1	2	3
e. Other	1	2	3

IV TEACHER BACKGROUND & EXPERIENCE

14. Please indicate the *highest* level of education you have *completed*.

(Circle one only)

a. Elementary school 1
b. High school 2
c. Community college diploma (or equivalent) 3
d. Teacher's college diploma (or equivalent) 4
e. Bachelor's degree 5
f. Master's degree 6
g. Doctoral degree 7

15. Please indicate the *highest* level at which you have *studied the following subjects.*

(Circle one on each line)

	Not studied at university 1	Bachelor's level 2	Master's/Doctoral level 3
a. Mathematics	1	2	3
b. Pure science (e.g., physics, chemistry)	1	2	3
c. Applied science (e.g., engineering, medicine)	1	2	3
d. Education	1	2	3

16. How long has it been since you last took a post-secondary course in each of the following areas?

(Circle one on each line)

	Never taken 1	More than 10 years 2	6-10 years 3	1-5 years 4	Currently enrolled 5
a. Mathematics	1	2	3	4	5
b. Pure science	1	2	3	4	5
c. Applied science	1	2	3	4	5
d. Education	1	2	3	4	5

17. As preparation for your work as a science teacher, how do you rate the overall quality of:

(Circle one on each line)

	Very unsatisfactory 1	Fairly unsatisfactory 2	Fairly satisfactory 3	Very satisfactory 4
a. Your education in science?	1	2	3	4
b. Your training as a teacher?	1	2	3	4

18. How helpful has your post-secondary education been to you as a science teacher in regard to the following areas?

(Circle one on each line)

	No help 1	Little help 2	Some help 3	Much help 4
a. Acquiring scientific knowledge and skills	1	2	3	4
b. Understanding interactions between science and society	1	2	3	4
c. Understanding the ways children and adolescents learn science	1	2	3	4

19. What science-related employment have you had other than teaching?

	(Circle all that apply)
a. None	1
b. Work in a science library	2
c. Routine work in a testing or analysis laboratory	3
d. Research or development work on methods, products, or processes	4
e. Basic research in physical, medical, biological, or earth science	5
f. Work in farming, mining, or fishing	6
g. Other industrial work including engineering	7

20. Rate the value of each of the following in-service experiences in terms of their contribution to your work as a science teacher. If you have no experience in a particular activity, please circle 0.

(Circle one on each line)

	Completely Useless 1	Fairly Useless 2	Fairly Useful 3	Very Useful 4	No Experience 0
a. Informal meetings with other science teachers	1	2	3	4	0
b. Informal meetings with university science education personnel	1	2	3	4	0
c. Informal meetings with scientists	1	2	3	4	0
d. Workshops presented by other teachers	1	2	3	4	0
e. Workshops presented by school board	1	2	3	4	0
f. Workshops presented by university science education personnel	1	2	3	4	0
g. Workshops presented by scientists	1	2	3	4	0
h. Workshops presented by Ministry/Department of Education officials	1	2	3	4	0
i. University courses in science	1	2	3	4	0
j. University courses in science education	1	2	3	4	0
k. Visits to other teachers' classrooms or other schools	1	2	3	4	0
l. Conferences or meetings arranged by science teachers' association	1	2	3	4	0
m. Visits to industries	1	2	3	4	0
n. Visits from industrial personnel	1	2	3	4	0

21. Generally, how willing would you be to participate in an in-service workshop in science education under the following circumstances:

(a) during school hours if release time was given?

	(Circle one)
a. Definitely would not participate	1
b. Probably would not participate	2
c. Probably would participate	3
d. Definitely would participate	4

(b) at a convenient time outside of school hours?

(Circle one)

a. Definitely would not participate 1
b. Probably would not participate 2
c. Probably would participate 3
d. Definitely would participate 4

22. How much in-service education per year do you feel *you* require in order to continue doing a good job of teaching science?

(Circle one)

a. None 1
b. 3-5 hours (e.g., one afternoon workshop) 2
c. 5-20 hours (e.g., several full days of workshops) .. 3
d. An intensive refresher course 4
e. A full year away from the classroom 5

23. How effective is the in-service program provided for science teachers in your school or district?

(Circle one)

a. Non-existent 1
b. Completely ineffective 2
c. Fairly ineffective 3
d. Fairly effective 4
e. Very effective 5

24. (a) If you had a choice, would you avoid teaching science altogether?

a. Yes .... 1 .... Please go on to part (b) of this question
b. No .... 2 .... Please go directly to Question 25.
c. Undecided .... 3 .... Please go directly to Question 25.

(b) If "Yes", for which of the following reasons?

(Circle all that apply)

a. Lack of resources 1
b. Inadequate background 2
c. Dislike of science 3
d. Working conditions 4
e. Student attitudes 5
f. Other 6

25. Please indicate the statement that most closely applies to your situation. In general, I teach my science classes:

(Circle one)

a. In a laboratory or specially designed science room 1
b. In a classroom with occasional access to a laboratory 2
c. In a classroom with facilities for demonstrations only 3
d. In a classroom with no special facilities for science 4

26. Which statements most closely apply to your situation regarding equipment and supplies for teaching science?

(Circle all that apply)

a. There is ample equipment for student use 1

b. There is inexpensive, donated, or outdated equipment for student use 2

c. There is virtually no equipment for student use .. 3

d. There is adequate equipment for demonstration purposes 4

e. There is virtually no science equipment at all 5

f. There are sufficient consumable materials (chemicals, biological supplies, graph paper, etc.) 6

g. There is access to computing facilities 7

h. There is adequate audio-visual equipment 8

27. Overall, how do you rate the quality of the facilities and equipment available to you for teaching science?

(Circle one)

a. Very poor 1

b. Poor 2

c. Good 3

d. Excellent 4

VI STUDENTS' ABILITIES & INTERESTS

28. What is your perception of your students' attitudes toward learning science this year?

The majority of my students are:

(Circle one)

a. Ready to drop science 1

b. Indifferent 2

c. Fairly motivated 3

d. Highly motivated 4

29. What is your perception of your students' backgrounds and abilities to undertake the science courses you teach this year?

(Circle one)

a. Completely inadequate 1

b. Fairly inadequate 2

c. Fairly adequate 3

d. Completely adequate 4

30. We are interested in your perception of any differences in attitudes and ability (relating to science courses) between the boys and girls you teach. Please indicate which statement corresponds most closely to your experience.

(a) Attitudes

(Circle one)

a. The girls are more motivated than the boys 1

b. I see no difference in motivation 2

c. The boys are more motivated than the girls 3

(b) Ability

(Circle one)

a. The girls have greater ability than the boys	1
b. I see no difference in ability	2
c. The boys have greater ability than the girls	3

31. Please estimate how many of your students engage in each of the following activities.

(Circle one on each line)

	Very few 1	About half 2	Very many 3	I don't know 4
a. A science fair project	1	2	3	4
b. Membership in a science-related club	1	2	3	4
c. A visit to a museum or science centre during the past year	1	2	3	4
d. Regularly read a science-related magazine or book	1	2	3	4
e. Regularly watch a science-related TV show (or listen to a radio show)	1	2	3	4
f. Pursue actively a scientific hobby	1	2	3	4

VII INSTITUTIONAL ARRANGEMENTS

32. Subjects Taught

(a) Which statement most closely describes your teaching situation?

(Circle one)

a. I teach only science subjects	1
b. I teach both science and mathematics	2
c. I teach a variety of subjects of which science is only one	3

(b) This year, most of my time is spent in teaching:

(Circle one)

a. Physics	1
b. Chemistry	2
c. Biology	3
d. Earth science	4
e. Other science subjects	5
f. Non-science subjects	6

33. Teaching Load

(a) How many different grades do you teach this year altogether?

(Circle one)

a. 1 only	1
b. 2	2
c. 3	3
d. more than 3	4

(b) How many different classes do you teach this year altogether?

(Circle one)

a. 1 only 1
b. 2-3 2
c. more than 3 3

(c) What is the average number of students in your classes?

(Circle one)

a. 20 or less 1
b. 21-25 2
c. 26-30 3
d. 31-35 4
e. over 35 5

34. This question concerns your assessment of the amount of time allocated to science at the level at which you teach.

(a) How adequate is the amount of time allocated to science (based on your view of its importance relative to the other subjects of the curriculum)?

(Circle one)

a. Inadequate 1
b. About right 2
c. Adequate 3

(b) How much time do you have to cover science courses?

(Circle one)

a. Too little time 1
b. Just enough time 2
c. More than enough time 3

VIII COMMUNITY & PROFESSIONAL SUPPORT

35. With reference to the science program in your *school*, which of the following best describes the form of leadership which exists?

(Circle one)

a. There is a specially designated department head for science 1
b. Leadership and coordination are carried out by a working group of teachers in the school 2
c. Leadership and coordination are carried out by the principal or vice-principal 3
d. Our school's science program has no particular form of leadership 4
e. I don't know 5

36. With reference to the science program in your *district/board*, which of the following best describes the form of leadership that exists?

(Circle one)

a. There is a specially designated science consultant, coordinator, or supervisor for science 1
b. Leadership and coordination are carried out by a working group of teachers in the district 2
c. Leadership and coordination are carried out by one of the school district superintendents 3
d. There is no particular form of leadership in science at the district level 4
e. I don't know 5

37. How important do *you* think various administrators and members of the community consider science to be relative to the other subjects in the school curriculum?

(Circle one on each line)

	Less important 1	Equally important 2	More important 3	I don't know 4
a. Your school principal	1	2	3	4
b. School board administrators	1	2	3	4
c. Parents	1	2	3	4
d. Trustees	1	2	3	4

Finally, we have three questions that focus on the role of industry in providing support for the work of science teachers. We are most interested in collecting teachers' views about this matter.

38. What experiences have you had of the involvement of industry with school science teaching?

(Circle all that apply)

a. Provision of curriculum materials 1
b. Financial support of activities such as science fairs 2
c. Visits to industry 3
d. Visits by industrial personnel to school 4
e. Provision of career information 5
f. Other experiences 6
g. No particular experience 7

39. In your judgement, are the contributions made by industry to science teaching . . .

(Circle one)

a. in the interests of the industry exclusively? 1
b. mostly in the interests of the industry? 2
c. equally helpful to both industry and school? 3
d. designed primarily to assist schools? 4
e. matters you have no opinion about? 5

40. Do you believe that it is appropriate for industry to be involved in science education at all?

(Circle one)

a. Yes 1
b. No 2
c. No opinion 3

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE.

If you have not already done so, make sure that your responses are recorded on the separate response sheet provided, then seal it in the envelope, and return it to the person who gave it to you. We do not need the questionnaire itself to be returned.

ACKNOWLEDGEMENTS

The Science Council of Canada acknowledges with thanks the authors of the many documents consulted during the development of this questionnaire. Questionnaires from the following studies have been of particular value.

Assessment of the Teaching of Science in Junior High Schools in the Maritimes, 1977.
The Teacher and Curriculum Development Project, Queen's University, Ontario, 1977
National Survey of Science, Mathematics, and Social Studies Education, U.S. National Science Foundation, 1977.
British Columbia Science Assessment, 1978.
Curriculum Task Force, Commission on Declining Enrolments in Ontario, 1978.
Étude Evalensci, University of Montreal, 1980.

SCIENCE COUNCIL OF CANADA
SCIENCE EDUCATION STUDY
A Questionnaire for Teachers of Science

RESPONSE SHEET

Please mark your response to each question by circling the appropriate number on this sheet, as clearly as possible. Most questions require only response only. However, a few, marked with an asterisk (*), may have multiple responses.

I GENERAL INFORMATION

				For Office Use Only
1.		1 2		(8)
2.		1 2 3		(9)
3.		1 2 3 4 5		(10)
4.		1 2		(11)
5.		1 2 3 4 5		(12)

II CURRICULUM & INSTRUCTION

6.	(a)	1 2 3 4	(h)	1 2 3 4	(13/20)
	(b)	1 2 3 4	(i)	1 2 3 4	(14/21)
	(c)	1 2 3 4	(j)	1 2 3 4	(15/22)
	(d)	1 2 3 4	(k)	1 2 3 4	(16/23)
	(e)	1 2 3 4	(l)	1 2 3 4	(17/24)
	(f)	1 2 3 4	(m)	1 2 3 4	(18/25)
	(g)	1 2 3 4	(n)	1 2 3 4	(19/26)
7.	(a)	1 2 3 4 0	(h)	1 2 3 4 0	(27/34)
	(b)	1 2 3 4 0	(i)	1 2 3 4 0	(28/35)
	(c)	1 2 3 4 0	(j)	1 2 3 4 0	(29/36)
	(d)	1 2 3 4 0	(k)	1 2 3 4 0	(30/37)
	(e)	1 2 3 4 0	(l)	1 2 3 4 0	(31/38)
	(f)	1 2 3 4 0	(m)	1 2 3 4 0	(32/39)
	(g)	1 2 3 4 0	(n)	1 2 3 4 0	(33/40)
8.	(a)	1 2 3 4			(41)
	(b)	1 2 3 4			(42)
	(c)	1 2 3 4			(43)
	(d)	1 2 3 4			(44)
	(e)	1 2 3 4			(45)
	(f)	1 2 3 4			(46)

III CURRICULUM RESOURCES

9.	(a) 1 2 3 4 0	(h) 1 2 3 4 0	(47/54)
	(b) 1 2 3 4 0	(i) 1 2 3 4 0	(48/55)
	(c) 1 2 3 4 0	(j) 1 2 3 4 0	(49/56)
	(d) 1 2 3 4 0	(k) 1 2 3 4 0	(50/57)
	(e) 1 2 3 4 0	(l) 1 2 3 4 0	(51/58)
	(f) 1 2 3 4 0	(m) 1 2 3 4 0	(52/59)
	(g) 1 2 3 4 0		(53)
10.	(a) K 1 2 3 4 5 6 7 8 9 10 11 12 13		(60-61)
	(b) 1 2		(62)
	(c) a.		(63-64)
	b.		
	c.		
	d.		
11.	(a) 1 2 3 4	(g) 1 2 3 4	(65/71)
	(b) 1 2 3 4	(h) 1 2 3 4	(66/72)
	(c) 1 2 3 4	(i) 1 2 3 4	(67/73)
	(d) 1 2 3 4	(j) 1 2 3 4	(68/74)
	(e) 1 2 3 4	(k) 1 2 3 4	(69/75)
	(f) 1 2 3 4		(70)
12.	(a) 1 2 3 4 5 6		(76)
	(b) 1 2 3 4 5 6		(77)
	(c) 1 2 3 4 5 6		(78)
13.	(a) 1 2 3		(79)
	(b) 1 2 3		(80)
	(c) 1 2 3		(81)
	(d) 1 2 3		(82)
	(e) 1 2 3		(83)

IV TEACHER BACKGROUND & EXPERIENCE

14.	1 2 3 4 5 6 7	(84)
15.	(a) 1 2 3	(85)
	(b) 1 2 3	(86)
	(c) 1 2 3	(87)
	(d) 1 2 3	(88)

16.	(a)	1 2 3 4 5			(89)
	(b)	1 2 3 4 5			(90)
	(c)	1 2 3 4 5			(91)
	(d)	1 2 3 4 5			(92)
17.	(a)	1 2 3 4			(93)
	(b)	1 2 3 4			(94)
18.	(a)	1 2 3 4			(95)
	(b)	1 2 3 4			(96)
	(c)	1 2 3 4			(97)
*19.		1 2 3 4 5 6 7			(98-104)
20.	(a)	1 2 3 4 0	(h)	1 2 3 4 0	(105/112)
	(b)	1 2 3 4 0	(i)	1 2 3 4 0	(106/113)
	(c)	1 2 3 4 0	(j)	1 2 3 4 0	(107/114)
	(d)	1 2 3 4 0	(k)	1 2 3 4 0	(108/115)
	(e)	1 2 3 4 0	(l)	1 2 3 4 0	(109/116)
	(f)	1 2 3 4 0	(m)	1 2 3 4 0	(110/117)
	(g)	1 2 3 4 0	(n)	1 2 3 4 0	(111/118)
21.	(a)	1 2 3 4			(119)
	(b)	1 2 3 4			(120)
22.		1 2 3 4 5			(121)
23.		1 2 3 4 5			(122)
24.	(a)	1 2 3			(123)
	*(b)	1 2 3 4 5 6			(124-130)

V PHYSICAL FACILITIES & EQUIPMENT

25.	1 2 3 4	(131)
*26.	1 2 3 4 5 6 7 8	(132-140)
27.	1 2 3 4	(141)

VI STUDENTS' ABILITIES & ATTITUDES

28.		1 2 3 4	(142)
29.		1 2 3 4	(143)
30.	(a)	1 2 3	(144)
	(b)	1 2 3	(145)
31.	(a)	1 2 3 4	(146)
	(b)	1 2 3 4	(147)
	(c)	1 2 3 4	(148)
	(d)	1 2 3 4	(149)
	(e)	1 2 3 4	(150)
	(f)	1 2 3 4	(151)

VII INSTITUTIONAL ARRANGEMENTS

32.	(a)	1 2 3	(152)
	(b)	1 2 3 4 5 6	(153)
33.	(a)	1 2 3 4	(154)
	(b)	1 2 3	(155)
	(c)	1 2 3 4 5	(156)
34.	(a)	1 2 3	(157)
	(b)	1 2 3	(158)

VIII COMMUNITY & PROFESSIONAL SUPPORT

35.		1 2 3 4 5	(159)
36.		1 2 3 4 5	(160)
37.	(a)	1 2 3 4	(161)
	(b)	1 2 3 4	(162)
	(c)	1 2 3 4	(163)
	(d)	1 2 3 4	(164)
*38.		1 2 3 4 5 6 7	(165-171)
39.		1 2 3 4 5	(172)
40.		1 2 3	(173)

Appendix B

Sampling, Estimation and Sampling Error Computations

Sampling Computations

The use of probability sampling allows calculation both of unbiased estimates of population characteristics and of sampling errors associated with those estimates. The purpose of this section is to review technical aspects of the sample selection and weighting procedures.

Sample Selection

The procedures used for sample selection are outlined in general terms in chapter I of this report. What follows is a more detailed account of how sample sizes were calculated and an illustration of their use in selecting a typical sample. Sample sizes were calculated for each teaching level (early, middle and senior years) according to our requirements for data reliability. The size of each required sample (n_o) is given by the following formula:

$$n_o = \frac{4pq}{d^2} \tag{1}$$

where d = error acceptable in estimates

p = proportion of teachers having a given characteristic

$q = 1 - p$

Since p was unknown, it was taken to be 0.5, giving pq a maximum value and ensuring a large enough sample size. Also, (as noted in chapter I, notes 3 and 7) d was taken to be 0.05 at the regional level and 0.1 at the provincial level, both at a 95 per cent confidence level.

If n_o thus calculated was found to be greater than five per cent of the population (N), a revised sample size (n′) was determined using the following finite population correction factor:

$$n' = \frac{n_o}{1 + n_o/N} \tag{2}$$

Finally, another correction factor was applied to adjust for the anticipated nonresponse rate, using the following formula:

$$n'' = n_o \text{ (or } n') \div \text{ expected response rate (0.8)} \tag{3}$$

where n″ is the sample size used for the next stage of the sampling process.

It was decided to sample elementary schools (defined for this purpose as those schools comprising kindergarten to grade 6) on the basis of the required numbers of early-years teachers, and to sample secondary schools (defined for this purpose as those comprising grades 7 to 13) on the basis of the total number of teachers required for both middle and senior years. (See chapter I, note 8 for a fuller version of this definition of "elementary" and "secondary.")

For every province and territory, a list of schools was available which showed the range of grades taught and the number of teachers employed. On the basis of these lists, all schools were classified as either elementary or secondary. In the case of elementary schools, all teachers were regarded as potential respondents, while in the case of secondary schools, approximately one-fifth of the teachers were so considered. The following general example illustrates the procedure that was used to select a sample.

Suppose that, in a given province, the calculation described above showed that a sample of x early-years science teachers was required. Using the average number of teachers per school in that province, it was estimated that y elementary schools would be required in order to obtain a sample of x science teachers. Following a random start, every zth school on the list was selected (where z is the total number of elementary schools in the province divided by y). Finally the total number of teachers in the selected sample of y schools was checked to ensure that it was greater than or equal to x. If this was found not to be the case, the selection procedure was repeated until an adequate sample was obtained.

Weighting

As explained in chapter I, a system of disproportionate sampling such as that used here requires a corresponding system of weighting of each teacher's responses in order that final estimates reflect the balance of the original population. The weights assigned to the responses of teachers in this survey were determined on the basis of the probabilities of the teachers' being selected. The probability of selecting a given teacher is the product of the probability of the teacher's school being selected and the probability of selecting a science teacher within that school. In the present survey, since all science teachers within selected schools were requested to respond, this latter probability was intended to be 1. The weight assigned to the responses of a given teacher is, then, the reciprocal of the probability of his or her being selected.

Additional weight was given to take into account nonresponse by both teacher and school. The final weight used for a particular set of responses thus consisted of the product of three components:

- the inverse of the probability of the school being selected:
- the inverse of the school response rate;

- the inverse of the teacher response rate (within responding schools).

Weights are thus dependent on the province and type of school (elementary/secondary) but independent of the teaching level (early/middle/senior years) within a given school. The formula for calculating weights for teachers at elementary schools is as follows:

$$w_e = \frac{M_e}{m_e} \times \frac{n''_e}{n'_e} \qquad (4)$$

where w_e = weight assigned to teachers from elementary schools
M_e = total number of elementary schools in the province
m_e = number of elementary schools responding to survey*
n''_e = number of teachers at elementary schools given a questionnaire*
n'_e = number of teachers at elementary schools responding to survey*

For secondary schools, a corresponding formula is used.

Calculation of Estimates

To this point, all calculations have been based on the two levels of school – elementary and secondary – which constituted our sampling frame. However, the estimates had to be expressed in terms of the three teaching levels – early, middle and senior years – by which the other parts of the study are structured. In responding to the survey, respondents classified themselves into these three categories, and when these data were analyzed, it was found that early- and middle-years teachers were located in both elementary and secondary schools while senior-years teachers came exclusively from secondary schools. This factor required that special calculations be undertaken to prepare balanced estimates for the three teaching levels. First, however, it was necessary to estimate the populations of teachers at each school level in each province. The formulae for calculation of weights can be used for this purpose also. As an illustration, the formula for the population of early-years teachers at elementary schools in a given province is as follows:

$$N_e = w_e n_e \qquad (5)$$

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* Indicates information collected from the control forms completed by principals

where N_e = number of early-years teachers at elementary schools

w_e = weight assigned to teachers from elementary schools

n_e = number of early-years teachers at elementary schools responding to survey

A corresponding formula may be used for estimating the number of early-years teachers at secondary schools (N_s), and the total number of early-years teachers in the province (N_e) is then the sum of N_e and N_s. Similar calculations may be made for the populations of teachers at the middle- and senior-years levels.

Estimates (in the form of percentages) for each response and teaching level can now be calculated. As an example, consider the data resulting from a particular response by early-years teachers in a particular province. To determine the proportion of early-years teachers in that province who responded in a particular way, the proportions of early-years teachers from elementary schools and from secondary schools are computed separately and then combined to form the net proportion. Specifically, the proportion of early-years teachers from elementary schools responding to a question in a specific way (p_e) is given by the following formula:

$$p_e = \frac{a_e}{n_e} \tag{6}$$

where a_e = total number of early-years teachers in elementary schools responding in the specified way

n_e = total number of early-years teachers in elementary schools responding to the survey

The proportion of early-years teachers in secondary schools responding in the specified way (p_s) is calculated in a parallel manner. The combined proportion (p_E) is then determined as follows:

$$p_E = \frac{N_e p_e + N_s p_s}{N_E} \tag{7}$$

where N_e = population of early-years science teachers in elementary schools

N_s = population of early-years science teachers in secondary schools

N_E = population of early-years science teachers in the province

Estimates for the middle years are calculated in an identical manner, while those for the senior years are simpler because they involve responses from secondary schools only.

Once provincial estimates are constructed as described here, it is possible to calculate national estimates also. Continuing the same example, the overall proportion of early-years teachers in Canada responding in the specified way to a particular question (p_{can}) is given by the following formula:

$$p_{can} = \sum_{k=1}^{12} \frac{N_k}{N_{can}} p_k \qquad (8)$$

where p_k = estimated proportion of early-years teachers in province K responding in the specified way

N_k = population of early-years science teachers in province K

N_{can} = population of early-years science teachers in Canada

Sampling Error Estimation

Every piece of information inferred from a sample is subject to sampling error. It is important to check that the errors due to sampling are not so large as to invalidate the results. The variance and standard error of an estimate are used to express sampling errors and, in the case of our survey, both have been calculated from our sample data.

The variance of a proportional estimate based on responses from elementary schools, var(p_e), is given by the following formula:

$$\text{var}(p_e) = \frac{1 - f_e}{n_e^2} \left(\frac{m_e}{m_e - 1} \right) \left[\sum_{j=1}^{m_e} a_{ej}^2 + p_e^2 \sum_{j=1}^{m_e} n_{ej}^2 - 2p_e \sum_{j=1}^{m_e} a_{ej}\, n_{ej} \right] \qquad (9)$$

where f_e = m_e / M_e

a_{ej} = number of teachers who responded in the jth elementary school in a particular way

n_{ej} = number of teachers who responded in the jth elementary school

j = 1, 2, 3, . . ., m_e

A corresponding variance can be calculated for a proportion based on responses from secondary schools. The overall variance of the proportional estimate var(p) is then given by the formula:

$$\text{var}(p) = \left(\frac{N_e}{N}\right)^2 \text{var}(p_e) + \left(\frac{N_s}{N}\right)^2 \text{var}(p_s) \quad (10)$$

The standard error of p is given by the following formula:

$$\text{s.e.}(p) = \sqrt{\text{var}(p)} \quad (11)$$

The variance of a proportional estimate at the national level, p_{can}, is determined by use of the following formula:

$$\text{var}(p_{can}) = \sum_{k=1}^{12} \left(\frac{N_k}{N_{can}}\right)^2 \text{var}(p_k) \quad (12)$$

where N_k = population of science teachers at a given level in province K

N_{can} = population of science teachers at that level in Canada

The standard error of p_{can} is given by the formula:

$$\text{s.e.}(p_{can}) = \sqrt{\text{var}(p_{can})} \quad (13)$$

The range of standard errors calculated in this way for national estimates in this survey is presented in Table I.5 of this report.

Reliability of the Data

The concept of standard error described here is the basis for determining the reliability of the estimates. It is used to compute a confidence interval at a specified level of probability. For example, for a 95 per cent probability level, there is a range around the true population value within which estimates from repeated samples can be expected to lie 95 per cent of the time. This range or confidence interval can be calculated using the following formula:

$$p = \pm 1.96 \times \text{s.e.} \quad (14)$$

The relatively small standard errors in our survey mean that the confidence intervals are correspondingly narrow and that the national estimates have a relatively high degree of reliability.

Notes

I. Survey Objectives and Methodology

1. The six regions are: Atlantic Canada, Québec, Ontario, Prairies, British Columbia and the Northwest Territories.

2. Estimates were produced from teacher census data collected annually by the Elementary-Secondary Section of the Education, Science and Culture Division of Statistics Canada.

3. We wanted regional estimates to be within five per cent, 95 per cent of the time.

4. We anticipated a response rate of 80 per cent after follow-up – that is, after teachers had been contacted a second or third time.

5. We assumed that the design effect, defined as the ratio of the variance of the estimate given by our sampling plan to the variance of the estimate given by a simple random sample of the same size would be equal to 1. This assumption was made because there was no reason to believe that responses of teachers within sampled schools would be highly correlated for the sort of topics covered in the questionnaire. Had there been a high degree of similarity in the responses of teachers from the same school, the effect would have been to inflate the variance of estimates, resulting in an increased ratio of variances and thus a design effect greater than 1.

6. Ten thousand questionnaires was set as a maximum.

7. We wanted provincial estimates to be within 10 per cent, 95 per cent of the time.

8. For the purpose of sampling, schools were classified into two categories – elementary or secondary – depending on the grade range of each school. We defined elementary schools as those schools containing grades kindergarten to grade 6 and secondary schools as those schools containing grades 7 to 13. Schools having both elementary and secondary grades, especially intermediate or middle schools, were placed into the category corresponding to the majority of its grades. Schools containing all grades (kindergarten through grades 12 or 13) were considered as secondary schools for sampling purposes. This procedure enabled us to obtain an adequate sample of middle-years teachers owing to the higher sampling ratios used for secondary schools.

9. The basis for classifying schools as urban or rural is the "metropolitan/nonmetropolitan indicator" used by Statistics Canada. This indicator identifies 26 communities in Canada as urban centres.

10. To estimate the number of science teachers in schools, it was assumed that teachers in elementary schools are generalists (that is, that they teach a variety of subjects) and are expected to teach some science as a part of their teaching assignment. Thus, every teacher was considered a potential respondent to our survey. In secondary schools, however, where most teachers are science specialists, we assumed that roughly one-sixth to one-quarter of the teachers (depending on the grade range of the school) teach science and were therefore potential respondents.

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