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ABSTRACT

Presented is a description of the study, an analysis of major findings, and recommendations directed towards those who share in the continuing task of improving the teaching of mathematics in British Columbia. The assessment was designed to evaluate students' achievement in and attitude toward mathematics, document changes in achievement by comparing the 1981 results to those obtained in 1977, and conduct a survey of teachers of mathematics. In addition, the assessment was directed toward identifying and clarifying different models for the mathematics curriculum. This second provincial assessment was carried out with over 90,000 students from grades 4, 8, and 12, and a sample of 2,500 tenth graders. Test booklets assessed mastery of: Number and Operation, Geometry, Measurement, Algebraic Topics, and Computer Literacy. The booklets also contained items designed to assess pupil attitudes. Two teacher questionnaires were developed, and instructors in every grade level were randomly selected as potential respondents. Overall student achievement results are considered encouraging, with measurement the cause for concern since it was consistently given the lowest rating. The teacher questionnaire indicated that many mathematics classes are taught by individuals who have had little professional or academic preparation. (MP)

The 1981 B.C. Mathematics Assessment

SUMMARY REPORT

by

id F. Robitaille

ubmitted to the
Learning Assessment Branch
Ministry of Education

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PREFACE

This <u>Summary Report</u> of the 1981 B. C. Mathematics Assessment contains a description of the study, an analysis of the major findings, and a number of recommendations directed toward those who share in the continuing task of improving the teaching and learning of mathematics in this province. The Assessment was designed to evaluate students' achievement in and attitude toward mathematics, to document changes in achievement by comparing the 1981 results to those obtained in 1977, and to conduct a survey of teachers of mathematics. In addition, the Assessment has been directed toward the goal of identifying and clarifying different models for the mathematics curriculum.

The report, like the proof of a mathematical theorem, conceals most of the time and effort that went into the planning and execution of the study. In all, the students and the teachers of mathematics, the personnel of the Learning Assessment Branch of the Ministry of Education, the staff of B. C. Research, and the members of the Contract Team, the Advisory Committee, and the Review Panels spent over 90 000 hours on the project--more hours than the average person works in a lifetime.

To the teachers of mathematics and their principals I would like to extend my thanks for the level of professionalism they exhibited by their willingness to participate in the various phases of the study. Special thanks are also due to a number of individuals whose expertise and dedication helped make what could have been a virtually impossible task into a rewarding, professional experience. This group includes Nancy Greer, Bob Wilson, and Alan Taylor of the Learning Assessment Branch as well as Mary Cooper and Barbara Holmes of B. C. Research, and Mike Dirks of U. B. C., my Research Assistant.

Finally, my thanks go to the members of the Contract Team for the fine work they did on the project. For each of them this meant adding an onerous task to already overcrowded schedules, with little prospect of any reward other than their personal satisfaction. Wendy Klassen, Ian de Groot, Les Dukowski, Tom O'Shea, and James Sherrill gave unselfishly of their time and talent to ensure the success of the 1981 Mathematics Assessment.

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Highlights of the 1981 Mathematics Assessment

The second provincial Mathematics Assessment had four specific objectives:

- to identify the major curriculum models for mathematics which are prevalent in B. C. and elsewhere;
- to evaluate and report on students' achievement in mathematics and their attitudes toward the subject;
- to assess the extent and direction of change in the pattern of students' achievement in mathematics since the first Mathematics Assessment was conducted in 1977;
- to survey teachers on a number of matters affecting the teaching and learning of mathematics.

A fifth objective of the project was to coordinate B. C. participation in the Second International Study of Mathematics which is being conducted by the International Association for the Evaluation of Educational Achievement (IEA). About 25 countries are participating in that study.

The Mathematics Assessment was carried out in early 1981. Over 90 000 students in Grades 4, 8, and 12, along with a sample of 2500 Grade 10 students, completed test booklets containing items designed to assess their mastery of five content domains: Number and Operation, Geometry, Measurement, Algebraic Topics, and Computer Literacy. The domains were subdivided into a number of objectives, some of which dealt with material that was not part of the prescribed curriculum in the province. These included areas such as Probability, Statistics, and Computer Literacy. Information was also collected from students about their attitudes toward mathematics and about certain aspects of their personal backgrounds. Results obtained by students were evaluated by three Interpretation Panels, one for each grade. The Panels assigned a rating of Strong, Very Satisfactory, Satisfactory, Marginal, or Weak to each item, objective, and domain result.

The question of which model for the mathematics curriculum was preferred by teachers, educators, and others in B. C. was addressed in two ways. First of all the topic was discussed by six Review Panels which were convened at various locations throughout the province. Secondly, more than 1500 teachers of mathematics in Grades 1 through 12 completed comprehensive questionnaires which included several items dealing with the issue of goals for the mathematics curriculum. The questionnaires also dealt with a number of other matters of interest in the field of mathematics education.

Among the major findings of the 1981 Mathematics Assessment are the following:

Students' Achievement

- Five domains were assessed at each of the three grade levels. The Interpretation Panels rated students' performance on nine of the domains as Satisfactory or Very Satisfactory, and six as Marginal. None was rated as Weak. This implies that students are learning most of the material expected of them and that they can apply that knowledge in testing situations.

- The lowest ratings at each grade level were given to results in the Measurement domain which concerned students' knowledge of the metric system and of applications of measurement such as perimeter, area, and volume.

- Results show clearly that, in spite of the campaign to have Canada adopt the metric system of measurement, students do not "think metric". In situations involving day-to-day usage of measurement, the majority of students in Grades 4, 8, and 12 use imperial units of measure rather than metric ones.

- Although students perform satisfactorily on computational skill items, results are weaker in areas involving what might be termed "numeracy". This weakness is especially apparent on items which require students to use estimation or to verify the reasonableness of an answer.

- Results in the Geometry domain appear to indicate that much of the geometric content contained in the present curriculum is not being taught.

- Grade 12 students who have elected not to take any more mathematics after Grade 10 generally performed poorly on all topics, including those items relating to consumer applications of mathematics. Their performance was significantly weaker than that of the sample of Grade 10 students who wrote the Grade 12 items.

- The group of Grade 12 students who have taken Algebra 12 did extremely well on all domains.

- Differences in achievement generally favored males over females, as they did in 1977. While these differences were small at Grade 4, they were quite substantial at Grade 12.

- Seven Change Categories consisting of items from the 1977 Assessment were included as part of the 1981 instruments. There were two Change Categories for each of Grades 4 and 8, and three for Grade 12. Students' performance increased on four of the Change Categories and remained the same on the other three. In no case was there a decrease.

Students' Background and Attitudes

- About 80% of the Grade 4 students have a positive attitude toward mathematics. At Grade 8 and 12, the percentages are 60% and 40% respectively. On the other hand, few students at any level have a decidedly negative attitude toward the subject.

- Females continue to be under-represented in most elective courses in mathematics at the senior secondary level. They constitute 40% of the Algebra 12 population, 30% of Computing Science 11, 30% of Geometry 12, 10% of Trade Mathematics 11, and 60% of the Consumer Mathematics 11.

- Only 10% of Grade 12 students have taken no mathematics courses beyond the Grade 10 level. Forty percent have taken Algebra 12.

- Few Grade 12 students have taken any of the elective courses in mathematics which are available. For example, only 6% of Grade 12 students have taken Geometry 12, the only formal geometry course in the curriculum.

- The use of calculators and computers in mathematics classes has increased considerably since 1977.

- Only 13% of Grade 12 students plan to enter the job market after completing secondary school. Slightly more than 30% plan to enrol in university or in university-transfer programs at a community college.

Goals for Mathematics Education

- All groups consulted agree that the major goal of mathematics education in B. C. should be to prepare students to function as enlightened consumers in a technological society.

- Other objectives which were highly rated included developing students' ability to use basic mathematical concepts and skills and to think logically.

- There is widespread agreement that students should be required to study mathematics each year from at least Grade 1 to Grade 11.

The Teaching of Mathematics

- Teachers of mathematics at all levels indicate that they enjoy teaching mathematics.
- Membership in the B. C. Association of Mathematics Teachers is not high. In fact, only 1% of elementary teachers, and 26% of secondary teachers of mathematics, are members of that association.
- The vast majority of teachers agree that secondary students should be permitted to use calculators in school, and there is at least moderate support for their being used in Grades 4 to 7.
- Many mathematics classes at the secondary level are taught by teachers who consider their academic or professional training to have inadequately prepared them for the task.
- Many mathematics classes at the junior secondary level are being taught by teachers who have little or no preparation, either academic or professional, in mathematics.

1. OVERVIEW

The 1981 Mathematics Assessment was conducted in February and March of 1981. In February, over 1500 teachers of mathematics in public schools throughout the province completed comprehensive questionnaires dealing with aspects of their backgrounds and professional preparation, as well as with teaching practices. In March, some 90 000[1] students enrolled in Grades 4, 8, and 12, along with a probability sample of approximately 2500 Grade 10 students, were administered the Assessment instruments. By design, the 1981 Grade 8 and Grade 12 populations were the Grade 4 and Grade 8 populations for the 1977 Assessment.

A province-wide assessment serves the educational system in a fashion analogous to that of a photograph of an event. The photograph enables an observer to examine carefully the status of the event at a particular moment in time and to study any relationships that might exist among the the component parts. In a similar way, each assessment makes it possible to examine "the state of the schools" with respect to a given area of the curriculum.

It was not the purpose of the 1981 Assessment to evaluate students' achievement in any particular course or program. Nor was the project concerned with evaluating the performance of individual students, their teachers, or their schools. Rather, the study was designed to evaluate the degree to which students in the province were mastering a number of important content objectives, and to present the results of that evaluation to educational decision-makers and the public.

Organization of the Assessment

A number of different groups participated in the design and execution of the 1981 Assessment. In addition to the thou-

[1]This number includes students from the public schools of the province and from those independent schools receiving financial support from the Ministry of Education. The results discussed in the remainder of this report are based solely on the information obtained from teachers and students in the public schools.

sands of teachers and students who completed instruments, these included personnel from the Learning Assessment Branch of the Ministry of Education, the members of the Contract Team, representatives from B. C. Research, as well as the members of the Technical Sub-Committee, the Advisory Committee, the Review Panels, the Interpretation Panels, and the teachers and students of the schools that participated in the pilot-testing.

The Contract Team had the primary responsibility for designing the Assessment, developing the necessary instrumentation, and reporting the results. The team was composed of two members of the Department of Mathematics and Science Education of the University of British Columbia, a member of the Faculty of Education of Simon Fraser University, and three classroom teachers: a primary teacher from Richmond, a junior secondary teacher from Langley, and a senior secondary teacher from North Vancouver. A doctoral student in Mathematics Education at U. B. C. served as research assistant on the project.

B. C. Research served as the Technical Agency for the Assessment. B. C. Research is the technical operation of the British Columbia Research Council, an independent, non-profit industrial research society. B. C. Research was responsible for overseeing the printing, distribution, and collection of the instruments; coordinating the scoring and analysis of all of the instruments; as well as providing consultative services to the Learning Assessment Branch and the Contract Team on matters relatin to the technical, statistical, and psychometric aspects of the study.

The Techr ' Sub-Committee consisted of representatives of the Learning ssment Branch, the Contract Team, and the Technical Agency. This committee served as the forum for discussion and decision-making on issues of a technical or statistical nature.

The Advisory Committee provided guidance and advice to the Contract Team and the Ministry of Education during the development of the instruments, the review of the results, and the preparation of the final reports. They also chaired the meetings of the Review Panels and of the Interpretation Panels.

The members of the Advisory Committee were selected from across the province by the Learning Assessment Branch to reflect a cross-section of opi ion on matters pertaining to the teaching and learning of matl. atics. In addition to two representatives of the Learning Assessment Branch, the chairman of the Contract Team, and two representatives from B. C. Research, the Advisory Committee consisted of four classroom teachers, a school principal, a district-level administrator, a university professor, and a school trustee.

Like the Advisory Committee, the Review Panels and the Interpretation Panels consisted of educators and informed members of the public selected from across the province. The task of the Review Panels was to discuss the goals and objectives of the mathematics curriculum in B. C., both present and future. After the Assessment data had been analyzed, the Interpretation Panels were convened to examine the results and to comment on the performance levels achieved.

Scope of the Assessment

The B. C. Provincial Assessments are based on the premise that the systematic collection and dissemination of comprehensive, reliable data are essential components of the effective management of education in this province. According to guidelines laid down by the Learning Assessment Branch, the objectives of each province-wide assessment are to:

- inform professionals and the public of some of the strengths and weaknesses of the public school system;

- assist the Ministry and school districts in making decisions related to the development, review, modification, revision, and implementation of existing curricula and supporting instructional materials;

- assist the Ministry in making decisions concerning allocation of resources;

- identify areas of need and provide directions for change in both pre-service and in-service teacher education and professional development;

- provide direction for educational research.

Within the framework of these guidelines, it was intended that the 1981 Mathematics Assessment would provide the Ministry of Education with much of the information required to make decisions about the need for a review or revision of the current mathematics curriculum, and about directions that any such process might take. Four specific goals were established:

- to identify those curriculum models for mathematics which are prevalent in British Columbia and elsewhere;
- to evaluate and report on students' achievement in mathematics and their attitudes toward the subject;
- to assess the extent and direction of change in the pattern of students' achievement since the 1977 Assessment;
- to survey teachers of mathematics on a number of matters which affect the teaching and learning of mathematics.

An additional task of the project was the coordination of B. C. participation in the Second International Study of Mathematics which is being conducted by the International Association for the Evaluation of Educational Achievement (IEA), and in which approximately 25 countries are participating. The report summarizing the results of B. C. participation in that study will be published as a separate volume by the Ministry of Education in 1982.

2. GOALS OF THE MATHEMATICS CURRICULUM

Mathematics has been an integral part of the school curriculum for so long and so universally that it is difficult to imagine schools without it. In fact, the question of why we teach the mathematics that we do, in the way that we do, to so many children, for so many years, scarcely ever arises. On the other hand, if a mathematics curriculum is to be evaluated, reviewed, or revised in an intelligent fashion, then these are precisely the issues which must be addressed.

The 1981 Mathematics Assessment provided an opportunity to raise such questions, not only theoretically, but practically as well. As a first step a paper entitled Curriculum Models in Mathematics was prepared and then utilized as a focal point for the project.[2] Its purpose was to identify widely-held points of view about the nature of mathematics, characteristics of different mathematics curricula, and a number of factors which affect the nature of that curriculum. The paper also served as a framework for designing the instrumentation to be used in the Assessment and for analyzing the results.

As a second step, six Review Panels were set up across the province: two to discuss the goals of the mathematics curriculum at the primary level, two at the intermediate level, and two at the secondary level. Each Review Panel was made up of teachers, administrators, and other educators, as well as school trustees and members of the public. Each Panelist was asked to read the Curriculum Models paper and to complete the Goals Survey questionnaire which had been developed for use as a basis for the deliberations of the Review Panels. The questionnaire dealt with the goals of the mathematics curriculum and its content, the importance of affective as well as cognitive outcomes, and instructional practices in mathematics education.

A number of the items from the Goals Survey questionnaire were also included on the questionnaires which were completed by over 1500 teachers of mathematics in the province. It was hoped that, on the basis of these items, it would be possible to partition teachers into categories according to their view

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[2]That paper appears as Chapter 2 in the General Report of the 1981 Assessment.

of the mathematics curriculum. That hope was largely realized with teachers of secondary school mathematics, but not with elementary teachers.

Models for the Mathematics Curriculum

The development of a mathematics curriculum is a complex process involving a number of important factors which influence the final outcome. As is illustrated by the diagram in Figure 1, the curriculum development process in mathematics is founded upon a particular set of beliefs and opinions concerning the nature of mathematics, its content, and its processes. Those beliefs and opinions are influenced and modified by the effects of a number of factors or parameters within which the school system operates. Although there are undoubtedly a large number of such factors, four would appear to be of particular importance. These are sociological factors, psychological factors, pedagogical factors, and technological factors.

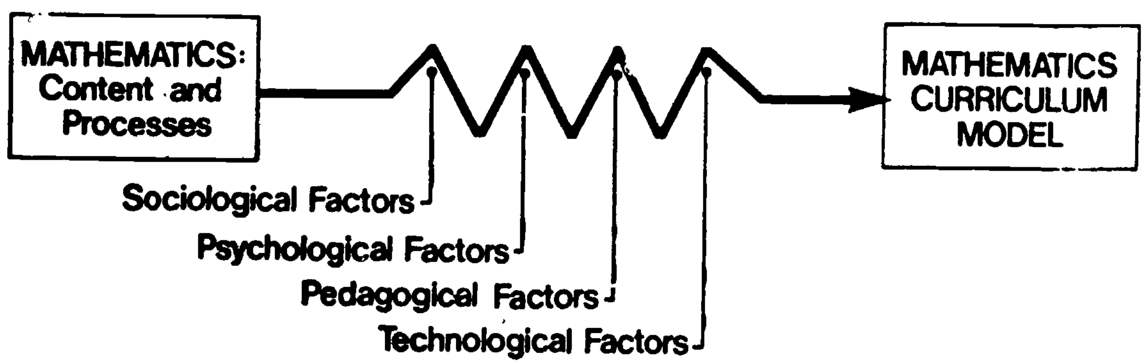


Figure 1. Development of a mathematics curriculum model.

The way in which mathematics is viewed by members of the mathematical community has a profound effect on the nature of the school mathematics curriculum. Differing views of what mathematics is, how it is used, and what mathematicians do can result in widely differing choices of content for the curriculum.

As surprising as it may seem to many, there is no universal agreement among mathematicians about what mathematics is.

Indeed, this question has consistently been a topic of heated debate among mathematicians and philosophers. It has been suggested, perhaps only partly in jest, that no group of more than two mathematicians could ever agree on a definition of mathematics.

One example of opposing points of view regarding the nature of mathematics, and one that has had important implications for the schools, is the distinction that is frequently drawn between <u>pure</u> and <u>applied</u> mathematics. There is no doubt, for example, that during the "New Math" era of the 1960s and 1970s the predominant influence on school mathematics came from pure mathematicians. The advice and opinions of applied mathematicians went virtually unheeded.

At the present time, recommendations are being made to give increased emphasis to the applications of mathematics in other fields. In other words, we may well be witnessing a move toward an applied mathematics viewpoint in school mathematics curricula. At the same time, however, there has recently been a considerable amount of pressure exerted on the schools to emphasize fundamentals--the so-called "back-to-basics" movement. In the case of mathematics, this has typically been interpreted to mean that development of the computational skills of arithmetic should take precedence over any other part of the mathematics curriculum, at least at the elementary school level.

In the Curriculum Models paper three models for the mathematics curriculum were outlined: a Pure Mathematics model, an Applied Mathematics model, and a Basic Skills model. A number of items from the Goals Survey questionnaire as well as the Teacher Questionnaires were then identified as being consistent with one or another of these three models. Those items were used as a means of finding out what views of the nature and content of school mathematics were prevalent in the province.

<u>The Goals Survey</u>

The members of the Review Panels were selected from various regions of the province and from among those groups having a particular interest in the field of mathematics education. They included teachers, administrators, college and university professors, school trustees, and members of the public. The Panels each met for an entire day to discuss the goals of school mathematics in B. C., using their responses to the Goals Survey questionnaire as a basis for their deliberations.

The Panelists experienced considerable difficulty in reaching agreement on the meaning of some of the terminology used in the questionnaire. Although words such as "logical reasoning", "specialist", and "computer literacy" are used frequently in educational circles, it was apparent that different Panelists held widely differing views about the meanings of those terms. This lack of agreement, more obvious in this type of forum than in data obtained from questionnaires, constitutes a significant limitation of such surveys of opinions and preferences.

No statistical analyses of the data collected from the Review Panels were conducted. Any conclusions they reached should be interpreted as being representative of the opinion of this group of people selected to represent the geographic zones of the province and those segments of the population having an interest in the mathematics curriculum of the schools. The results should not be viewed as being necessarily representative of the opinion of the province as a whole.

In the opinion of the Panelists, the mathematics curriculum should emphasize one major theme: developing in students the abilities, concepts, and skills they will need in order to participate successfully in our technological society. Also highly rated were the goals of familiarizing students with fundamental mathematical ideas and processes, and developing students' ability to think logically. Those goals were the ones most highly rated by teachers as well.

The Review Panels agreed that mathematical concepts and problem solving should be important parts of the curriculum, and results from the Teacher Questionnaires support this view. The Panelists felt that computer literacy should be included in the curriculum, but there was some disagreement about the grade levels at which it should be introduced, and whether or not it should be part of the mathematics curriculum.

Panelists expressed their opinions on a number of questions concerning ways in which schools and classes should be organized for the teaching of mathematics. They were in favor of grouping students by ability for mathematics instruction: by classes at the secondary level, and within classes at the elementary level. They saw a few possible advantages to encouraging students to specialize in mathematics in Grades 11 and 12, but felt that those advantages were outweighed by the disadvantages.

The practice of organizing mathematics courses by semesters, whereby a student might study mathematics from September to January during a given school year and then not do any mathematics during the second half of that year, was also discussed. Generally speaking, the advantages which were identified for semestering tended to emphasize administrative concerns, while the disadvantages were primarily pedagogical in nature.

Panelists were strongly of the opinion that some form of mathematics course should be required of all students from Grade 1 to Grade 11 and that, at the senior secondary level at least, there should be a wide variety of mathematics courses available to students. They agreed that the teaching of mathematics in secondary schools should be restricted to those teachers who had the appropriate academic and professional preparation. There was moderate support for the idea of using specialists to teach mathematics at the elementary level as well. Similar opinions were expressed on the Teacher Questionnaires.

Results from both the Goals Survey and the Teacher Questionnaires show moderate to strong support for the use of calculators by students in school, even at the elementary level. Similarly, there was widespread support for the introduction of the topic of computer literacy into the school curriculum, although a majority felt that it should be dealt with in a number of courses and not be restricted to the mathematics classroom.

In terms of the three models for the mathematics curriculum developed in the Curriculum Models paper, little or no support was expressed by the Review Panels for implementing a Pure Mathematics model. Instead, they appeared to support a combination of the Applied Mathematics-Basic Skills models: a model where the basic skills are applied in everyday, real-life situations.

Teachers' Preferences for Curriculum Models

Items from the Teacher Questionnaires which appeared to relate to the Pure, Applied, and Basic Skills curriculum models were identified and utilized to categorize teachers as preferring one or the other of those models. Factor analyses of the data failed to confirm the existence of groups of teachers supporting the models as defined by those items. Among elementary teachers, for example, only one coherent grouping was found that resembled any of the three models. For that reason, no further attempt was made to investigate the curricular model preferences of elementary teachers.

Among secondary teachers, three factors were identified and, although they do not correspond exactly to the three identified in the Curriculum Models paper, they do appear to be fairly closely associated with them. The first factor, termed the School Mathematics factor, includes items which stress the importance of topics which have traditionally been viewed as integral parts of the school mathematics curriculum: for example, recognition of geometric figures, and solution of equations. Teachers in this category feel it is important for prospective teachers to have good backgrounds in mathematics as well as in methods of teaching algebra and geometry.

The second factor includes items which emphasize the applications of traditional topics from the secondary mathematics curriculum in other areas of mathematics. These include logic, probability, and graphing techniques. This factor was called the Applications factor.

The third factor, the Real-World Mathematics factor, includes those items which stress the importance of consumer and career mathematics and of training students to apply the mathematical techniques they have learned in real-world settings.

Secondary teachers were given a score for each of the three models according to their responses to the items which defined them. Each teacher was then identified as preferring the model for which he had the highest score. The distribution of teachers among models was very even: 36% for the Real-World Mathematics model, and 31% for each of the other two.

Analysis of the Teacher Questionnaire data in light of the curricular preferences of teachers yield a number of interesting results. Those teachers who selected the Real-World Mathematics model have fewer years of teaching experience than those in the other two groups, they prefer to teach at the junior rather than the senior secondary level, and are more likely to be teaching other subjects in addition to mathematics. Moreover, about 20% of these teachers have never completed a mathematics course beyond the secondary school level, and almost 40% of them have had no training in the teaching of mathematics. Fifty percent of these teachers have not attended a mathematics session at a conference or a workshop in the past three years.

On the other hand, those teachers who prefer the School Mathematics model tend to be those who have the most experience, who teach only mathematics, and who prefer to teach at the senior secondary level. Only 3% of these teachers have had no post-secondary training in mathematics, and 18% of them have never taken a course in the teaching of mathematics. Almost two thirds have attended a mathematics conference or workshop in the past three years.

Teachers who support the Applications model tend to fall between these two extremes. This was the case with seven of the nine comparisons which were made among the three groups.

3. THE STUDENTS OF MATHEMATICS

Approximately 90 000 students enrolled in Grades 4, 8, and 12 participated in the 1981 Mathematics Assessment. Taking into account the sampling that was done in some of the larger school districts, the return rates were 96% at Grade 4, 91% at Grade 8, and 80% at Grade 12. As is shown in Table 1, these results compare very favorably with those from the first Mathematics Assessment in 1977.

Table 1
Participation Rates
(Percent)

Grade	1977	1981
Grade 4	97	96
Grade 8	90	91
Grade 12	71	80

The purpose of this Assessment was to evaluate the performance of all students at a given level, not only those who are following a particular program. For that reason, at the Grade 12 level, all students were required to participate whether or not they were studying mathematics at the time. Viewed in this light, the 80% participation rate at the Grade 12 level is very high.

3.1 Student Characteristics

Each Assessment booklet contained a number of background information items. In most cases those items dealt with variables which research has shown to be linked to academic achievement. Some of the results from these Reporting Categories are discussed in Part 5 of this report. In this section they are used to describe the population of students who participated in the Assessment.

Sex

At each grade level the population is fairly evenly split between males and females. In Grades 4 and 8, boys outnumbered girls by small margins; the reverse was true at Grade 12.

An analysis of courses taken by sex of student was carried out among Grade 12 students. Results of this analysis show that, up to and including Algebra 11, males and females are equally represented. Beyond that level, however, the picture changes dramatically. Males constitute approximately 60% of the Algebra 12 population, the same proportion as in 1977. Males form 70% of the Computing Science 11 and Geometry 12 populations, and almost 90% of the Trades Mathematics 11 population. The only senior course in which females outnumber males is Consumer Mathematics 11, where 60% of the students are female. In summary, females continue to be under-represented in mathematics courses at the senior secondary level, a situation that remains virtually unchanged since 1977.

Mathematics Background of Grade 12 Students

Students are not required to take mathematics courses beyond Math 10. Results from the Assessment show that only 10% of Grade 12 students have completed no more than this minimum requirement, and that almost 40% of them have taken Algebra 12, a 5% increase over 1977.

Senior elective courses attract relatively small numbers of students. Eighteen percent of these Grade 12 students have completed Consumer Mathematics 11, and 11%, Trades Mathematics 11. Only 8% have studied Computing Science 11; 3%, Probability and Statistics 12; and, perhaps most disquieting of all, only 6% have completed Geometry 12. It may be that these numbers are so small because the courses are relatively new additions to the curriculum and, as a result, are not being offered in many schools.

Calculator and Computer Usage

Only 4% of Grade 4 students have used a calculator in school compared to almost 40% who have used one at home. Calculator usage in school increases to 15% at the Grade 8 level and almost 75% in Grade 12. Over 95% of Algebra 12 students use calculators regularly in school and for homework.

Over two thirds of Grade 12 students and about one half of Grade 8 students said there were computers available in their schools. When computers are utilized, they tend to be used more in mathematics and computer science classes than in other subject areas.

The use of calculators and computers in schools has increased since 1977, and will probably continue to do so. This growth is occurring in spite of the lack of clear guidelines and curricular recommendations from the Ministry of Education. If the maximum benefit is to be derived from such technological advances, that gap must be filled.

Homework Assignments

Students in Grades 8 and 12 who were taking a mathematics course at the time of the Assessment were asked how much time they had spent on their most recent homework assignment. Over 40% at each level indicated they had spent between 11 and 30 minutes on it. Fewer than 5% said it had taken them more than an hour to do their last mathematics assignment, while some 7% at each level said that they never had any homework assignments in mathematics.

Part-Time Employment of Grade 12 Students

About 62% of Grade 12 students have part-time jobs, up from 54% in 1977. On the average, the students spend about 9 hours per week working at those jobs.

Future Plans of Grade 12 Students

Only 13% of Grade 12 students plan to enter the job market without any further education, down from about 20% in 1977. Approximately 30% plan to enrol in university or in university-transfer programs at community colleges. Fewer than 10% have yet to decide on their educational plans for the future.

3.2 Metric Usage

Canada has committed itself to the adoption of the metric system of measurement, and the changeover has been taking place gradually over the past several years. The schools, on the other hand, have been directed to make the changeover more rapidly. The SI[3] metric system of measurement is taught, and virtually all of the approved textbooks use SI units exclusively.

[3] Le Système International d'Unités.

In an effort to ascertain to what degree students in the province "think metric", that is operate in the metric system without recourse to the imperial system, they were asked to respond to four questions, giving, in each case, the answer that came to mind first. They were also told that both answers to each question were correct. The questions and answers, along with the percent of students selecting each option, are shown in Table 2.

Table 2
Responses to Metric Usage Items
(Percent)

	Grade 4	Grade 8	Grade 12
How much does a bicycle weigh?			
About 15 kilograms	40	26	16
About 35 pounds	59	72	82
What is the temperature in this room?			
About 20 degrees	61	38	40
About 70 degrees	38	60	59
How far is it from Prince George to Prince Rupert?			
About 700 kilometres	37	30	22
About 450 miles	63	67	77
How much gasoline can the gas tank in a large car hold?			
About 90 litres	41	22	19
About 20 gallons	59	74	79

Only on one item, the one involving temperature, and only at one level, Grade 4, did more students select the metric choice than the imperial. In the majority of cases they opted overwhelmingly for the answer expressed in imperial units. Clearly, these students do not "think metric".

These results indicate that the campaign to have imperial units replaced by metric units in everyday life appears to have been less than successful up to this time. This conclusion is illustrated most dramatically at the Grade 4 level where students have been taught the metric system and only the metric system since they first enrolled in school. In spite of that fact, only about 40% of the Grade 4 students chose the metric alternative on three of the four questions.

3.3 Attitudes toward Mathematics

Students' test booklets contained a set of items designed to assess their attitudes toward mathematics. For Grade 8 and Grade 12 students, there were nineteen items in the scale; for Grade 4, there were eight. The items were selected and adapted from among those used in the 1978 assessment of mathematics conducted by the National Assessment of Educational Progress in the U. S. A. and, more recently, in the Second International Study of Mathematics.

Affective outcomes, such as attitudes, are notoriously difficult to specify and evaluate. However, since there appears to be continuing interest in their relationship to students' achievement, it was considered essential that an effort be made to include an attitude scale as part of the Assessment.

Table 3
Attitudes toward Mathematics
(Percent)

Attitude	Grade 4	Grade 8	Grade 12
Strongly Positive	35	11	6
Positive	43	49	35
Neutral	19	34	41
Negative	3	6	16
Strongly Negative	0	0	2

The results displayed in Table 3 show that students' attitudes decline rather dramatically over the period between Grade 4 and Grade 12, from a high of almost 80% with strongly positive or positive attitudes toward mathematics in Grade 4 to 40% in Grade 12. This decline in positive attitudes, however, is not accompanied by parallel growth in negative attitudes. Instead, the largest group at Grade 12 has a neutral attitude.

Responses to certain items showed considerable stability across grade levels. For example in response to the item "I really want to do well in mathematics", 90% of Grade 4, 89% of Grade 8, and 78% of Grade 12 students responded positively. Similarly, positive response rates to the statement "I feel good when I solve a mathematics problem by myself" were 86%, 83%, and 86% respectively.

Other items evoked different attitudes at the three grade levels. For example, while 63% of Grade 4 students are "looking forward to taking more mathematics", only 56% of Grade 8 and 24% of Grade 12 students share that opinion.

4. ACHIEVEMENT RESULTS

The 1981 Mathematics Assessment evaluated students' achievement in mathematics at three grade levels (4, 8, and 12), at three levels of cognitive behavior (Computation and Knowledge, Comprehension, and Application), and in five content domains (Number and Operation, Geometry, Measurement, Algebraic Topics, and Computer Literacy). The structure of this aspect of the Assessment is shown in the Item Specification Model displayed in Figure 2

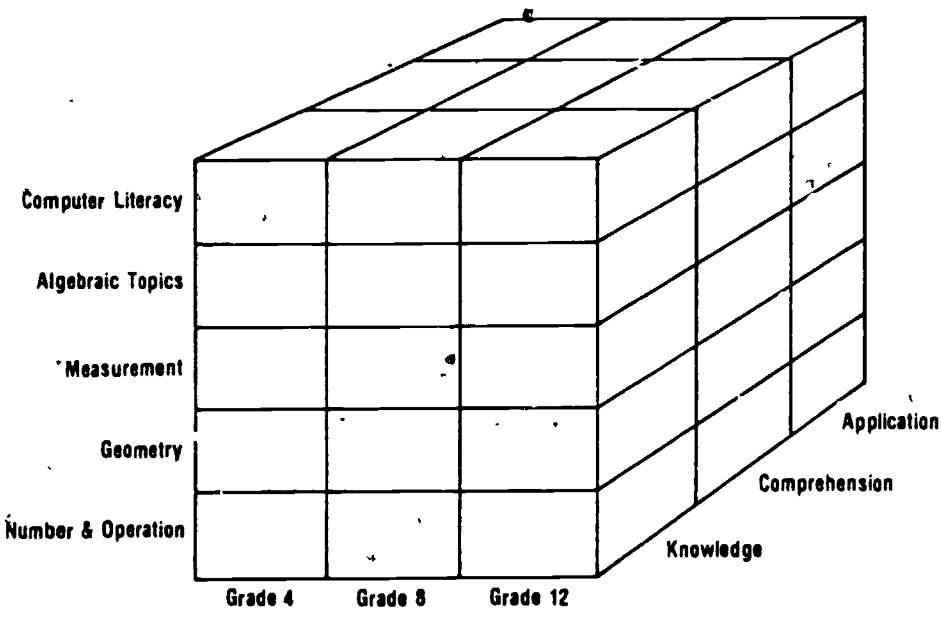


Figure 2. Item Specification Model.

The five domains were selected as representing major areas of content appropriate to the mathematics curriculum. Each domain except Computer Literacy was itself broken down into a number of objectives representing more specific topics. This division of the domains into objectives is summarized in Table 4.

Table 4
Domains and Objectives

Domains	Objectives Grade 4	Grade 8	Grade 12
1. Number & Operation	Number concepts & computation	Whole numbers	Number concepts
	Estimation	Fractions & decimals	Fractions & decimals
	Fractions & ratio	Ratio, proportion, & percent	Ratio, proportion, & percent
2. Geometry	Geometric figures	Geometric figures	Geometric figures
	Geometric relationships	Geometric relationsnips	Geometric relationships
		*Logical reasoning	*Logical reascning
3. Measurement	Iength, area, volume, mass	Metric units	Metric units
	Time & temperature	Area & volume	Area & volume
4. Algebraic Topics	Number Sentences	Expressions, equations, & inequalities	Expressions, equations, & inequalities
	Graphs	Graphs	Graphs
	*Probability	*Probability	*Probability
		*Statistics	*Statistics
5.*Computer Literacy			

* denotes content not contained in the present curriculum in B. C.

The relative importance of the domains varies from one grade to the next, and this was reflected in the Assessment by varying the number of items used to assess a given domain in different grades. For example, 41% of the Grade 4 items, 35% of the Grade 8 items, and 24% of the Grade 12 items belonged to the Number and Operation domain. On the other hand, the proportion of items devoted to the Algebraic Topics domain ranged from a low of 17% at Grade 4, to 29% at Grade 8, and 35% at Grade 12.

Some of the objectives dealt with content that is not explicitly part of the prescribed curriculum but whose inclusion in that curriculum has been recommended on a number of occasions and by various groups. These objectives--Logical Reasoning, Probability, Statistics, and Computer Literacy--involved relatively few items.

At each of Grades 4 and 8, 138 cognitive items, evenly divided among three booklets, were employed. For Grade 12, because many districts have small enrollments at that level, only 90 items divided between two booklets were used. This was necessary in order to produce reliable item-statistics for the summary of results which each school district receives on the performance of its students.

Since one of the major goals of the 1981 Assessment was to document the direction and extent of change in students' achievement patterns in mathematics since 1977, a number of items from the first Assessment were included in the 1981 pool of items. These change items were grouped into Change Categories: two Change Categories for each of Grade 4 and Grade 8, and three for Grade 12. Each Change Category consisted of approximately ten items.

Testing was done during a one-week period in March 1981. Teachers were asked to set aside 45 minutes for giving instructions, for distributing the booklets to their students, and for the testing itself.

All cognitive items in the booklets were multiple-choice with five response choices. Four of the choices were possible answers to the item; the fifth was "I don't know".

When the data had been analyzed, three Interpretation Panels, one at each grade level, met to study the results and rate the level of performance attained by the students on each of the items, objectives, and domains. Each result was assigned one of the following categorizations:

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

When this task was completed, the Panels then rated students' performance on each objective and domain in the same way.

In arriving at their ratings, Panelists were asked to bear in mind not only the proportion of students who had responded correctly, but also the difficulty of the item. Thus, a result of 40% on a difficult item might be more commendable than one of 70% on an easier item. This frequently proved to be a difficult task for the Panelists.

4.1 Grade 4

The Grade 4 item pool contained 138 cognitive items designed to evaluate students' achievement on eleven objectives grouped into five domains. Table 5 summarizes the ratings given by the Grade 4 Interpretation Panel to the results on each domain and objective along with the corresponding numbers of items and mean-percent-correct values.

Table 5
Grade 4: Summary Statistics

Domain/Objective	Number of Items	Provincial Mean (%)	Panel Rating
Number and Operation	57	70	VS
Concepts and computation	36	74	VS
Estimation	9	62	S
Fractions and ratio	12	62	VS
Geometry	21	62	S
Geometric figures	9	75	VS
Geometric relationships	12	52	S
Measurement	30	60	M
Length, area, volume, mass	18	58	M
Time and temperature	12	63	M
Algebraic Topics	24	58	S
Number sentences	9	55	M to S
Graphs	6	68	S
Probability	9	55	S
Computer Literacy	6	41	S

On the whole, these results are quite encouraging. They indicate that students at this level are acquiring many of the mathematical concepts and skills required of them. The Interpretation Panel rated results on eight of the eleven objectives as being Satisfactory or better; none was rated as being Weak. According to the Panel, students' performance was weakest in the Measurement domain.

Number and Operation

Items in this domain dealt with many of the major concepts and skills of the arithmetic content of the primary grades. The Very Satisfactory rating given by the Interpretation Panel to students' achievement level in this domain indicates they were quite pleased with the results. Performance on 26 of the 57 items was rated as Very Satisfactory or Strong. Only 4 item-results were judged to be Weak.

Students performed very well on items testing place value concepts, computational skills, rounding numbers to the nearest 100, and recognition of unit fractions in part-whole settings.

Students' performance was weaker on items which required them to read and interpret sentences, to perform more than one operation, to recognize a fraction as a subset of a set, and to round a number to the nearest 10. For example, performance on Item A/24[4] was rated as Marginal.

A/24. Round off 43 to the nearest ten.

	% of students
30	7
50	8
40	61†[5]
44	20
I don't know	5

[4]A/24 means Item 24 in Booklet A.

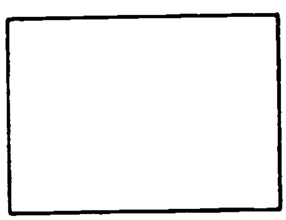
[5]† indicates the correct response.

Geometry

The geometry items involved recognition of geometric figures and terminology as well as geometric relationships such as congruence and symmetry. Ten item-results were rated Very Satisfactory or Strong, while only two were judged to be Weak.

Students performed very well on items which required them to recognize geometric figures. On items involving terms such as "symmetry" and "congruent" however, the performance level was considerably weaker. For instance, 14% were able to answer Item C/27 correctly. In spite of the low level of performance, on this item dealing with a topic from the curriculum, the Panel judged the result to be Marginal since it was clear to them that students had not been taught this material. They were also of the opinion that it would be unwise to emphasize vocabulary and terminology in geometry at the expense of concept development and concrete experience.

C/27. How many lines of symmetry does this shape have?



	% of students
1	1
2	14†
3	1
4	74
I don't know	10

Measurement

The 30 Items in this domain assessed students' knowledge of the SI metric units of length, area, volume, and mass as well as their knowledge of time and temperature. Their performance on this domain was judged to be weaker than on any of the others. One half of the 30 item-results were given ratings of Marginal or Weak, while only nine were rated Very Satisfactory or Strong.

Students had difficulty with items which tested their familiarity with the metric units. For example, as is shown in Item A/39, only 20% chose 35 kg as a likely mass for a ten-

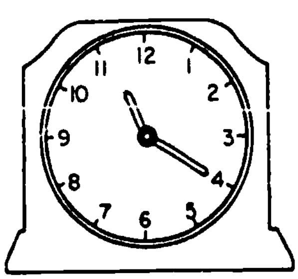
A/39. A ten-year-old boy is likely to weigh:

	% of students
35 grams	7
75 grams	18
35 kilograms ....,..	20†
75 kilograms	40
I don't know	14

year old boy. Almost the same number chose 75 g, a highly improbable answer, and 40% chose 75 kg, another improbable answer. Students did not do particularly well on an item which asked them how many centimetres there are in a metre. Only 67% obtained the correct answer. On an example involving temperature expressed in degrees Celsius, only 26% chose 25°C as an appropriate temperature for a sunny day while 27% chose 55°C and 34% chose 85°C. The Panel expressed disappointment with these results, particularly in view of the fact that these students had been taught only the metric system since they entered school.

Items requiring students to read clocks or thermometers were well done. For example, 90% obtained the correct answer to Item A/29.

A/29. What time does this clock show?



	% of students
11:20	90†
4:00	1
11:40	7
12:20	2
I don't know	1

Algebraic Topics

Performance on the 24 items in this domain was rated as Satisfactory. Six item-results were rated Very Satisfactory or Strong and six as Marginal or Weak. The items dealt with the use of symbols, solution of number sentences (equations), reading and interpreting graphs, and elementary probability concepts.

Students' ability to select the number sentence needed to solve a word problem was rated Satisfactory, as was their ability to read and interpret graphs. Performance on items involving missing addends, and recognition of inequality symbols was somewhat poorer.

Computer Literacy

The six computer literacy items dealt with topics such as the capabilities and limitations of computers, the impact of computers on society, and fields of application of computers. They did not deal with topics from the field of computer science. The Panel rated students' performance on this non-curricular objective as Satisfactory. That rating was based primarily on the fact that they felt that since this material was not part of the prescribed curriculum, it would not be reasonable to expect high levels of performance.

4.2 Grade 8

The Grade 8 item pool consisted of 138 cognitive items divided among 13 objectives grouped into five domains. Table 6 summarizes the ratings given by the Grade 8 Interpretation Panel to the results on each domain and objective, along with the corresponding numbers of items and mean-percent-correct figures.

On the whole the Grade 8 results were given lower ratings by the Grade 8 Interpretation Panel than were results at either Grade 4 or Grade 12 by their respective Panels. Student achievement on only one objective, Graphs, was rated better than Satisfactory, while performance on five objectives was judged to be Marginal, and on one objective to be Weak. These latter objectives include some of the major content areas of the Grade 8 curriculum: fractions and decimals; ratio, proportion, and percent; metric units; and area and volume. Three of the five domain results were judged to be Marginal. There is some evidence, particularly as concerns students' performance on the items repeated from the 1977 Assessment, to indicate that the Grade 8 Interpretation Panel was quite conservative in its ratings.

Table 6
Grade 8: Summary Statistics

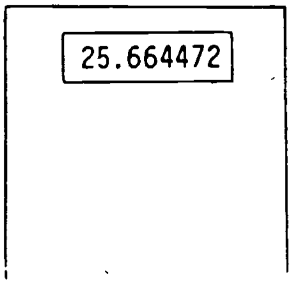
Domain/Objective	Number of Items	Provincial Mean (%)	Panel Rating
Number and Operation	48	63	M
Whole numbers	18	69	S
Fractions and decimals	18	59	M
Ratio, proportion & percent	12	61	M
Geometry	24	58	M
Geometric figures	6	57	M
Geometric relationships	12	52	M
Logical reasoning	6	69	S
Measurement	21	46	M
Metric units	9	57	M
Area and volume	12	37	W
Algebraic Topics	39	52	S
Equations and inequalities	18	56	S
Graphs	6	64	VS
Probability	6	41	S
Statistics	9	44	S
Computer Literacy	6	60	S

Number and Operation

By the time they reach Grade 8, students are expected to have learned how to add, subtract, multiply, and divide whole numbers, fractions and decimals. Moreover, they should have learned a number of fundamental mathematical concepts as well as techniques for solving word problems, including those involving the use of proportions or percent. Items in the Number and Operation domain were intended to assess students' mastery of those objectives. Overall performance on those items was judged to be Marginal.

Results indicate that Grade 8 students' ability to perform the four basic operations with whole numbers, fractions, and decimals is Satisfactory. Lowest ratings were given to results on items which required students to solve word problems, to compare fractions, to convert fractions to decimals and percents, and to estimate. For instance, 38% obtained the correct answer to Item A/11 which required them to estimate a product. This result was rated Weak.

A/11. The diagram shows a calculator display. Use estimation to decide which of the four exercises would have that answer.



	% of students
5.3269 x 4.8179	38†
3.8245 x 7.93345 ...	27
114.971 x 0.56487 ...	9
131.427 x 10.6304 ...	8
I don't know	17

Geometry

Items in this domain were designed to evaluate students' knowledge of a number of fundamental geometric terms and theorems, their ability to visualize objects in space, and their grasp of concepts such as symmetry. In addition, six logical reasoning items were included in this domain. Performance in the Geometry domain was Marginal.

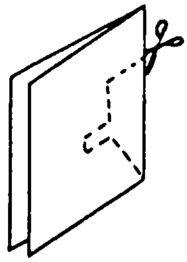
On the whole, results on the terminology, spatial visualization, and logical reasoning items were at least Satisfactory. For example, 90% of students obtained the correct answer to Item A/42, a performance which was rated Strong.

Less positive results were obtained on items dealing with knowledge of elementary theorems in geometry. Only one-fourth of students appeared to be familiar with the relationship between the sides and angles of an isosceles triangle--28% responded "I don't know" to that item. On Item A/41, which dealt with the Theorem of Pythagoras, only 17% obtained the correct answer and 36% chose the "I don't know" option.

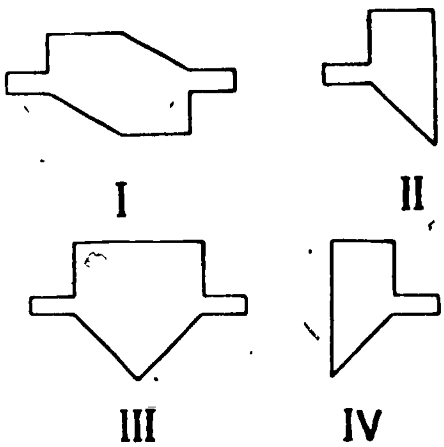
The Interpretation Panel felt that these results indicated that instruction in geometry was being neglected, and that steps should be taken to correct this situation. Similar comments were made by the Grade 8 Interpretation Panel in 1977.

Measurement

The Measurement domain included items which tested students' familiarity with SI metric units as well as with the concepts of perimeter, area, and volume. Their performance in this domain was rated as Marginal; on the perimeter, area, and



A/42. What will the figure above look like when it's cut out and unfolded?



	% of students
I	2
II	5
III	90†
IV	2
I don't know	1

A/41. The legs of a right triangle are 6 cm and 8 cm long. How long is the hypotenuse?

	% of students
48 cm	31
7 cm	10
100 cm	6
10 cm	17†
I don't know	36

volume objective it was Weak.

Achievement on items dealing with length was generally Satisfactory or better, but not on items dealing with mass and temperature. Students also appear to have difficulty converting from one metric unit to another. Item B/44 is an example. Performance on this item was rated Weak.

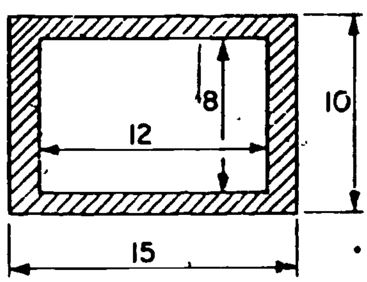
Results on items dealing with area and volume were quite poor. All seven items on the topic of area resulted in perfor-

B/44. What is the combined mass of three objects having masses of 600 g, 1.02 kg and 32 g ?

	% of students
1.652 kg	25†
2.04 kg	7
843 g	10
733.02 g	26
I don't know	33

mance levels that were rated Marginal or Weak. On Item B/18, for example, 30% chose the "I don't know" option.

B/18. What is the area of the shaded portion of this figure?



	% of students
54	33†
96	21
120	7
60	10
I d n't know	30

Algebraic Topics

The 39 items in the Algebra domain dealt mainly with algebraic expressions, solution of equations and inequalities, and reading and interpreting graphs. In addition, some elementary notions from the areas of Probability and Statistics were included, though they are not explicitly included in the curriculum at this level. The Panel rated the results obtained in this domain as Satisfactory.

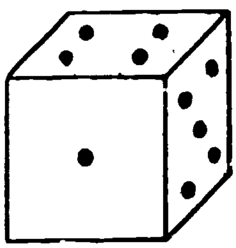
Students demonstrated an ability to solve simple equations in one variable. On Item B/22, 72% obtained the correct answer, a Satisfactory result. On less straightforward examples, results were somewhat poorer.

B/22. Solve: 3x - 3 = 12

	% of students
x = 7	2
x = 4	6
x = 3	2
x = 5	72†
I don't know	11

Achievement on three of the four objectives in this domain was rated Satisfactory; on the fourth, it was Very Satisfactory. The Panel was pleased with students' performance in this domain, even in Probability and Statistics which are not part of the prescribed curriculum. For example, their performance on Item A/45 was rated as Satisfactory.

A/45. If on the roll of a die the probability that a five will appear is 1/6 then the probability that a five <u>or</u> a three will appear is:



	% of students
1/6	20
1/36	7
1/3	49†
1/12	14
I don't know	10

Computer Literacy

The six items in the Computer Literacy domain assessed students' knowledge of some basic non-technical matters about computers. The items treated topics such as the strengths and limitations of computers, their social impact, and areas of application. The items did not include programming, flow charting, or other aspects of computer science. Students' performance on the items in this domain was rated a-

Satisfactory; however, the Panel awarded this rating primarily because the material was considered to be unfamiliar to the students rather than because their performance level was satisfactorily high.

4.3 Grade 12

The Assessment instruments for Grade 12 were administered to all students enrolled in Grade 12 whether or not they were currently studying mathematics. The items did not constitute a test of any single course, such as Algebra 11 or 12, but rather were intended to evaluate students' mastery of a number of concepts and skills which, for the most part, they could reasonably be expected to have acquired upon completion of secondary school. Although some of the items dealt with content outside the prescribed curriculum, the vast majority dealt with topics customarily treated at the Grade 10 level or lower.

Since Math 10 is the last mathematics course which all students are required to take, a decision was made to include a sample of Grade 10 students in the Assessment. Their inclusion permitted comparisons to be drawn not only with the Grade 12 population as a whole but also with that subset of Grade 12 students who had taken no mathematics beyond the Grade 10 level. The performance of the Grade 10 sample was not rated by the Interpretation Panel. Their comments pertain only to the results obtained by the entire Grade 12 group.

In the Grade 12 pool of items, there were 90 items divided among five domains sub-divided into 13 objectives. Table 7 presents a summary of the ratings given by the Grade 12 Interpretation Panel to the results on each domain and objective.

The differences between the means for the Grade 10 sample and the Grade 12 group are consistently small. At the domain level, they vary between two and six percentage points, all in favor of Grade 12. None of the differences at the level of objectives exceeds 7%, and most of them are 4% or less.

Overall, judging from the ratings of the Interpretation Panel, the performance of the Grade 12 students appears to be adequate, although there are a number of areas which the Panel singled out as requiring increased attention. Results on eight of the 13 objectives were rated as being Satisfactory or Very Satisfactory. None was rated as Weak.

Table 7
Grade 12: Summary Statistics

Domain/Objective	Number of Items	Provincial Mean (%) Gr.10	Gr.12	Panel Rating
Number and Operation	22	55	59	M
Number concepts	6	53	55	M
Fractions and decimals	10	55	60	M
Ratio, proportion & percent	6	57	63	S
Geometry	18	59	61	S to VS
Geometric figures	6	55	56	S
Geometric relationships	6	46	49	M to S
Logical reasoning	6	75	79	VS
Measurement	12	55	57	M
Metric units	6	62	66	S
Area and volume	6	47	48	M
Algebraic Topics	32	48	54	S
Equations and inequalities	14	49	56	S
Graphs	6	70	74	VS
Probability	6	49	54	S
Statistics	6	23	30	W to M
Computer Literacy	6	61	66	S to VS

Number and Operation

The items in this domain dealt with topics such as estimation, scientific notation, order of operations, computational skills, and ratio, proportion, and percent. The fact that the Interpretation Panel assigned an overall rating of Marginal to the results obtained on this domain may be taken as an indication of concern on their part. For the 22 items in this objective, 12 results were rated Satisfactory or Very Satisfactory and four as Weak.

The Panel felt that students' ability to use estimation skills, as illustrated in Item B/20, required some improvement. They expressed the opinion that exercises requiring such skills should be included throughout the curriculum so that students would learn to assess the reasonableness of results.

Students' ability to perform routine computations with fractions and decimals and to use ratio, proportion, and percent was rated as Satisfactory.

B/20. The closest estimate for $\sqrt{640}$ would be:

	% of students Gr.10	Gr.12
20	8	8
30	8	6
25	43	46†
80	36	34
I don't know ..	5	6

Geometry

The Interpretation Panel was unable to settle on a single classification of results on the 18 items in this domain. They eventually agreed to categorize the results as being somewhat better than Satisfactory and less than Very Satisfactory.

In the opinion of the Panel, students' ability to identify basic geometric figures is Satisfactory. They expressed some concern about the representativeness of the items in the Geometric Relationships objective and had difficulty assigning a rating to the students' performance on these items. They gave a rating of Very Satisfactory to the results on the Logical Reasoning items, one of only two objectives to be accorded such a high rating.

Measurement

As was the case for Grades 4 and 8, the Grade 12 results in Measurement were ranked lowest of all the domains by the Interpretation Panel. Of the twelve item-results in this domain, eight were rated as Marginal or Weak, two as Satisfactory, one as Very Satisf :tory, and one as Strong. On a more positive note, students showed that they were familiar with the Celsius temperature scale and, on Item B/12, that they could convert units within the metric system. On a similar item where students were asked to calculate the number of metres in 0.65 km, however, only 53% obtained the correct answer.

In the area and volume objective, five of the six item-results were rated as Marginal or Weak by the Panel. An example of an item where the students' performance was rated as Weak is shown in Item B/21.

Results in this domain indicate areas where achievement is less satisfactory than desired. Students graduating from

B/12. 5 metres is the same length as:

	% of students Gr.10	Gr.12
50 centimetres	5	7
500 centimetres	87	85†
50 millimetres	1	1
500 millimetres	3	2
I don't know	3	5

B/21. The perimeter of a square is 12 centimetres. Find the area in square centimetres.

	% of students Gr.10	Gr.12
48	14	12
9	36	38†
12	4	4
144	40	39
I don't know ..	6	8

secondary school should be familiar with elementary concepts of measurement, area, and volume, and be able to apply them in more or less routine situations. These results indicate that many students are unable to do so.

Algebraic Topics

The Algebraic Topics domain for Grade 12 included such traditional topics as expressions, equations, inequalities, and graphs, as well as elementary notions of probability and statistics which are not part of the curriculum. The Interpretation Panel rated the overall performance of students on this domain as being Satisfactory. Ten item-results were rated as Satisfactory or better while four were rated as Weak.

Students displayed a Satisfactory level of performance on items dealing with algebraic expressions, equations, and inequalities. On items dealing with graphs, their performance was Very Satisfactory, as it was on items dealing with basic concepts of probability.

Computer Literacy

The six items in the Computer Literacy domain assessed students' knowledge of some basic, non-technical matters about computers. The items treated topics such as the strengths and limitations of computers, their social impact, and areas of application. The items did not include programming, flow charting, or other aspects of computer science. Students' performance in this domain was rated as Satisfactory to Very Satisfactory in view of the fact that the material tested was not part of the prescribed curriculum.

Problem Solving and Consumer Mathematics

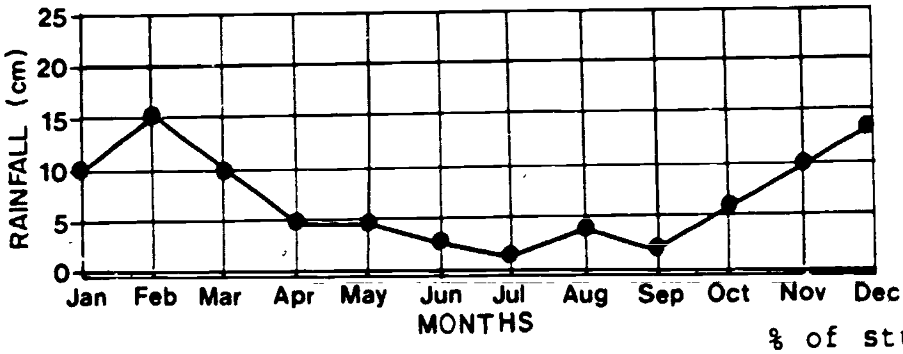
The Assessment items may be grouped into categories in a variety of ways to highlight areas of interest. Two such areas at the Grade 12 level are Problem Solving and Consumer Mathematics, both topics of current interest in the field of mathematics education.

Sixteen problem solving items were selected from the five domains and examined as a group. The items dealt with word problems of the type typically found in textbooks, but also included a few less routine items as well, such as Item B/21 which was discussed earlier.

Overall, the mean percent correct for the sixteen problem-solving items was 59% for Grade 12 and 55% for the Grade 10 sample. The Interpretation Panel rated nine of the item-results as Satisfactory or better and seven as Marginal or Weak. This would seem to indicate an adequate performance level, but not a particularly strong one.

The fifteen consumer mathematics items dealt with topics such as calculating simple interest, reading information from graphs and tables, calclulating taxes and commissions, and deciding on the best price for an article. The Interpretation Panel rated six of these item-results as Satisfactory or better and nine as Marginal or Weak. Performance was generally good on items dealing with graphs, as is shown by the result on Item A/1 which was rated Strong.

A/1. For how many months was the rainfall more than 5 cm?



	% of students Gr.10	% of students Gr.12
3	2	2
4	2	2
6	90	92†
7	5	4
I don't know ..	2	1

On the other hand, three of the four Consumer Mathematics items dealing with statistics resulted in Weak ratings. In general, these results are disappointing.

4.4 Changes in Achievement since 1977.

Eighty items from the 1977 Assessment were repeated on the 1981 instruments as a means of obtaining information on the direction and extent, of changes in patterns of students' achievement during the intervening four years. The items selected for use as change items were those that coincided with the topics being evaluated in the 1981 Assessment and on which fewer than 80% of the students in 1977 had obtained the correct answer. The latter criterion was used in order to eliminate those items on which students had performed so well in 1977 that there would be little likelihood of growth.

The items selected were separated into seven Change Categories. At the Grade 4 level there were two such categories: Number and Operation, and Measurement. There also were two at the Grade 8 level: Number and Operation, and Geometry and Measurement. For Grade 12 there were three: Number and Operation, Geometry and Measurment, and Algebraic Topics.

Overall results showed increases ranging between 2% and 5% in the mean-percent-correct values on four of the seven Change Categories. The other three showed no significant change. In other words, at all three grade levels and for all Change Categories, there were no declines in achievement levels.

Although none of the changes are dramatic, these results are encouraging. They indicate that gains have been made in students' achievement on a number of important topics from the mathematics curriculum since 1977.

5. STUDENTS' BACKGROUND AND ACHIEVEMENT

In the 1977 Assessment the relationships between a number of personal attributes of students and their achievement were examined, and a number of interesting results obtained. Among the factors which were identified at that time as being possibly related to achievement were date of birth of Grade 4 students, gender, first language, and, among Grade 12 students, parental education and future plans. Similar analyses were undertaken with the 1981 data using a 10% random sample of the Grade 4, 8, and 12 populations.

For several of these analyses the Grade 12 sample was partitioned into three categories according to the students' background in mathematics. The three categories were labelled Math 10, Algebra 11, and Algebra 12. The first group, Math 10, consisted of a sample of those Grade 12 students who had taken neither Algebra 11 nor Algebra 12, although they might have taken one or more senior elective courses in mathematics. This group included those students who had taken no mathematics beyond the minimum required. The Algebra 11 group consisted of a sample of students who had taken Algebra 11 and, perhaps, one or more electives, but who had not taken Algebra 12. The third group, Algebra 12, consisted of a sample of those students who had taken Algebra 12.

There is always a danger that data such as these will be misinterpreted as implying the existence of a cause-and-effect relationship between a given student-background variable and achievement. In fact, no such conclusion is warranted. The Assessment data may indicate the existence of a linkage between the two, but they cannot validly be used to conclude that changes in one variable will result in changes to the other. For example, if the results were to show, as they did in 1977, that Grade 4 students who watch four hours of television each day perform better on the Assessment items than those who watch less television, this should not be taken to imply that students might improve their achievement in mathematics by increasing the amount of time they spend watching television. All that can be concluded is that there appears to be a relationship between the two.

Sex Differences in Achievement--Grades 4, 8, and 12

In 1977, results from the Assessment indicated the existence of differences in achievement between boys and girls at all three grade levels and especially at the higher cognitive levels. These differences favored males over females and were more pronounced in the later grades than in Grade 4. Similar results were found in 1981.

Analysis of variance of the domain means for boys and girls in Grade 4 revealed two statistically significant but numerically small differences: one in favor of the girls on Geometry and one in favor of the boys on Measurement. Three similarly small but significant differences were found at Grade 8, this time all in favor of the males. These occurred in Geometry, Measurement, and Computer Literacy.

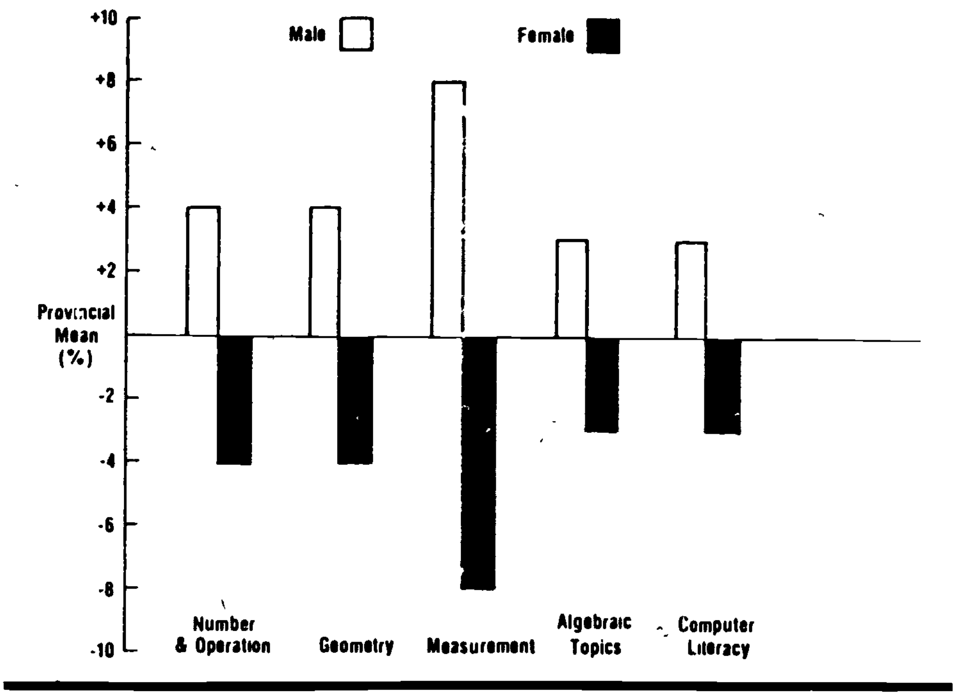


Figure 3. Grade 12--Sex differences in achievement.

As is shown in Figure 3, the differences at the Grade 12 level are quite large, as much as 17% on the Measurement domain. Even when mathematics background is controlled, the differences in achievement between males and females at the Grade 12 level remain pronounced. That is, when the Grade 12 group is divided into the Math 10, Algebra 11, and Algebra 12 sub-groups, the differences in achievement within each sub-group parallel those within the entire population.

First Language--Grades 4, 8, and 12

The results of the 1977 Mathematics Assessment showed that, in Grades 8 and 12, students who were not born in Canada and who had spoken a language other than English at home before starting school appeared to suffer no educational handicap insofar as mathematics achievement was concerned. Similar, but not the same, data were collected in 1981 in order to examine the more specific question of the relationship between first language learned and achievement in mathematics. Students were separated into two groups: one consisted of those students who had learned English as a first language, the other of those who had not. At each grade level, the English-as-a-first-language students outnumbered the others by about 8 to 1.

Among Grade 4 students statistically significant differences, two of four percent and one of three favoring the English-as-a-first-language group, were found on three of the domain comparisons. One such difference was noted in Grade 8, and none in Grade 12. In other words, analysis of these results does not reveal the existence of any strong relationship between students' first language and their level of achievement in mathematics.

Attitudes--Grades 4, 8, and 12

Correlation coefficients were computed to investigate the strength of the relationship that exists between achievement scores and students' attitudes toward mathematics. T[illegible] analysis indicated that at all three levels, there is a moderate correlation between the two. The correlations tended to increase with grade level, but remained in the moderate range.

Mathematics Background--Grade 12

Evaluating the Assessment results is more problematic at the Grade 12 level than at either of the other two because the Grade 12 population is so diverse mathematically. Some of these students have fulfilled the minimum requirements by taking Math 10 and no more. Others have elected to discontinue taking mathematics courses after completing Algebra 11, and still others have taken Algebra 12 and one or more of the senior electives which are available.

In order to investigate the extent of the differences in achievement among the three Grade 12 sub-populations and the Grade 10 sample, the achievement results were re-examined within the three sub-populations of Grade 12 defined earlier, using the Grade 10 sample as a benchmark for comparisons. As the graph in Figure 4 indicates, there are dramatic differences among the four groups on each domain.

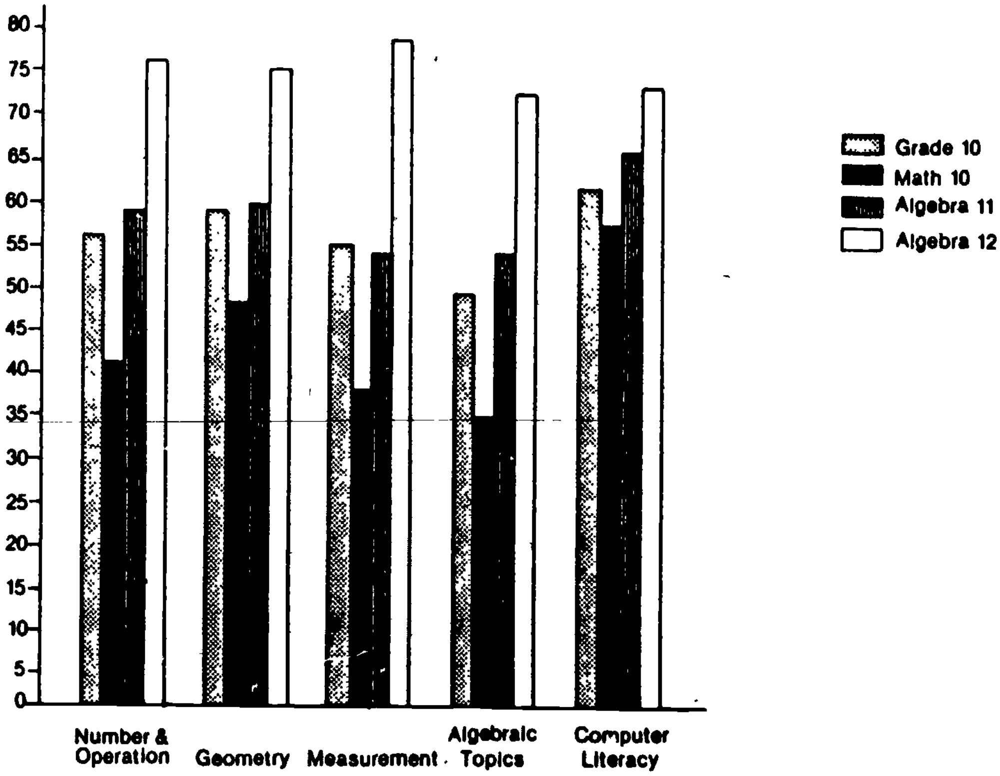


Figure 4. Grade 12--Achievement by mathematics background.

As was the case in 1977, the results show that the Algebra 12 sub-population had the highest mean-percent-correct on each domain, and the Math 10 sub-population had the lowest. The differences between these two extremes ranged from a high of 42% in the Measurement domain to a low of 16% on Computer Literacy, a domain which dealt with content outside the prescribed curriculum. The low level of achievement by students in the Math 10 sample may be due in part to their having forgotten much of the material tested, as well as to the fact that these students are probably among the least capable mathematically.

The performance of the Grade 10 sample is interesting for two reasons. On the one hand, these students performed at almost the same level as the Algebra 11 sub-population of Grade 12 students, and, on the other hand, their performance was considerably superior to that of the students in the Math 10 sub-population.

Future Plans--Grade 12

Slightly more than 30% of the students in the Grade 12 sample intend to continue their studies at university or in a university transfer program at a community college. About 25% plan to enrol in various technical and vocational programs, and 15% intend to work full-time. The comparative performance of these three groups is shown in Figure 5.

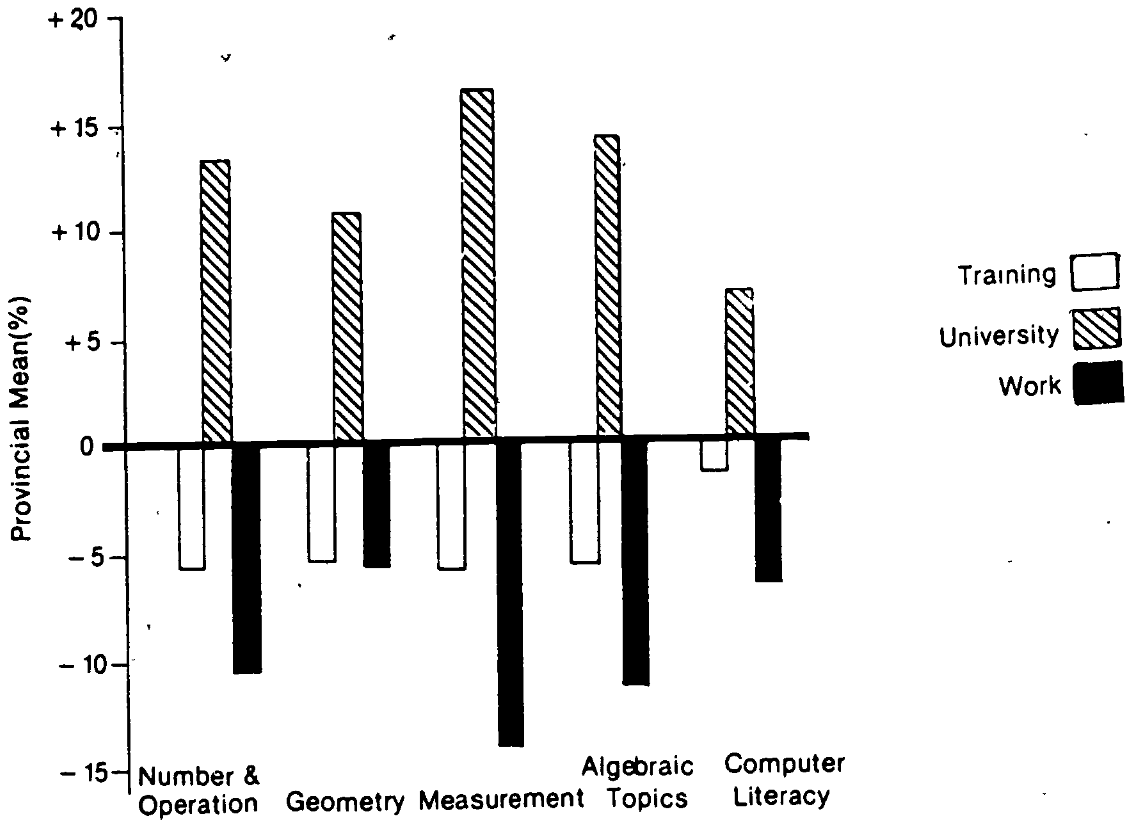


Figure 5. Grade 12--Achievement by future plans.

The performance of the university sub-group is superior to both of the others on every domain, and that of the sub-group that intends to seek full-time employment after completing Grade 12 is lowest in each case. The gap between highest and lowest ranges from a high of 31% on the Measurement domain to a low of 14% on the Computer Literacy domain.

Closer examination of the make-up of these three groups of students shows that they are similar to the sub-populations determined by mathematics background. Almost 60% of the Algebra 12 students are in the University sample, and only 5% are in the Work sample. Among the Math 10 group, 25% plan to begin work after finishing Grade 12, and only 5% are in the University sample. To a considerable degree, the results based on future plans of students are a replication of the results based on mathematics background.

6. THE TEACHERS OF MATHEMATICS

Teachers of mathematics at every grade level from 1 to 12 were randomly selected as potential respondents for one of the two Teacher Questionnaires which were developed for this Assessment, one for elementary teachers and the other for secondary teachers. Of the 1165 questionnaires distributed to elementary teachers, 868 were completed and returned--a return rate of 75%. At the secondary level, 733 out of 951 were completed--a return rate of 77%. These return rates are very high indeed for this type of survey.

On the average, elementary teachers have been teaching for more than five years, and doing so in self-contained classrooms. Virtually none of these teachers belongs to either of the major professional associations for teachers of mathematics: the B. C. Association of Mathematics Teachers (BCAMT) and the National Council of Teachers of Mathematics (NCTM). On the other hand, slightly more than 50% have attended a mathematics conference, workshop, or in-service day in the past three years. Elementary teachers enjoy teaching in general and, in particular, they enjoy teaching mathematics.

On the average, the teachers of mathematics at the secondary level have also been teaching for at least five years, although not necessarily teaching mathematics exclusively. In fact, almost half of them teach other subjects in addition to mathematics, and 30% teach only one mathematics class. The vast majority do not belong to either the BCAMT or the NCTM. Ninety percent of these teachers have had some training in mathematics at the post-secondary level, but almost 30% have never taken a course in methods of teaching mathematics. Like their counterparts at the elementary level, teachers of secondary school mathematics enjoy teaching and, given the choice, would continue to teach mathematics.

A large number of both elementary and secondary teachers, 19% and 16% respectively, consider themselves to be inadequately prepared to teach mathematics, and these teachers share a number of distinctive opinions and characteristics. Compared to the rest of the population, fewer of these teachers have participated in mathematics workshops or conferences recently. They feel that academic preparation in mathematics is a less important part of a teacher-education program than the other teachers do, and they attach less importance to emphasizing consumer application of mathematics and problem-solving.

Perhaps even more disturbing is the group consisting of the almost 50% of teachers of secondary mathematics who teach other subjects as well. Results show that one fourth of these teachers have no background in mathematics beyond the secondary school level, more than half of them have never taken a course in methods of teaching mathematics, and almost 70% have not attended a mathematics conference or workshop in the past three years. Teachers in this category teach mainly at the junior secondary level, and it is likely that they teach only one mathematics class.

Taken together, these results show that, particularly at the junior secondary level, many mathematics classes are being taught by teachers who have little or no professional or academic preparation for the task. On the one hand, the number of students enrolling in university teacher-education programs for secondary mathematics has declined sharply in the past several years. The situation is complicated by the fact that, on the other hand, there appears to be a widely-held opinion that anyone can teach Grade 8 mathematics and, because of that, teachers who are untrained in the subject are sometimes required to teach such a class in order to complete their teaching schedules. The situation seems certain to become worse unless appropriate measures are taken.

7. THE TEACHING OF MATHEMATICS

The Teacher Questionnaires were divided into several sections, some of which were designed to collect information from teachers regarding a number of topics related to the way mathematics is taught in the schools of the province. These sections dealt with such matters as implementation of the prescribed curriculum, use of calculators and computers, and evaluation of students' achievement. In addition, teachers were asked to select one of the classes they were currently teaching and to provide information about the teaching methods, materials, and techniques they employed with that class.

Program Implementation

Teachers feel that the curriculum guide for mathematics issued by the Ministry of Education is helpful to them in planning their teaching, and over 80% indicated that they had referred to it at some time during the year. They feel that the curriculum guide should include a statement of minimal content objectives for each grade or course, a separate list of the topics to be taught for each grade, a number of suggestions concerning appropriate methods and materials to be used, and an order in which to teach the topics for each grade.

Teachers feel that the statement of cognitive goals for the mathematics curriculum contained in the curriculum guide coincides well with their own views. In their opinion, the two most important of those goals are the following:

The mathematics program will enable the student

- to identify and use the basic properties and operations of the real number system.
- to apply knowledge of mathematics to familiar physical or environmental situations in order to construct a descriptive mathematical model of the situation or to solve a problem arising from the situation.

The curricular goal which was ranked last in importance concerned geometry.

Two thirds of the teachers believe that all students should be required to take mathematics courses every year, at least through Grade 11, and, according to many, in Grade 12 as well. They strongly support the idea that secondary mathematics courses should be taught by specialists and there is a moderate degree of support for making use of specialists at the intermediate grade level as well. In their opinion, students should be grouped according to ability for mathematics instruction: between classes at the secondary level and within classes at the elementary.

Calculators and Computers

The proportion of teachers who say that calculators should be used in schools has increased significantly since 1977. Results show that over 90% of mathematics teachers believe that students should be permitted to use calculators in mathematics classes at some level, although a majority of elementary and junior secondary teachers do not, in fact, permit students to use calculators in their classes. Whereas the support for their use is strongest at the secondary level, over a third of elementary teachers feel it would be appropriate to use calculators in Grades 4 to 7. Secondary teachers tend to disagree with this opinion. There is very little support among teachers for using calculators in Grades 1 to 3.

Over 60% of secondary teachers and only 12% of elementary teachers have access to computers for instructional purposes. Teachers at all levels came out strongly in favor of using computers in their classrooms, of learning to use micro-computers, and of including computer literacy in the curriculum, although not necessarily as part of the mathematics curriculum.

Assessment and Testing

Almost half of the secondary teachers and a third of the elementary teachers have read one or more of the reports from the 1977 Mathematics Assessment. In addition, 40% of both groups combined feel that the results and recommendations of that study have influenced their teaching. Taken together, these results show that the Learning Assessments conducted by the Ministry of Education are having an impact on the teaching of mathematics in the province.

The Mathematics Achievement Tests published by the Learning Assessment Branch are the standardized tests that are most commonly used by teachers of secondary mathematics. Among elementary teachers they are second in popularity only to the Canadian Test of Basic Skills. Both groups of teachers, however, make much more extensive use of tests they prepare themselves than they do of tests published by others. A majority, 53%, of secondary teachers agree that an examination in mathematics analogous to the English Placement Test should be used to determine placement in university.

Class-Specific Information

At the elementary level, the average class consists of 23 students who, according to their teachers, have a wide range of ability. At the secondary level, the average size of a mathematics class is 25, and the range of student ability in classes is seen to be as wide as at the elementary level. This latter finding might seem somewhat surprising in view of the widespread use of ability grouping for secondary school mathematics. However it may be an indication that such grouping does not, in fact, result in homogeneous classes.

The structure of the average lesson has changed very little since 1977, and probably for much longer than that. Students spend a great deal of time listening to the teacher's explanations and working alone on exercises from the textbook. Occasionally students get to work together in small groups but this is not customary even at the elementary level. Virtually none of the teachers makes use of laboratory activities or projects in mathematics. The typical mathematics class is, in short, highly structured, teacher-centered, and almost totally predictable in format.

During a typical class, teachers spend 40% of their time making presentations to the entire class or to a small group and supervising seat-work. Secondary teachers say that they spend an average of 24 minutes preparing for each mathematics class, compared to 18 minutes for elementary teachers. Almost 30% of elementary teachers do not give their students homework assignments in mathematics. Textbooks are used almost exclusively as sources of exercises.

Teachers feel that the present curriculum meets the needs of their students. A majority of them are of the opinion that the development of concepts and skills in arithmetic and algebra, problem solving, and logical thinking should be emphasized. Areas such as geometry, structure of the number system, consumer mathematics, and probability are seen as being considerably less important. Only 8% of elementary teachers feel that geometry should receive much emphasis, the lowest level of support for any of the twelve areas of mathematics listed.[6]

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[6]The list of topics was based on one drawn up by the National Council of Supervisors of Mathematics in the U. S. A. as a list of basic skills for the mathematics curriculum.

8. CONCLUSIONS AND RECOMMENDATIONS

Some of the findings of the 1981 Mathematics Assessment warrant special attention because of their significance to the teaching and learning of mathematics. Moreover, the analysis of the Assessment data has given rise to a number of questions and issues which should be addressed in the near future. The Contract Team, having considered the data in some detail, has reached several conclusions about the state of mathematics in the schools of the province, and has a number of recommendations to make to those whose responsibility it is to ensure that the teaching and learning of mathematics continue to improve.

First and foremost, the overall achievement results are encouraging. They show that, for the most part, students are learning the content expected of them. This opinion is strengthened by the fact that results from the Change Categories indicate that some improvement in achievment levels has occurred since 1977.

Of the total of 15 domain scores at Grades 4, 8, and 12, nine were rated as either Satisfactory or Very Satisfactory. None was rated as being Weak. Of the five domains at each grade level, Measurement is the cause for most concern since it was consistently given the lowest rating.

The process by which the ratings were reached, however, is a cause for some concern. First of all, and as has been mentioned earlier, the Interpretation Panels had considerable difficulty in judging students' performance on difficult items. In most cases their judgment was based almost solely on the percent of students who obtained the correct answer, with little or no weight being attached to the difficulty of the item concerned. Secondly, the Panels rated performance on all of the non-curricular objectives as Satisfactory because those objectives dealt with content that was unfamiliar to the students. In effect this renders their ratings in those areas almost impossible to use to answer questions about the advisability of adding those topics to the mathematics curriculum. The Learning Assessment Branch should take steps to alter the interpretation process in order to circumvent these problems in future assessments.

From the other components of the Assessment, the Contract Team identified a number of areas that seem to be especially significant. Along with the achievement results, they form the basis for the recommendations that are listed below.

On the basis of a project as large as the present one, it would be an easy matter to put forward dozens of recommendations, and the temptation to do so is rather strong. However, in the hopes of seeing most, if not all, of them acted upon it seems prudent to limit the number of recommendations and to include only those which, in the opinion of the Contract Team, are in most urgent need of attention.

The results of the assessment have indicated that student achievement in mathematics is generally satisfactory. There are, however, some areas which, in the opinion of the Contract Team, require additional attention.

Recommendation 1

We recommend that teachers of mathematics give increased attention to the following topics:

- *in primary grades, the concepts of inverse operation, missing addends, re-grouping, subset-set models for fractions, and estimation*
- *in intermediate grades, operations with decimals, numeration (including properties of zero), estimation, and percent*
- *in secondary grades, estimation, operations with decimals, problem-solving, and consumer applications*
- *at all levels, the metric system, perimeter, area, and volume*

Questionnaire results show that the use of calculators and computers, both in school and in the home, is increasing and teachers have not been provided with sufficient assistance for making use of these technological aids.

Recommendation 2

a) We recommend that the Curriculum Development Branch immediately establish a committee to consider how calculators and computers should be used and at what grade levels.

This committee should make recommendations, not only about appropriate uses of calculators and computers, but also about financial implications regarding both hardware and software.

b) We recommend that, based on the recommendations of the above committee, the Curriculum Development Branch develop materials for teaching computer literacy.

In line with the opinions expressed by teachers and members of Review Panels, those materials should be usable in the context of several different courses.

c) We recommend that Program Implementation Services develop appropriate in-service programs to facilitate successful utilization of the above materials at the classroom level.

Results of the Goals Survey and the opinions expressed by members of the Review Panels and by teachers on the Teacher Questionnaires provide valuable guidance for future revision of the mathematics curriculum.

Recommendation 3

a) We recommend that the forthcoming revised mathematics curriculum include among its major goals, the development of student skills in problem-solving, logical thinking, and consumer applications of mathematics; and that the topics of probability and statistics be included as important and identifiable components.

b) We recommend that, in any revision of the mathematics curriculum, the Curriculum Development Branch restructure the Curriculum Guide and Resource Book to include:

- *separate sections of the guide for each grade*
- *minimal content objectives for each grade*
- *suggested order for treating the topics in the course*
- *suggested time allocations for topics*
- *suggestions regarding appropriate methods and materials for teachers to use*

The results of the Teacher Questionnaire indicate that the vast majority of teachers consider that compulsory mathematics to the end of Grade 10 is insufficient.

Recommendation 4

We recommend that all students be required to take some form of mathematics course each year at least from Grade 1 through Grade 11.

In the opinion of the Contract Team, the Teacher Questionnaire results indicate that an unacceptably large number of teachers of mathematics are inadequately prepared, either academically or professionally.

Recommendation 5

a) We recommend that School Boards and Principals attempt to ensure that only persons with academic and professional training in mathematics education are permitted to teach mathematics at either the elementary or the secondary school level.

b) We recommend that all Faculties of Education in the universities of the province of British Columbia include, as a compulsory component for elementary teacher preparation, a course in methods of teaching mathematics.

c) We recommend that Program Implementation Services, with the cooperation of School Boards and Faculties of Education, organize, and provide adequate funding for, in-service programs for the re-training of those teachers who, for whatever reason, have been asked to teach mathematics but do not have the necessary preparation.

From the results of the Teacher Questionnaire, it is evident that teacher-made tests form a substantial component of the evaluative data used by teachers in making decisions about students. It is essential that such instruments be both reliable and valid and that teachers be able to interpret the results of these tests in a professional manner.

Recommendation 6

a) We recommend that the Faculties of Education in the universities of the province of British Columbia ensure that all of their students are exposed to the principles of test construction and analysis of test data as well as to other methods of assessing student performance.

b) We recommend that School Boards organize in-service programs for their teachers on principles of test construction, analysis of test data, and other methods of assessing student performance.

c) We recommend that the Learning Assessment Branch continue developing classroom achievement tests, publishing reference materials for the use of teachers, and providing in-service assistance in methods of student evaluation.

There is considerable evidence that the geometry included in the prescribed curriculum is not being taught in all classes and that many teachers do not see geometry as a particularly important part of the curriculum. Moreover, in the 1980/81 school year, only six percent of the Grade 12 students were enrolled in Geometry 12.

Recommendation 7

We recommend that, in the forthcoming revision of the mathematics curriculum, the Curriculum Development Branch determine the place and the role of geometry at all levels of the curriculum.

At the present time, only one percent of elementary teachers belong to the British Columbia Association of Mathematics Teachers.

Recommendation 8

We recommend that the British Columbia Association of Mathematics Teachers take steps to make membership in the B.C.A.M.T. more attractive to teachers of mathematics in the province, especially at the elementary level.

Results from the metric usage items indicate that students do not "think metric", that is, they do not use metric units as their first or most natural response to a measurement situation.

Recommendation 9

We recommend that the Minister of Education alert the Metric Commission of Canada to the fact that students do not "think metric", and request the Metric Commission take action to increase the use of metric units in the media and to educate the public in the use of metric units.

Following the 1977 Mathematics Assessment and the 1978 Science Assessment, a discussion paper entitled Gender and Mathematics/Science Education in Elementary and Secondary Schools, was commissioned by the Ministry of Education. The results of this Assessment indicate no significant change in the rate of participation of females in mathematics courses at the senior secondary level. Moreover, the pattern of differences in achievement between males and females remains unchanged.

Recommendation 10

We recommend that the Minister of Education charge the appropriate sections of his Ministry with examining and, where appropriate, acting upon the recommendations of discussion paper 08/80: Gender and Mathematics/Science Education in Elementary and Secondary Schools.

APPENDIX A

MEMBERS OF REVIEW PANELS

Primary Panels

Kelowna

Jean Aston, Teacher, Penticton School District
Barb Boonstra, Teacher, Kamloops School District
Eric Buckley, Okanagan College
John Ciriani, Cariboo College
Winnie Collins, Teacher, Vernon School District
Diane Lubnowsky, Parent, Kelowna
Jennifer Murphy, Teacher, South Cariboo School District
John Opra, Principal, Revelstoke School District
Joe Petrelta, Teacher, Kelowna School District
George Staley, Teacher, Kelowna School District

Richmond

Peter Bullen, University of British Columbia
Don Cook, Principal, Abbotsford School District
Gale Corder, Teacher, Delta School District
Heather Kelleher, Teacher, New Westminster School District
John McMaster, Teacher, Trail School District
Ruth Miller, Trustee, Powell River School District
Suzanne Montemuro, Parent, North Vancouver
Ron Popoff, Teacher, West Vancouver School District
Sheila Roberts, Teacher, Vancouver Diocese
Elizabeth Robertson, Teacher, Vancouver School District
Doug Super, Coordinator, Richmond School District
Polly Weinstein, University of British Columbia

Intermediate Panels

Richmond

Robert Betts, Teacher, Burnaby School District
Richard Bury, Teacher, Surrey School District
Sr. Helen Danahy, Principal, Vancouver Diocese
Bill Davidson, Teacher, Coquitlam School District
Grace Dilley, Helping Teacher, Surrey School District
Art Fletcher, Superintendent, Lillooet School District
George Ivanisko, Supervisor, Langley School District
Hannu Makinen, Teacher, Delta School District
Robert Rennie, Capilano College
Gail Spitler, University of British Columbia
Bill Wallace, Principal, Burnaby School District

Qualicum

Bob Campbell, Teacher, Victoria School District
Ron Edmonds, Teacher, Victoria School District
Don Frewing, Teacher, Sooke School District
Ted Horn, University of Victoria
Lois Macy, Trustee, Qualicum School District
Mark Mahovolich, Teacher, Saanich School District
Greg Murray, Teacher, Lake Cowichan School District
Peter Smart, Royal Roads College
Walter Tangye, Trustee, Saanich School District
Bill Van Dyke, Principal, Society of Christian Schools
James Wilson, Teacher, Campbell River School District

Secondary Panels

Richmond

Jack Bulier, Teacher, Delta School District
Helen Casher, Trustee, Maple Ridge School District
Ken Corbett, Teacher, Richmond School District
Harvey Gerber, Simon Fraser University
Tom Howitz, University of British Columbia
John Klassen, Teacher, North Vancouver School District
George Main, Principal, Langley School District
Wayne Matthews, Teacher, North Vancouver School District
Fil Muaro, Teacher, Grand Forks School District
John Turnbull, Teacher, Richmond School District

Prince George

Doug Cutler, Teacher, Smithers School District
Ken Dick, Principal, Prince George Diocese
Dan Dobrinsky, Teacher, Quesnel School District
Margaret Ernst, Trustee, Quesnel School District
Dave Hamblin, Teacher, Cariboo-Chilcotin School District
Harry Hufty, Coordinator, Prince George School District
Jennifer Johnston, Teacher, Prince George School District
Henry Kuiperi, Teacher, Fort Nelson School District
Clint Lee, College of New Caledonia
Jake Penner, Teacher, Prince George School District
Ed Zolinski, Teacher, Peace River North School District

APPENDIX B

MEMBERS OF INTERPRETATION PANELS

Grade 4

Franca Boratto, Multi-Cultural Worker, Vancouver
Pat Craig, Teacher, Sunshine Coast School District
Margaret Diana, Teacher, Victoria School District
Randolph Gris, Principal, Nelson School District
Irene Macrae, Trustee, Qualicum School District
John Opra, Principal, Revelstoke School District
Ann Peterson, Teacher, Terrace School District
Mark Proctor, Teacher, Vancouver School District
Marilyn Shore, Teacher, Cariboo-Chilcotin School District
Gail Spitler, University of British Columbia
Mary Stewart, Teacher, Richmond School District
Angie Thorn, Teacher, South Cariboo School District
Jean Vallance, Primary Supervisor, Langley School District
Marilyn Wood, Parent, Richmond

Grade 8

Jim Bourdon, Supervisor, North Vancouver School District
Terry Demchuk, Principal, Trail School District
Chris Donaldson, Parent, West Vancouver
John Gordon, Teacher, Delta School District
Pat Henman, Teacher, Abbotsford School District
Tom Howitz, University of British Columbia
Phil Judd, Teacher, Cowichan School District
Ed Kwasniewski, Teacher, Nelson Diocese
Lenore Lawrence, Trustee, Peace River South School District
Les Matthews, Principal, Chilliwack School District
David Miller, Teacher, Qualicum School District
Jack Morrison, Teacher, Prince George School District
Eunice Parker, Trustee, Coquitlam School Board
Jesse Rupp, Teacher, West Vancouver School District
Bill Seaton, Okanagan College

Grade 12

Helen Casher, Trustee, Maple Ridge School Board
John Ciriani, Cariboo College
Lloyd Colling, Supervisor, Nechako School District
Elaine Curling, Teacher, Victoria School District
Margaret Ernst, Trustee, Quesnel School Board
Chester Gris, Teacher, Creston School District
Ted Horn, University of Victoria
David Kennedy, Teacher, Langley School District
Mike Law, Teacher, Lillooet School District
Ray Leung, Teacher, Sooke School District
Art Olsen, Teacher, New Westminster School District
Les Phillips, Teacher, Coquitlam School District
Peter Woolley, Institute of Chartered Accountants
John Worobec, Consultant, Vancouver School Board

APPENDIX C

LIST OF PILOT SCHOOLS

Primary (Grade 4 Items)

Alice Brown Elementary, Langley School District
Arthur Hatton Elementary, Kamloops School District
Bear Creek Elementary, Surrey School District
Birchland Elementary, Coquitlam School District
Burrard View Elementary, North Vancouver School District
Cascade Heights Elementary, Burnaby School District
Charles Dickens Elementary, Vancouver School District
Clinton Elementary, Burnaby School District
Coghlan Elementary, Langley School District
Davie Jones Elementary, Maple Ridge School District
Franklin Elementary, Vancouver School District
Gabriola Elementary, Nanaimo School District
George Jay Elementary, Victoria School District
George Vanier Elementary, Surrey School District
Glenrosa Elementary, Central Okanagan School District
Golden Ears Elementary, Maple Ridge School District
Hastings Elementary, Vancouver School District
James Ardiel Elementary, Surrey School District
James Bay Community Elementary, Victoria School District
Lakewood Elementary, Prince George School District
Latimer Road Elementary, Surrey School District
Lord Strathcona Elementary, Vancouver School District
Malaspina Elementary, Prince George School District
Marigold Elementary, Victoria School District
McCloskey Elementary, Delta School District
Mount Benson Elementary, Nanaimo School District
Mundy Road Elementary, Coquitlam School District
Pitt Meadows Elementary, Maple Ridge School District
Port Guichon Elementary, Delta School District
Ralph Bell Elementary, Kamloops School District
Raymer Elementary, Central Okanagan School District
Shortreed Elementary, Langley School District
Thomas Kidd Elementary, Richmond School District
Thunderbird Elementary, Vancouver School District
University Hill Elementary, Vancouver School District
Walter Moberly Annex Elementary, Vancouver School District
Webber Road Elementary, Central Okanagan School District
Westsyde Elementary, Kamloops School District

Intermediate (Grade 8 Items)

Burnsview Jr. Secondary, Delta School District
Britannia Secondary, Vancouver School District
Cedar Jr. Secondary, Nanaimo School District
City School, Vancouver School District
D.P. Todd Secondary, Prince George School District
Edmonds Jr. Secondary, Burnaby School District
Eric Hamber Secondary, Vancouver School District
Frank Hurt Secondary, Surrey School District
George Pringle Secondary, Central Okanagan School District
Guilford Park Secondary, Surrey School District
Hastings Jr. Secondary, Coquitlam School District
Hollywood Road Secondary, Central Okanagan School District
King George Secondary, Vancouver School District
Lakewood Jr. Secondary, Prince George School District
Lambrick Park Secondary, Victoria School District
L.A. Matheson Secondary, Surrey School District
Mountain Secondary, Langley School District
Montgomery Secondary, Coquitlam School District
Poppy Secondary, Langley School Distict
R.C. Palmer Secondary, Langley School District
Royal Oak Secondary, Burnaby School District
Sutherland Secondary, North Vancouver School District
University Hill Secondary, Vancouver School District
Vancouver Technical, Vancouver School District

Secondary (Grades 10 and 12 Items)

Britannia Secondary, Vancouver School District
D.P. Todd Secondary, Prince George School District
Eric Hamber Secondary, Vancouver School District
Frank Hurt Secondary, Surrey School District
George Pringle Secondary, Central Okanagan School District
Guilford Park Secondary, Surrey School District
Hollywood Road Secondary, Central Okanagan School District
Lambrick Park Secondary, Victoria School District
L.A. Matheson Secondary, Surrey School District
Matthew McNair Secondary, Richmond School District
Mountain Secondary, Richmond School District
R.C. Palmer Secondary, Richmond School District
Poppy Secondary, Langley School District
Royal Oak Secondary, Burnaby School District
University Hill Secondary, Vancouver School District
Westsyde Secondary, Kamloops School District
Sutherland Secondary, North Vancouver School District