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A study of teaching secondary school mathematics

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A STUDY OF TEACHING SECONDARY SCHOOL MATHEMATICS

by

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CHAPTER I

THE PROBLEM, PROCEUDRES AND COURSES IN MATHEMATICS

For quite a number of years there have been certain groups of people, interested in mathematics, who have desired to strengthen the program in the secondary schools. Of course, mathematics has been an integral part of the high school program, not only in general education, but in the preparation of youth for the scientific and engineering professions. But many people now claim that a more rigorous curriculum should be provided, both in breadth and depth of content, in order to more adequately prepare high school graduates to proceed towards high level scientific programs. There are widespread demands also, for the introduction of some of the newer materials and ideas to the curriculum. The present program does not take into account the continuous revolution mathematics is now experiencing. "Present courses in mathematics contain little that is less than 150 years old. Undoubtedly much that is old is still good, but dogged adherence to the 'traditional' mathematics may perpetuate inadequacy."[1]

I. THE PROBLEM

Importance of the problem. The present apparent stress on mathematics seems to follow, quite logically, the great resurgence of

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[1]Report of the Royal Commission on Education in Alberta, 1959 (Edmonton: The Queen's Printer, 1959), p. 106.

scientific research during and following the second world war. And nothing has accentuated this stress in mathematics and science, more than the successful launching, by the Russians, of the first earth satellite in October 1957. That event was not, however, the beginning of a movement to modify and improve the mathematics program.

Some fruitful work has been continuing over the past years, by many groups of interested people. Since 1954 the Mathematical Association of American has sponsored a "Committee on the Undergraduate Program". The committee has sought to introduce some modern topics and to bring calculus to the freshmen. The College Entrance Examinations Board established the "Commission on Mathematics" to consider broadly the secondary-school college-preparatory mathematics curriculum and make recommendations on its modernization and improvement. The "University of Illinois Project", for the improvement of school mathematics is planned to create a four year program in college preparatory mathematics in the manner of contemporary mathematicians. The Secondary-School curriculum Committee of the "National Council of Teachers of Mathematics", is giving attention to the Mathematics program for all students in grades seven through twelve.[2]

These groups, and others, have been showing genuine concern and interest in the secondary school mathematics program. Their work in some instances goes back to the early years of the second world war.

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[2]John R. Mayor, "Efforts to Improve Programs and Teaching in Mathematics," Bulletin of the National Association of Secondary School Principals, May, 1959.

Admiral Rickover has pointed out a real need in respect to mathematics in that the industrial power of a nation depends on the scientific and engineering professions. "These professions," he said, "are dependent upon the flow of capable, well-trained persons. And industry is today short more than 40,000 engineers and will require a minimum of 30,000 per year for years to come."[3]

This need for more people trained in mathematics and science, is not confined to America. An article appearing in the "Times Educational Supplement," (London) under the title, Shortage of Scientists and Mathematicians says:

> In order to staff the Secondary Grammar and Technical Schools, England and Wales need 4600 men and 3500 women teachers of mathematics and science. This is about 30 per cent more than are presently engaged in the profession. It must be borne in mind that teaching is only one of the professions open to mathematics graduates. Industry appears to have an almost insatiable demand for them. Ths conclusion is inevitable: there are not enough graduates in mathematics coming from English and Welsh Universities to meet these needs. The shortage will tend to be worse. Since well qualified mathematics teachers are not entering schools, the tendency will be, presumably, that fewer children will be inspired to continue the study of the subject beyond their school days.[4]

This quotation was made several years ago, but it points up a problem in addition to the need for mathematicians--the need to inspire present day high school students to study the subject beyond their high school days.

The opinion of another writer is indicated by:

. . . However, if present trends continue, the U.S.S.R. will

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[3]Hyman G. Rickover, "The Situation in American Engineering and Scientific Education," School and Society, May, 1956.

[4]A. Young, "Shortage of Scientists and Mathematicians," Times Educational Supplement, May 14, 1950.

> graduate 420,000 engineers in the period 1956-60 as against our (the U.S.) 150,000. As far as scientific fields as a whole are concerned, only one-fifth of our college graduates are trained in these fields as aginst two-thirds in Russia. But more important than the need for more scientists, is the need for better ones.[5]

In Alberta, a Royal Commission completed (in Dec., 1959) a study of all phases of education. It noted that, "dramatic changes have taken place in mathematics." And it may be added that many of these changes were during the past fifty years. It is true also that new and wider applications are being made of mathematics, and in the words of the Commission, "These things must certainly have an impact on the mathematics programs in the public schools."[6]

The opinion of the members of the staff of the Department of Mathematics, University of Alberta, is indicated by:

> The shortage of qualified mathematicians in industry and in universities is now acute and likely to become worse. More students than ever before must enter our honor schools of mathematics, and these must receive their basic training in the high schools. If the supply of highly trained scientists and engineers in the top levels of design and development and in the operation of elaborate electronic equipment of today is to continue, the high schools must perform the task of setting these young men and women on the high academic road. A course of mathematics with a modern flavour is a good foundation on which to build a sound scientific education.[7]

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[5] L. M. Gould, "Education for Survival," College and University, Spring 1959.

[6] Report of the Royal Commission on Education in Alberta, 1959, op. cit., p. 106.

[7] Report of the Royal Commission on Education in Alberta, 1959, Ibid., p. 106.

This increased need for people with an interest in and a knowledge of mathematics is widespread. There are, "many areas of business, such as accounting, data processing, and decision making by administrators, making increasing use of mathematics, quite often the newer mathematics."[8]

It may be assumed that the continued flow of young people with aptitudes for mathematics to the colleges and universities, is contingent upon the quality of their instruction in the secondary schools. Here it is vitally important that programs be examined at every step, and in relation to all phases of mathematics. This may be the means of building and sustaining an enlightened opinion to this program.

Purpose of the study. In general the purposes of the study were: (1) to gather data relating to the status of the secondary school mathematics program in Alberta; (2) to analyze the data in appropriate form and present the findings in a full report; and (3) to review some of the related, current literature on mathematics curricula, methods and evaluation of student learning.

Assumptions. The study was based on these assumptions: (1) Supervision and In-Service training of teachers of mathematics is not a common practice in Alberta high schools; (2) There is probably no widespread and conscious effort to teach for transfer; (3) No single method of teaching is employed, to the exclusion of others; (4) A program of enrichment will be in direct proportion to school size; (5) School libraries are

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[8] E. G. Begle, "The School Mathematics Study Group," The Bulletin of the National Association of Secondary-School Principals, May, 1959, p. 26.

inadequate; (6) Special mathematics rooms and equipment are inadequate; and (7) Data may be obtained relating to the mathematics program in Alberta high schools, by means of a questionnaire.

Scope of the study. Research on the problem was confined to the secondary schools of the province of Alberta. The study was limited to the courses comprising the mathematics program in grades nine, ten, eleven and twelve. The schools in the study were taken from the list of Accredited Secondary Schools in Alberta, which is published annually in December, by the Provincial Department of Education.

There were about 300 schools teaching up to and including work at the grade twelve level. This included all private and Indian schools as well as the public and separate (Parochial) schools. There were some others teaching up to grades nine or ten but these were not included in the study.

For data gathering an arbitrary sample of 170 schools was drawn, which is about 57 per cent of all schools.

Definitions of terms used. (1) The Secondary School and High School refer to grades nine, ten, eleven and twelve; (2) The Department of Education is the Alberta Provinvial Department of Education. It is the agency of government having overall direction and control of the schools; (3) Accredited Secondary Schools are those schools whose programs and facilities have been assessed and authorization has been given to them, by the Department of Education, to carry out these programs.

II. COLLECTION OF DATA

The sample. A proportionate sampling, stratified with randonization within each category was used. The sample included about 70 per cent of the high schools in each size category--according to the number of teachers. The total number sampled was 170 high schools. Of these 170 schools, forty-five were in the size having one to three teachers, seventy-four were of the four to six teacher size, twenty-three of the seven to ten teacher size and twnety-eight had eleven or more teachers. Returns were received from 153 schools or 90 per cent of them. These data are given in Table I. Since the schools were classified as: City Schools, Private Schools, and Town and Village Schools, Table II was drawn up to show those data.

The questionnaire.[9] The questionnaire consisted of three parts: (1) Part I, covering certain items about the school, the faculty and some administrative provisions related to mathematics classes; (2) Part II, on methods of presentation of materials and evaluation of pupil progress; and (3) Part III, on libraries, special rooms and equipment.

The Method. The questionnaires were mailed to the principals of the schools selected. They with the mathematics teacher(s) were asked to complete them. An accompanying letter explained the nature of the project and asked for their co-operation. A second follow-up letter was sent four weeks later. Finally a few personal letters with additional copies of the questionnaire were mailed. The names of the schools and

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[9] Appendix A.

TABLE I

NUMBER AND PERCENT OF RESPONDENTS

BY TYPE OF SCHOOL

	1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	11-15 TEACHERS	Over 15 TEACHERS	TOTAL
SAMPLE[a]	45	74	23	14	14	170
RESPONSE[b]	35	68	23	14	13	153
PERCENTAGE b is of a	77.7%	91.9%	100.0%	100.0%	93%	90.0%
RESPONSES NOT USABLE	1	1	0	0	1	2

TABLE II

NUMBER AND PERCENT OF RESPONDENTS,

BY TYPE OF SCHOOL

	CITY SCHOOLS	PRIVATE SCHOOLS	TOWN & VILLAGE SCHOOLS	TOTAL
SAMPLE[a]	12	9	149	170
RESPONSE[b]	11	9	133	153
PERCENTAGE b is of a	91.7%	100.0%	89.2%	90.0%

their principals were obtained from the list of Accredited Secondary Schools in Alberta, which is published annually in December.

III. COURSES IN MATHEMATICS

Description of courses. (1) Mathematics 9 is the course given to all students in grade nine. It consists of algebra, geometry and arithmetic; (2) Mathematics 10 is the course given to students who follow the academic pattern. It is a continuation of Mathematics 9, and consists of about two-thirds geometry and one-third algebra, with one chapter on arithmetic; (3) Mathematics 11 is available for grades ten or eleven or twelve. It is a course of business arithmetic; (4) Mathematics 20 is a continuation of Mathematics 10 and it is for the academic program. The course is composed of about two-thirds algebra and one-third geometry; (5) Mathematics 21 is a general course in arithemtic developed from the point of view of the consumer. It is available to all students in grades eleven or twelve; (6) Mathematics 30 is an advanced course in algebra, and a continuation of mathematics 20; (7) Mathematics 31 is a general course in trigonometry. A prerequisite to it is Mathematics 20.

CHAPTER II

BACKGROUND INFORMATION

For some years there has been a wide general interest in all phases of mathematics at the high school level. Much has been written to show that the situation is unsatisfactory. And still much more has been written by way of suggesting changes and remedies. Special committees, study groups and associations have been working on programs encompassing all areas of the mathematics curriculum. A brief review is made of some of those things here.

I. PROVISIONS FOR THE GIFTED

Laycock points out that, "many different terms have been used to convey the idea of superior endowment: gifted, exceptional, superior, rapid learner, able student, bright, exceptional and even genius."[1] That many of these terms are used interchangeably, without giving precise definitions, is noted rather frequently. But most writers upon careful definition use the words gifted or talented. "The term 'gifted children' is generally used to mean 'academically talented' as measured by standardized intelligence and achievement tests. This usage is particularly popular at the secondary level and points to the extremely important characteristics of gifted children--their intellectual ability

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[1] S. R. Laycock, Gifted Children (Toronto: The Copp Clark Publishing Co., Limited, 1957), p. 9.

and academic achievement."[2]

There are numerous provisions that are being made for the gifted students in mathematics. The Madison, Wisconsin public schools in 1957 commenced a revision of their mathematics curriculum. McCloskey reported that, "The primary object the preparation of an accelerated program for gifted students."[3] The program involved building a special curriculum in order that the students might attain advanced placement. It was also concerned with a reorganization and modernization of the mathematics curriculum.

Other plans have been reported, too. Seattle, Washington has had a project under way since 1952. The Seattle project commences special work at the seventh grade and regularly places its able students in intermediate algebra in grade nine. Thus, by the time many of these students finish high school, they will have completed one course in mathematical analysis.[4]

The Bronx High School of Science, working with a very highly selected group of students, has introduced a program that carries their ablest

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[2]Robert F. Dehaan, "Identification of the Gifted," Education, November, 1959.

[3]Don G. McClosky, "Proposed Revision and Acceleration of the High School Mathematics Program," School Science and Mathematics, March, 1960, p. 214.

[4]Elizabeth Roudebush, "The Seattle Project for Talented Students," Bulletin of the National Association of Secondary School Principals, May, 1959. p. 80.

students through such courses as analytic geometry, calculus, abstract algebra, statistical inference and linear programming.[5]

In the Cincinnati public schools the philosophy persists that the talented child should be stimulated to go as far as he can each year, and they outline an accelerated plan of study for him.[6] Mildred Kieffer holds the point of view, . . .that exploration of many areas and interests, rather than early specialization, is sound for elementary school children . . ."[7]

This plan in the elementary schools, coupled with a strong four year high school program, prepares the students for the College Entrance Examination Board tests and for advanced placement.

These programs that have been noted are being done in the high schools. Others are of a somewhat different nature have been tried. The State University of Florida sponsored, in the summers of 1958, 1959 a program for the mathematically talented. Their program was threefold: (1) to identify talented high school youngsters capable of becoming research mathematicians or exceptional mathematics teachers; (2) To develop and enhance the interests of such young men and women by providing them with new insights into an expanding mathematical body of knowledge; and (3) To bring these youngsters into contact with research mathematicians and

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[5]Irving A. Dodes, "Mathematics in the Bronx High School of Science," Bulletin of the National Association of Secondary School Principals, May, 1959, p. 83.

[6]Mildred Kieffer, "Meeting the Needs of Cincinnati's Gifted Pupils," Bulletin of the National Association of Secondary School Principals, May, 1959, p. 89.

[7]Ibid.

mathematical content of a kind not commonly found in high school courses."[8]

The students selected for this summer program, spent six weeks on the campus and gave three hours per day to mathematics lectures, plus some study of the Russian language and other cultural activities. The sponsors in evaluating the program felt that in addition to tangible results shown by tests, there were others such as enthusiasm and keener interest for mathematics.

Of interest to those working with the gifted is the work of the College Entrance Examination Board, and the Advanced Placement Program. The tests under this program are directed to the gifted pupil. This means that a program may be set up in any school, that leaves the twelfth grade free for analytic geometry and calculus. Students who are successful in these tests may receive college credit and they may commence college work at an advanced level.

The foregoing plans and programs are most helpful in promoting an advanced program for some of the gifted. Passow and Brooks make this observation:

> Unless the gifted can be identified and immersed in rich experiences, there is danger they will not develop positive attitudes towards mathematics, or acquire the insights, skills and understandings essential for higher specialization."[9]

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[8]Eugene D. Nichols, "A Summer Mathematics Program for the Mathematically Talented," Mathematics Teacher, April 1960, p. 235.

[9]A. Harry Passow and Deton J. Brooks, Jr., "Mathematics and Gifted Students--Some Problem Areas," Bulletin of the National Association of Secondary-School Principals. May, 1959, pp. 65-66.

These men raise the following questions:

(1) Can the gifted be identified adequately?
(2) How much mathematics should he have?
(3) What should be the nature of the mathematics for the gifted?
(4) What kinds of special provision should be made for the gifted student in mathematics?
(5) Who should teach the gifted, mathematics?[10]

An area of some concern in regard to a program for the talented in mathematics, is the large number of students enrolled in small high schools. In Colorado, 165 of the 265 high schools have fewer than 150 students enrolled in grades nine to twelve.[11] In an area comprising the six mountain states, it was found that almost half the schools had fewer than 100 students enrolled.[12] In these small schools there must be only a limited mathematics offering. A study by Moore showed that of the 460 high schools in Nebraska, only nine per cent of them offered Trignometry, and only four per cent of the schools having an enrollment of 51-100 offer Trigonometry.[13]

On a national basis there are many capable students enrolled in small high schools. This represents a great potential of young scientists and engineers. Their opportunities are obviously limited. Some educators are exploring additional possibilities to enhance these few opportunities. One way may be the wide use of educational television.

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[10]Ibid. pp.66-70; M.H. Ahrendt, "Education of the Mathematically Gifted" Phi Delta Kappan, 34: 285-87, April 1953; Howard Fehr,"Mathematics for the Gifted," Bulletin of the National Association of Secondary-School Principals, 38: 103-110, May 1954; Kenneth E. Brown and Philip G. Johnson, "Education for the Talented in Mathematics and Science" (Washington: U.S. Government Printing Office, 1952, pp. 3-6).

[11]Milton Beckman, "Problems of Mathematics in the Small High Schools, Bulletin of the National Association of Secondary-School Principals, May 1959, p. 37.

[12]Ibid., p. 38.

[13]Barry Moore, "Mathematics Course Offerings and Enrollments in Nebraska Public Schools," The Mathematics Teacher, 1957, p. 37.

II. PROVISIONS FOR THE SLOW LEARNER

The slow learner is generally identified on the basis of tests--both achievement and intelligence tests. It should be noted, however, that some group tests give better measures of the lower ranges of ability; others measure higher ranges more accurately. Individual tests are generally more accurate than group tests, especially for the slow learner.

Some variations appear in the literature in respect to the IQ range of the slow learner. Lee Boyer places him in the IQ category 75-90, and says, "He is the pupil who does not make average progress in mathematics classes."[14] Potter and Mallory conclude that with about half of the population in the 90-110 IQ category, with 25 per cent above and 26 per cent below, the 80-90 IQ class would include those called slow learners--about 16 per cent of the population.[15]

The current literature on the slow learner is not so extensive as that about the gifted. But it should be noted that a very small percentage of students are in the talented class, while a much larger group crowd the slow learner category. Most educators are not unaware of the problem and hence much has been written and said in respect to a program in mathematics education for them. It is certainly encouraging to see that the non-college group is not being forgotten.

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[14]Lee E. Boyer, "Provisions for the Slow Learner," The Mathematics Teacher, April 1959, p. 44.

[15]Mary Potter and Virgil Mallory, "Education in Mathematics for the Slow Learner," National Council of Teachers of Mathematics, (Washington: National Education Association, 1958), p. 12.

There is need for much study and research on the teaching of mathematics to the slow learner. Potter and Mallory describe this problem under: (1) Methods (administrative and teaching); (2) Characteristics of slow learners; (3) Factors of instruction; and (4) Materials of instruction.[16]

One question that immediately arises is: "Who is the slow learner?" Here is one answer to that question:

> (1) The pupil has an IQ between 70-90 on the Pintner Test of Mental Abilities.
> (2) The pupil's reading level shows a retardation of at least two years on the Standford Reading Achievement Test.
> (3) The pupil's score on the New York City Arithmetic Achievement Test, is at least two years retarded.
> (4) A final criterion is: "What was the opinion of the pupil's previous teacher?"[17]

Another provision for this group is to teach them by use of concrete or semi-concrete materials. This is often referred to as the Laboratory approach to mathematics. Sims and Oliver favor it strongly:

> Most people are familiar with the laboratory as used in the natural sciences. Through objectifying ideas and principles, through demonstrations, through participation in various experiments, and through opportunities to gain skill in types of manipulation, the learners are able to give meaning to verbalisms. Why should these learners be denied a similar opportunity to find life in mathematics as a system of ideas?[18]

Lee Boyer, in an article previously cited, strongly urges the use of ability grouping, as a means of assistance. This, coupled with small

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[16]Mary Potter and Virgil Mallory, Ibid., pp. 3-4.

[17]Stephen Krulik, "Experiences With Some Different Topics for Slow Learners," Bulletin of the National Association of Secondary-School Principals, May, 1959, p. 43.

[18]Weldon Sims and Albert Oliver, "The Laboratory Approach to Mathematics," School Science and Mathematics, 50:621.

classes, provides a first provision for this group.[19] But, this provision of ability grouping is not possible in the many schools with small enrollment. It then becomes necessary to adjust the work within the class so that the slow learner may profit from it. This may take the form of dividing the class into two or more sections and informally differentiating the curriculum to meet their needs. Teachers here recognize the merits of individual help to the slow learner during supervised study periods or during laboratory periods.

In addition to finding suitable methods to teach the slow learner, educators desire to give him a suitable program. In other words: "What mathematics is essential and can be learned by students of low scholastic ability?"[20] Fehr indicated that they do best by laboratory work, geometrical constructions, group discussions and short concentrated study or practise. The content materials which these people may need most are items such as budgeting, installment buying, cost of operating a car or buying a home or reading a graph. These topics are learned best in a concrete practical situation that has face value to the student.[21]

Some problems, questions and areas of concern have been raised in connection with the slow learner. Some explanations and answers have been given, and some bibliographical works noted. There is much literature available, but all of these areas need constant re-examination,

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[19] Lee Boyer, op. cit., p. 46.

[20] Howard F. Fehr, "Teaching High School Mathematics," Department of Classroom Teachers, American Educational Research Association of National Education Association, p. 12. (Washington, D.C., National Education Association, 1959).

[21] Ibid., pp. 14-15.

and educators seem to be aware of this need.

III. TRANSFER OF TRAINING

Any discussion on background material related to the teaching of secondary school mathematics, must take into account the question of transfer of training. The implications are far reaching as may be judged by the vigorous controversy that has gone on for decades. E. R. Hedrick, writing in The Mathematics Teachers says:

> It appears to me that we will get very little transfer unless we make it part of our business to teach it: every day and at every opportunity, in large matters and in small numerical instances.[22]

Butler and Wren present a rather good picture of this topic in their book, Teaching Secondary Mathematics:

> There can be no doubt that many extravagant and unjustified claims have been made with regard to the disciplinary values of mathematics. On the other hand, the willingness to accept uncritically the "no transfer" dictum has undoubtedly led to statements and beliefs equally extravagant and quite as far from the truth. Competent psychologists are agreed that the truth lies somewhere between the two extreme positions. There is no longer any doubt that transfer does take place.[23]

That this subject has an almost compelling interest was indicated earlier in noting the claims made both for and against it. In point of the number of research studies that have appeared in the literature, it

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[22] E. R. Hedrock, "Teaching for Transfer of Training in Mathematics," The Mathematic Teacher, 30:51-55.

[23] Charles H. Butler and F. Lynnwood Wren, "The Teaching of Secondary Mathematics," (New York: McGraw Hill Book Co., Inc. 1951), p. 82; W. C. Bagley, "Education and Emergent Man," (New York: Thomas Nelson and Sons, 1934), pp. 82-93; Charles H. Judd, "Education as Cultivation of the Higher Mental Processes," (New York: The Macmillan Co., 1936), pp. 198-201; William Betz, "The Teaching and Learning Process in Mathematics," The Mathematics Teacher, 42 (1949) 49-55.

seems that this compelling interest is also still evident. Dr. Pedro T. Orata, a dedicated student of transfer of training, summarizes the evidence in these words:

> The evidence that has accumulated in the last six years confirms overwhelmingly the findings that have been summarized by the present reviewer, first in 1927 and again in 1935, namely: first, transfer is a fact as revealed by nearly eighty percent of the studies; second, transfer is not an automatic process that can be taken for granted, but it is to be worked for; and third, the amount of transfer is conditioned by many factors, among which are: age, mental ability; (possibly) the time interval between learning and transfer; degree of stability attained by the attitude toward the learning situation, and efficient use of past experience; accuracy of learning; conscious acceptance by the learner of methods, procedures, sentiments and ideals; meaningfulness of the learning situation, the personality of the subject--greater transfer in extroverts than in introverts; method of study; suitable organization of subject matter presentation; and provision for continuous reconstruction of experience.[24]

Orata also summarizes in tabular form the results of the research on transfer experiments from 1890 to 1941. Of the 211 experiments, 164 showed clear evidence of transfer. This is just under 80 per cent.

Myron Rosskopf has written a good account of transfer of training, which appeared in the Twenty-first Yearbook of the National Council of Teachers of Mathematics. In summary he says:

> Thus we see that, except for the first, each of the theories of transfer of training has implications for the teaching of mathematics. It is not necessary to regard them as mutually exclusive; aspects of the doctrine of identical elements, generalization and reorganization of experience are applicable in mathematics classrooms. Of the four theories of transfer that have been formulated, that of formal discipline is the only one that is thoroughly discredited.

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[24]Pedro T. Orata, "Recent Research Studies in Transfer of Training with Implications for the Curriculum, Guidance and Personnel Work," Journal of Educational Research, 35: 81-101, Oct., 1941.

> All others are accepted, if not totally then in part, by all groups of psychologists.[25]

There are still some unanswered problems about transfer of training. The first is: How can mathematics be taught to develop the largest possible transfer? Others arise too: How much practice work or drill is necessary so that students may recognize concepts? What are the implications of transfer of training on general mathematics courses? How can one facilitate transfer from mathematics to physics or chemistry? or from mathematics to English? These are genuine questions and are worth serious consideration and additional research.

As a conclusion for this section two leading authors on the teaching of mathematics, speak of transfer training:

> In a broad sense the disciplinary effect of sound mathematical study may be thought of as involving potentially such values as the awareness of, and insistence upon precision; the establishment of self reliance and the self imposition of responsibility for information, procedure and results . . . the habitual testing of inferences . . . the ability to generalize relationships; the ability to discriminate between sound and specious argument and between valid inferences and unwarranted inferences, . . .the ability to generalize relationships and to apply generalizations. In particular, the ability to generalize meanings, symbols, relationships and processes and to apply such generalizations to new situations represents transfer of the most genuine and vital sort. In fact this is precisely, what is implied by the expression "functional" mathematics, which has come into use as the dominant idea for the courses in general mathemathics as well as for the more formal sequential courses. Indeed, this aspect of transfer would seem to be at the very root of all really functional education. It is implied on every application and every interpretation of any concept or circumstance, for correct interpretation must form the basis of any intelligent application, whether to a problem in physics or geometry or to a business or social situation. A denial of this sort of transfer value seems utterly

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[25] Myron Rosskopf, "Transfer of Training," Twenty-First Yearbook, National Council of Teachers of Mathematics, (Washington: The Council 1954), p. 219.

inconsistent with the advocacy of teaching for meanings and making education really functional.[26]

IV. GUIDANCE IN MATHEMATICS

In these days of specialization in jobs where much of the preparation is made in high school, and where there are many free electives for students to take, it seems logical that some guidance service is essential to high school boys and girls. They are not all able to make decisions which will be good for them in the long run, and so often they follow certain programs simply because they are easy or popular, or their friends are there. Some of these may lead to satisfying jobs but in many cases their school program is completely inadequate to serve their needs and desires.

Every school principal, and possibly every high school teacher, can detail mistakes in choices of curriculum by students. These mistakes may be related to ability (or lack of it), to interests, to desires and ambitions of parents for their children. Often times the mistakes result from no overall, long-range planning--or the general immaturity of many high school students. Since it is part of the work of the secondary school to assist students to cultivate tastes and interests and abilities, which are of enduring use, some guidance seems appropriate.

The field of mathematics offers great opportunities for those who have, or who cultivate an interest, and who have the particular ability to successfully achieve in it. It is not the job of the counsellor,

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[26]Butler and Wren, op. cit., pp. 82-83.

teachers or principal to "sell" the subject to the student--if he lacks the normal prerequisites. But there is nothing to replace dynamic enthusiasm of the teacher, in the urging of students to achieve their best, mathematically. Mathematics is most useful not only to the potential scientific people, but to people simply because they are consumers, or because they ply occupations requiring it or simply because they need to understand so many aspects of our civilization.

Because of the widespread needs and use of mathematics, students require information regarding its use in so many fields. Most school programs require students to take mathematics through the ninth grade. Some require all students to take additional mathematics. In Alberta, for example, all pupils are required to take at least one year of mathematics in Senior High School. These courses are presumed to satisfy basic needs of consumers without any specialization. Vocational information of a detailed nature is essential as for example, what mathematics is needed for the boy who wishes to take a course in automotive mechanics? what courses are required for the student who wished to enter a first class technical school? what courses are required to matriculate to a university? These and many other questions should be answered in a proper guidance program in mathematics.

The best single source of information available in respect to guidance in mathematics is the Guidance Pamphlet in Mathematics for High School Students, which is distributed by the National Council of Teachers of Mathematics. The pamphlet deals with ten well defined sections, which are listed on the next page.

I. Mathematics for Personal Use.
II. Mathematics Used by Trained Workers.
III. Mathematics for College Preparation.
IV. Mathematics for Professional Workers.
V. Women in Mathematics.
VI. Mathematics Used by Civil Service Workers.
VII. Mathematics needed in Occupations in the Armed Forces.
VIII. Mathematical Organizations.
XI. Graduate Schools Offering the Doctorate in Mathematics.
X. Selected references on Mathematical Careers.[27]

The organization of this pamphlet makes it possible for a student to read a section that he is particularly interested in, for example, he may wish to know what mathematics are necessary for Civil Service Workers. He could find the members of workers in mathematics and statistics employed by the government and also something of their preparation mathematically.

Pamphlets are distributed by most colleges, technical schools, nursing training schools, etc. which give detailed information of the preparation necessary in high school to meet their entrance requirements. If many of these are available, pupils may be apprised of specific requirements. For example the nursing training institutions in Alberta require girls to have credit in Mathematics 20. Students knowing this can make suitable preparation rather than be disappointed upon application for entrance. The University of Alberta through its Student Counselling Services is giving much information to the high schools of a guidance nature. These things in total indicate a trend of thinking that regards guidance in mathematics rather important.

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[27] National Council of Teachers of Mathematics, Guidance Pamphlet in Mathematics for High School Students (Washington: The Council 1956) p. v.

Time was when about the only avenue of work for a mathematician was teaching. Dr. Louis Schmittroth in a lecture entitled, "Mathematics and Industry," given at the Institute for Collegiate Teachers of Mathematics at Missoula, Montana, in the Summer, 1959, said:

> In 1941 there were 150 mathematicians holding senior positions in U. S. industry, and working as such. While current figures are not complete, this number has grown to 15,000 and the demand is ever increasing.[28]

This sort of information, in itself, is most meaningful to students, and, if available, may serve a useful purpose. But basically, students must hear from their teachers, counsellors and other guidance personnel that mathematics requires serious and sustained application and this should be begun in high school. A deep and abiding interest must be developed. Without good counselling, far too many potential mathematicians fall into elective courses of only transitory interest and value. Teachers must be prepared to philosophize with their students and try to give answers to such questions as, "What good is geometry?" or "Why study mathematics?" These things assist students to see purpose and meaning in this subject.

V. METHODS IN MATHEMATICS

Methodology in mathematics covers a wide range of territory. But it will be assumed here that methods have to do with the actual presentation of materials to students in the classroom. According to

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[28]Louis M. Schmittroth, Lecture: "Mathematicians in Industry," Summer Institute for Collegiate Teachers of Mathematics, Montana State University, Summer, 1959.

Butler and Wren, "It is this phase of instruction that makes the heaviest demand upon the skill and artistry of the teacher. The primary jobs are to explain, to make clear, to challenge, to guide to discovery and to develop understanding."[29] Many things, then, are involved, for example: review of the old, preview of the new, development of lecture, heuristic, genetic and laboratory methods of teaching, developmental teaching, directed study, drill, teaching for transfer, grouping, and long range planning.[30]

A survey of the research[31] in mathematics education during 1955-56 indicated much interest in content and sequence of mathematics courses. But it was noted there was no general agreement. Several studies emphasized understanding concepts. Some work with experimental groups indicated that these groups made progress with most methods when they were used by skilled or specially trained teachers.[32] The background and qualification of the teacher seems most significant.

In summary some needs were pointed out:

(1) The studies reflect a need for state groups of teachers or national committees to identify crucial problems so some direction might be given to reserach.

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[29]Charles H. Butler and F. Lynwood Wren, "The Teaching of Secondary Mathematics," (McGraw Hill Book Company, Inc. New Yor, 1951), p. 159.

[30]Ibid., pp. 158-193.

[31]Kenneth E. Brown, "Analysis of Research in Teaching of Mathematics, 1955-56, Bulletin No. 4 (Washington, U. S. Government Printing Office, 1958) cited in, The Mathematics Teacher, December 1958, p. 593.

[32]Ibid., p. 595.

(2) There should be greater co-ordination of effort in attacking identified problems. An entire mathematics staff might concentrate its research efforts on a single problem.
(3) The results should be published.

The University of Illinois has had a project for the improvement of teaching of secondary mathematics, going on for several years.[33] According to Beberman, the director of the project, they, ". . . seek to bring mathematics into the teaching of mathematics, and to encourage the learner to discover as much of the subject as time and circumstances will permit."[34]

This committee decided that a realistic proposal for improvement would have to include classroom tested instructional materials. In the year 1959, over eighty schools throughout the country were trying the U. S. I. C. M.[35] Program, and the eighth version of instructional materials, for the beginning course has been released to the profession.[36]

Another feature of their program has been the development of special teacher editions. According to Beberman these editions are really compendia of pedagogy and mathematics.[37] This idea is at least one way to bring new thinking in methods to the teacher in a way he can get it

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[33] U.I.C.S.M. Staff, The University of Illinois Mathematics Program, (Urbana, Ill.: The Committee, June 1959, Mimeo. 11 pp.).

[34] Max Beberman, "Improving High School Mathematics Teaching," Educational Leadership, December, 1959, p. 162.

[35] U.I.C.S.M. - University of Illinois Committee on School Mathematics.

[36] Max Beberman, op. cit., p. 164.

[37] Ibid.

and use it.

In the readings on method it is sometimes asserted that fine ideas are worked out but seldom get into the classroom. Mr. A. W. Jones, an Australian who visited American classroom said:

> I had read various yearbooks of the National Council of Teachers of Mathematics; had seen some of your excellent text books (with teachers' guides), and some of the materials and aids supplied by various agencies. In the classroom I expected to see the activities suggested in these sources to enliven the work and stimulate the pupils. I was very disappointed.[38]

It appears that more concerted effort should be made to bring fruitful ideas and practices to the classroom. This leads quite naturally to in-service education. Brandon says:

> Today it can be said that an instructional program moves forward on the in-service education of the professional staff. In-service education becomes the medium for professional growth of the staff. . . It can become the proverbial leaven in the loaf; a force working silently but vigorously, to cause change.[39]

This entire issue of Educational Leadership is devoted entirely to the question of in-service education of teachers. Some suggestions gleaned from it to promote this phase of professional growth are:

(1) Ascertain what are the professional needs.
(2) Promote workshops and seminars.
(3) Promote and take advantage of off-campus courses.
(4) Promote observation and intervisistation of teachers.[40]

A text book published in England, Teaching of Mathematics,[41] is of

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[38] A. W. Jones, "Mathematics Teaching in American Classrooms," The Mathematics Teacher, May, 1958, p. 345.

[39] Bertha M. Brandon, "In-Service Education for Elememtary Teachers," Educational Leadership, March, 1960.

[40] Ibid.

[41] Incorporated Association of Assistant Masters in Secondary Schools, The Teaching of Mathematics, (Cambridge: At the University Press, 1957).

general interest not only because of its excellent content, but to make some comparisons between it and Canadian and American texts. Considerable effort is expended throughout the book on the influence of psychology on teaching. One succinctly stated phrase is most applicable: "If we are to teach John Latin, we must understand John as well as understand Latin."[42] Two essential conclusions, from the work of psychologists seem to be: "(1) The fundamental importance for the pupil of motive and purpose; (2) The disabling effects produced in the pupil by emotional reactions, such as fear or dislike of the subject taught and loss of confidence through lack of success."[43]

In respect to presentation of material, three items are especially worth noting:

> (1). . .This would imply a closer association of mathematics with everyday life, and a wider field of exercises in which reasoning can be applied.
> (2). . .There is a perpetual temptation to show the tool and then apply it to the problem, whereas the reverse is the more effective procedure: first show the problem, then the evolution of the tool, lastly, the application of the tool to wider fields.
> (3). . .Attention must be given to the kind of material, to the conscious cooperation of the pupil, to explicit attention to possible transfer from mathematical to non-mathematical processes.[44]

VI. THE EDUCATION OF TEACHERS OF MATHEMATICS

"If we are to teach John Latin (Mathematics), we must understand John as well as to understand Latin (Mathematics)."[45]

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[42] Ibid., p. 7.

[43] Ibid.

[44] Ibid., pp. 9-13.

[45] Ibid., p. 7.

This indicates a broad two-fold program for the teacher--the subject matter and appropriate psychological studies. The subject matter must include courses on methodology. Teacher education includes pre-service education and, in addition, continued in-service education.

According to Fehr, the teacher's mathematics education should:

> (1) Give the teacher a deep and broad knowledge of the methods, content, and structure of pure mathematics considerably beyond that of secondary school mathematics.
> (2) Embrace the formal study of several field of knowledge where mathematics is used, e.g., physics, chemistry, and engineering.
> (3) Initiate an accumulation of mathematics applicable to a wide variety of situations and appropriate for use at all levels of high school instruction.
> (4) Be professionalized to the extent that, wherever possible, it is linked with secondary school mathematics.
> (5) Include specific provisions for the study of basic concepts and mathematical methods of statistics, including knowledge of the application.
> (6) Give specific attention to the history and development of mathematics, with stress on implications for secondary school teaching.
> (7) Give specific attention to the nature of high school teaching of non-academic students with special reference to arithmetic teaching.
> (8) Include technics for operating mathematics laboratories, including the construction and use of mechanical models.[46]

Teacher education is not always this adequate. It is not uncommon for many teaching majors to include only nine to twelve hours beyond the calculus. The College Entrance Examination Board state that a program of education of secondary school mathematics teachers might be built around a major of 24 semester hours beyond the calculus.[47] This would appear to be adequate time for a satisfactory program.

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[46]Howard F. Fehr, Teaching High-School Mathematics, (Washington: National Education Association, 1955), pp. 30-31.

[47]Marc A. Laframboise, "The Education of Secondary and Collegiate Mathematics Teachers," School Science and Mathematics, p. 267.

Quite a number of specific programs for mathematics teachers were noted, with some variation in course content and sequence. All seem to call for a strong program of preparation. This is an abrupt change from programs even 25 years ago. For example, it was noted in the Fourteenth Yearbook of the National Council of Teachers of Mathematics that the median number of hours for a mathematics major was a twenty-eight.[48] And this undoubtedly included college algebra, analytic geometry and calculus.

In contrast, Laframboise suggests the following program:

> (1) Principles of mathematics: concepts regarding logic, number systems, groups, rings, fields, sets, theory of equations, algebraic functions, with the traditional necessary topics, and analytic geometry with an introduction to exponential and logarithmic functions, limits and calculus.
> (2) A thorough course in calculus along with solid analytic geometry through quadric surfaces and some theory of determinants and matrices.
> (3) Advanced calculus and differential equations, and a first course in each of probability and statistics and plane statics and dynamics.
> (4) Foundations of mathematics, projective geometry, history of mathematics, theory of numbers.[49]

Howard Fehr, in an article entitled, The Education of Teachers of Mathematics, makes essentially the same proposals, and then adds:

> All of the proposed courses, while essentially textbook in nature, should be accompanied by assigned collateral readings from periodicals and reference books. This required reading is absolutely necessary to the development of scholarly teachers who must come to know that the textbook is only a part of any study, either in high school or in college. The work at all times should be related,

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[48] Fourteenth Yearbook, National Council of Teachers of Mathematics, "The Training of Mathematics Teachers," (New York: Bureau of Publications, Teachers College, 1939), p. 174.

[49] Laframboise, op. cit., p. 268.

> when the relation is pertinent, to the high school program in mathematics. In the course in methods of teaching mathematics, which should be taught by a person competent in mathematics, the high school material should be enriched by continuous reference of it to the advanced treatment of the same material that takes place in collegiate study.[50]

It was noted that in-service education for the existing staff, is desirable, since many and possibly most of these teachers have been prepared far short of these goals. Various methods and ideas are set forth, such as conferences, institutes, professional meetings, study groups, evening or Saturday lecture programs sponsored by the university and private reading.

These ideas are all explored in the current literature being cited. Others are significant too: Shell Oil Company has been sponsoring summer institutes for mathematics and science teachers, at Stanford University and Princeton University. A limited number of teachers from Canada and the United States have been paid to attend these institutes. General Electric has been sponsoring such programs almost continuously since 1945. The National Science Foundation of the United States is continuously sponsoring institutes throughout the country. Others could be detailed. This approach has resulted in upgrading the qualifications of many teachers and represents a most tangible interest, by industry, in assisting in this vital phase of education.

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[50]Howard Fehr, "The Education of Teachers of Mathematics," Bulletin on the National Association of Secondary School Principals, pp. 171-172.

VII. EVALUATION IN MATHEMATICS

A program of evaluation in mathematics is a continuous and integral part of mathematics education. It is an attempt by the teacher to assess student progress and understanding; to discover weaknesses in previous work and for testing the grasp of a new section of work. Evaluation may serve also as a check on methods of presentation and the effectiveness of teaching. Education is becoming a more exacting profession and hence the necessity to have first-hand information continuously on all aspects of the work. A business firm must keep running accounts of sales, inventory, expenses and profits and can not wait until year end to know if it has made a profit or loss. Thus an evaluative program does more than check on a completed process. It is concerned with the objectives of instruction and of guidance.

Evaluation has broadened much in scope during the last two decades. Futhermore,

> . . . the scope of testing has been greatly extended and an even larger group of teachers has become concerned with the evaluation of more than subject matter achievement. They recognize that mastery of various bodies of subject content is but one aspect of education; and they are attempting to evaluate the development of interests, appreciations, and other characteristics of personality to which the schools are increasingly directing their attention. In this connection it is important to note that evaluation means more than the giving of tests and examinations: the term is used to refer to any method of obtaining and interpreting evidence about the development of pupils.[51]

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[51]Joint Commission of the Mathematical Association of American, Inc. and the National Council of Teachers of Mathematics, "The Place of Mathematics in Secondary Education," Fifteenth Yearbook of the National Council of Teachers of Mathematics (New York: Bureau of Publications, Teachers College, Columbia University, 1940) p. 163; cited by Butler and Wren, op. cit., p. 201.

Hilda Taba groups the major responsibilities of evaluation as follows:

> (1) To help provide more intelligent guidance of teaching and learning.
> (2) To develop more effective curricula and educative experiences.
> (3) To secure more intelligent and effective cooperation with parents and community.
> (4) To provide an adequate and effective basis for reporting progress.[52]

Sheldon Myers, in an article entitled, A New Approach to evaluation of Competence, points out that,

> Modern mathematics is not modern in content only; it is modern in its approach as well. Modern mathematics in the high school and college today requires that teacher and student approach the study of mathematics creatively. It is for this reason that newer approaches to the measurement of mathematical competence it is this kind of thinking which will play an even greater role in later courses of the student.[53]

The implication is clear: whatever skill or understanding or ability serves as a goal, then tests must be devised to measure that goal. Johnson states this most appropriately:

> If we accept goals such as attitudes and appreciations, we need to measure our students' status relative to these goals. If we are teaching how to study mathematics or how to read mathematics, we should test our students' progress in learning these skills. If we are attempting to teach how to apply mathematical learning to new situations, we need to devise tests of this ability. . .Thus, it appears we will need to use a variety of evaluative instruments in the classrooms.[54]

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[52]Hilda Taba, "The Functions of Evaluation," Childhood Education, 15:245-246, February 1939, cited by Butler and Wren, op. cit., p. 202.

[53]Sheldon S. Myers, "A New Approach to Evaluation of Competence," Bulletin of the National Association of Secondary School Principals, May, 1959, p. 153.

[54]Donavan A. Johnson, "What Can the Classroom Teacher Do About Evaluation?" Bulletin of the National Association of Secondary School Principals, May, 1959, p. 156.

The Twenty-second Yearbook of the National Council of Teachers of Mathematics devotes a large part to evaluation of mathematical learning. The contents of this section are:

(1) Evaluation of Mathematical meanings and understandings.
(2) Evaluation of ability to apply mathematics.
(3) Evaluation of the application of mathematical reasoning standards to non-mathematical situations.
(4) Evaluation of attitudes and appreciations.
(5) Reporting to parents.[55]

This section constitutes much new material. Numerous writers in the current literature are approaching evaluation along these same lines, and some of the ideas are most provocative. For example Fehr discusses the nature of, characteristics of, and developmental procedures for creating appreciation in mathematics.[56] He then attempts to identify the areas of learning for which tests can be devised. It is noted that, while this area is recognized as one fertile in resources, it is yet wide open for research. Little has actually been produced, in the way of quantitative measurements.

Another item appearing time and again in evaluation in mathematics is that of measuring how well students apply types of reasoning learned in mathematics to a variety of non-mathematical situations. Bjarne R. Ullsvik and Harry Lewis selected a description of ten behaviours

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[55]National Council of Teachers of Mathematics, "The Evaluation of Mathematical Learning," Twenty-Second Yearbook of the National Council of Teachers of Mathematics, (Washington: The Council, 1954), p. xiii.

[56]Howard F. Fehr, "Teaching of Measurements and Appreciation in Mathematics," Twenty-Second Yearbook of the National Council of Teachers of Mathematics, (Washington: The Council, 1954), pp. 389-390.

and listed a test item for each. The student then studies the test items and seeks to discover the appropriate behaviour.[57] This is one example. Lewis used other procedures to evaluate the development of critical thinking through the teaching of plane demonstrative geometry: (1) an analysis of monthly reports (which the students were asked to write), and (2) a study of questionnaire responses given at the end of the course.[58]

It is noted that these are attempts at evaluation beyond that of the ability to recall information and perform certain skills. These ideas are certainly more elusive to grasp, but do present a great challenge to teachers, principals and other researchers.

VIII. THE MATHEMATICS ROOM

The section is concerned with the literature about rooms that may be called "special mathematics rooms" or "mathematics laboratory." This provision is not common at present, and it appears (from the literature) that there is no widespread demand for it. However, some concern and interest is being shown and it seems that this is an area for increased study and research.

In an examination of some of the texts on teaching secondary mathematics, for example--Butler and Wren--considerable information was given

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[57] Bjarne R. Ullsvik and Harry Lewis, "Evaluation of the Application of Mathematical Reasoning Standards to Non-Mathematical Situations, Ibid., pp. 370-371.

[58] Harry Lewis, "An Experiment in Developing Critical Thinking Through the Teaching of Plane Demonstrative Geometry," Doctor's Dissertation, (New York: New York University, 1950), cited in Twenty-Second Yearbook, Ibid., pp. 379-383.

regarding equipment. "The mathematics laboratory is no longer a misnomer or a mere phrase; it has become in many places an established medium through which the courses have been given new meaning and interest."[59]

In the text, The Teaching of Mathematics, the authors have this to say:

> Although we have sought throughout the country for evidence of the success of mathematics rooms or laboratories and have appealed through the press for information, very little material has reached us. We have, therefore, been forced to the conclusion that, though much may have been said or thought about developing such rooms in schools, very little work has actually been done.[60]

This same committee devotes an entire chapter to a discussion of the mathematics room, and in so doing states three reasons for it:

> (1) First, there is evidence that schools which have devoted a room specially to mathematical work have found the resulting stimulus has amply justified the experiment.
> (2) Secondly, though these notes have in mind grammar schools, it is probably true that they could be of greater use in modern schools. . .
> (3) Thirdly, we as a committee believe that this kind of development in teaching is to be encouraged and we hope that our words may give some of our readers a desire to experiment.[61]

The twenty-second yearbook of the National Council of Teachers of Mathematics devotes one section to laboratory teaching. While it is not intended to deal with methods here, it is worth noting that emphasis is laid upon the necessity of having adequate space and equipment to carry out appropriate laboratory activities. The committee notes that,

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[59] Chas. H. Butler and F. Lynwood Wren, op. cit., p. 97.

[60] The Incorporated Association of Assistant Master in Secondary Schools, The Teaching of Mathematics, (Cambridge, England: The University Press, 1957), p. 179.

[61] Ibid.

"Teachers are beginning to request such space for mathematics rooms and architects are planning for such space in new buildings."[62]

Bartnick has gathered considerable material together and has compiled a booklet, Designing the Mathematics Classroom. This is the most complete single treatment moted, so the table of contents is given:

I. Introduction.
II. Physical Features of the Mathematics Classroom.
III. Furnishings for the Mathematics Classroom.
IV. Equipment for the Mathematics Classroom.
V. Other Facilities.
VI. Summary of Physical Features and Furnishings.
VII. Typical Floor Plans.
VIII. Bibliography.[63]

It should be noted that many schools may have considerable equipment already placed in several rooms. In this case a little reorganization may produce a suitable laboratory. In other instances there are many rooms without fixtures and equipment, and these might readily be made into suitable rooms. Certainly the advantages of laboratory teaching may be seized upon by utilizing whatever space and equipment that are available. But whenever new construction is planned, there is a considerable body of information available to provide features that are now considered desirable and helpful. In Bartnick's Chapter 7 there are some excellent floor plans shown, that are representative of present thinking. It is suggested that:

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[62] The National Council of Teachers of Mathematics, Emerging Practices in Mathematics Education, (Washington: Nathional Council of Teachers of Mathematics, 1954), p. 101.

[63] Lawrence P. Bartnick, Designing the Mathematics Classroom, (Washington: National Council of Teachers of Mathematics, 1957).

> Interested readers will find it advantageous to study carefully the content of each floor plan, make comparisons, and then reach individual conclusions pertinent to local philosophy and objectives. The floor plans can be invaluable as guideposts from which sound adaptations can be made according to local need.[64]

Berger and Johnson have compiled a booklet, A Guide to the Use and Procurement of Teaching Aids for Mathematics.[65] While it is true that most of this information is available from many sources, this one source may be of genuine value. The compilers note that:

> The use of teaching aids in Mathematics is not new. Ever since primitive man drew pictures on cave walls to describe the size of a herd of deer, some form of picture or concrete referent has been used to teach mathematical ideas. In recent years new materials, new equipment, and new emphasis on discovery and sensory experience have put teaching aids in the spotlight as never before.[66]

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[64] Ibid., p. 29.

[65] Emil J. Berger and Donovan A. Johnson, A Guide to the Use and Procurements of Teaching Aids for Mathematics, (Washington: The Council, 1959).

[66] Ibid., p. 36.

CHAPTER III

PRESENTATION OF DATA

This report presents the information taken from the questionnaire sent to a sample of Alberta secondary schools. It comprised three main sections: (1) Part I sought information relating to personnel, class size, time distribution and administrative provisions; (2) Part II inquired into methods of presenting and evaluating materials; and (3) Part III asked for information relative to the mathematics library and teaching facilities.

I. PERSONNEL, CLASS SIZE, TIME DISTRIBUTION

Personnel

Numbers of teachers. In the tabulation of data from the questionnaire, the schools have been categorized according to the numbers of teachers in this manner: (1) One to three teachers; (2) four to six teachers; (3) seven to ten teachers; and (4) eleven or more teachers. Since the study is concerned with methods of teaching, it seemed logical to make this sort of classification.

In Alberta there is great variation in the size of the secondary schools. The range is from one teacher in the far north to sixty-four teachers in some of the large city schools. The latter is certainly not typical since 90 per cent of the schools have thirteen or fewer teachers. Of the 170 schools in the sample the following is a classification by numbers of teachers: (1) 45 schools with one to three

teachers; (2) 74 schools with four to six teachers; (3) 23 schools with seven to ten teachers; and (4) 28 schools with eleven or more teachers. The most common size school is the one with four teachers --31 of the 153 schools responding had this number, which is just over 20 per cent. Two schools reported 64 teachers and nine schools indicated they had 20 or more teachers. This is about six per cent of the schools.

Qualifications of teachers. Of interest in conjunction with this study, is information regarding the academic background in mathematics, of the teaching personnel. Table III gives a summary of this information in terms of the grades in which teachers are employed and the number of university courses they have taken. A university course in Alberta is one lasting for the duration of the academic year, which is about eight months. Translated into credits on the quarter basis, it represents nine to twelve quarter credits or six to nine semester credits.

Of those who teach grade nine, more than half have taken no mathematics beyond high school, while smaller numbers have taken one, two, four or more courses. One grade nine teacher out of ten has taken four or more university courses--about 36 to 48 quarter hours of credit. A progressive, but certainly not an abrupt, improvement is shown in the higher grades. For grade ten, one teacher in three is listed under no university courses, and about one out of five has taken four, or more, courses. This pattern continues in grade eleven where it is 28.6 per cent for no courses and 25 per cent for four, or more courses. The teachers in grade twelve have the best academic preparation--one in six has had

TABLE III

THE PROPORTION OF MATHEMATICS TEACHERS IN GRADES 9, 10, 11 AND 12, WITH VARIOUS AMOUNTS OF UNIVERSITY ACADEMIC BACKGROUND IN MATHEMATICS*

	No University Courses	1 University Courses	2 University Courses	4 or more University Courses	Total
GRADE 9	390	147	121	78	736
TEACHERS	53.0%	20.0%	16.5%	10.5%	100.0%
GRADE 10	195	104	153	111	563
TEACHERS	34.5	18.5	27.2	19.8	100.0
GRADE 11	142	94	138	125	499
TEACHERS	28.6	18.8	27.6	25.0	100.0
GRADE 12	55	44	117	112	328
TEACHERS	16.5	13.4	35.8	34.3	100.0

*Report of the Royal Commission on Education in Alberta, 1959, p. 111.

no courses and one in three, has had four or more courses.

The report of the Royal Commission has this to say relative to teacher preparation:

> The major fact is, of course, that no part of the curriculum can be better than the teachers. Alberta's mathematics teachers include some of the best, but the over-all picture is depressing. That the quality of mathematics teachers warrants special attention is strikingly indicated by the table.
>
> The table shows that many teachers have no university mathematics training, and that only a handful have four university courses. Entrance requirements to the Faculty of Education have been such that of those teachers who have no university courses a considerable proportion may not have achieved even the full high-school mathematics program. The Commission views this as a truly deplorable situation and re-emphasizes strongly the need to improve the preparation of teachers. . .[1]

Numbers of students. Since there are some special problems in teaching mathematics inherent in small high schools, some information regarding enrollment was sought. In the small high school, it is impossible to have a high degree of specialization among teachers, or to offer a variety of courses, or to group students by ability. These represent some of the problems related to methods of teaching.

Alberta has about 300 high schools and enrollment data are given on the 149 schools replying to this item. Consequently, since it has been assumed this is a typical sample, the data given in Table IV represent about one-half the school population in Alberta, for these grades.

The top two rows of figures in Table IV show the numbers of high schools with fewer than 100 pupils--79 schools making 53.1 per cent, and

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[1] Report of the Royal Commission on Education in Alberta, 1959. (Edmonton: The Queen's Printer, 1959), pp. 110-111.

TABLE IV

ENROLLMENTS IN ALBERTA HIGH SCHOOLS

Size of School	Number of Schools	Percent of Sample	No. of Students	Percent of Sample
Less than 50	26	17.5%	961	3.9%
50 - 99	53	35.6	3,809	15.7
100 - 149	29	19.5	3,422	14.1
150 - 199	11	7.3	1,871	7.6
200 - 249	7	4.6	1,609	6.7
250 - 299	9	6.1	2,440	10.2
300 - 399	3	2.0	1,107	4.7
400 - 499	4	2.7	1,671	6.9
500 - 599	1	.7	510	2.2
600 - 799	0	.0	0	.0
800 - 999	3	2.0	2,769	11.5
1000 and over	3	2.0	3,981	16.5
	149	100.0%	24,150	100.0%

4,770 pupils making 19.6 per cent of them. There are, then 46.9 per cent of the schools enrolling 80.4 per cent of the pupils. It may be noted further that 72.6 per cent of the high schools in Alberta enroll fewer than 150 pupils per school. This represents about one-third of the secondary school population. The most common school size is in the 50 to 99 pupil range. There were 53 such schools enrolling 3,809 students which is about 15 per cent. Three schools reported enrollments greater than 1000 students. This represents two per cent of the schools, but over 16 per cent of the school population.

These data point out clearly that there are still many students enrolled in the small high schools of the province.

Class Size

Division of classes. In these days when there are so many large classes, it appeared significant to poll mathematics teachers in respect to the maximum number of students they believed there should be in a class. They were asked to indicate at what number a class should be divided. This question was not in relation to the actual situation, but rather what teachers believed it should be.

A summary of the results appear in Table V. These data are given by numbers and percentages according to the different categories of schools. Most schools of the three smallest categories agree that classes should not be larger than thirty students. In schools having eleven or more teachers, over 40 per cent say they would allow classes to reach an upper limit of thirty students, while 52 per cent of them say classes might have 35 students before a division is made. Only one

TABLE V

NUMBERS AND PERCENTAGES OF HIGH SCHOOLS SHOWING PLACE OF DIVISION OF CLASSES, BY SIZE OF SCHOOL

	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers		All Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
What do you consider the upper limit, as to the numbers of pupils in a mathematics class, before a division is made:										
1. 30 students	21	65.6%	39	59.1%	14	60.9%	11	40.7%	85	57.4%
2. 35 students	8	25.0	18	27.3	5	21.7	14	51.9	45	30.4
3. 40 students	3	9.4	8	12.1	3	13.0	2	7.4	16	10.8
4. 45 students	0	0.0	1	1.5	0	0.0	0	0.0	1	0.7
5. Over 45 students	0	0.0	0	0.0	1	4.4	0	0.0	1	0.7
Total	32	100.0%	66	100.0%	23	100.0%	27	100.0%	148	100.0%

school, of the 148 reporting on this question, would have a class as large as 45, and one school said there might be over 45 students before a division was made.

There is a definite tendency of belief, in all schools, that classes should not be larger than thirty pupils--57.5 per cent reported thus. In fact, 87.8 per cent of schools would keep classes at 35 or fewer students. A few respondents said: "Thirty students are too many in a class." A few others said: "I would keep classes at 15 to 20 students." In general, these teachers prefer small classes.

Actual size of classes. In determining the size of classes, the respondents were asked to check one of five size categories for each mathematics course. The sizes were: 20 or fewer students; 21 to 25 students; 26 to 30 students; 31 to 35 students; and over 35 students. The number of classes and percentages are set out in Table VI on pages 48 to 51.

Some facts stand out. Small schools have small classes. This is likely because of small numbers of students, rather than deliberate planning. The schools of one to three teacher size largely had classes of fewer than 20 students, but a small percentage of them had classes of 26 to 30 students. Only one school in this category reported a class larger than 25 pupils.

Another point is significant: the class size category of 20 and fewer students shows an inverse relationship to the size of the school, in every mathematics course. It may be presumed that larger schools cannot afford the luxury of the very small class, when there are many students to accommodate.

TABLE VI

NUMBERS AND PERCENTAGES OF HIGH SCHOOLS
REPORTING SIZE OF MATHEMATICS CLASSES
BY CLASS AND SIZE OF SCHOOL

	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers		Total Schools	
Class Size	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 9										
20 and under	24	72.7%	19	32.2%	0	0.0%	0	0.0%	43	33.3%
21 - 25	8	24.2	12	20.3	7	50.0	6	26.1	33	25.6
26 - 30	0	0.0	15	25.4	0	0.0	11	47.8	26	20.2
31 - 35	1	3.1	7	11.9	2	14.3	6	26.1	16	12.4
Over 35	0	0.0	6	10.2	5	35.7	0	0.0	11	8.5
Total	33	100.0%	59	100.0%	14	100.0%	23	100.0	129	100.0%

TABLE VI (continued)

Class Size	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers		Total Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 10										
20 or less	28	87.5%	30	46.9%	4	14.3.%	3	8.8%	65	41.1%
21 - 25	4	12.5	16	25.0	9	32.1	4	11.8	33	20.9
26 - 30	0	0.0	7	10.9	7	25.0	12	35.3	26	16.5
31 - 35	0	0.0	8	12.5	3	10.7	11	32.3	22	13.9
Over 35	0	0.0	3	4.7	5	17.9	4	11.8	12	7.6
Total	32	100.0	64	100.0%	28	100.0%	34	100.0%	158	100.0%
MATH. 11										
20 or less	13	86.7%	24	82.7%	8	47.1%	7	25.9%	52	59.1%
21 - 25	2	13.3	1	3.5	3	17.6	6	22.2	12	13.6
26 - 30	0	0.0	2	6.8	2	11.8	6	22.2	10	11.4
31 - 35	0	0.0	1	3.5	3	17.6	5	18.5	9	10.2
Over 35	0	0.0	1	3.5	1	5.9	3	11.2	5	5.7
Total	15	100.0%	29	100.0%	17	100.0%	27	100.0%	88	100.0%

TABLE VI (continued)

Class Size	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers		Total Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 20										
20 or less	31	96.9%	42	65.6%	9	37.5%	2	6.5%	84	55.6%
21 - 25	1	3.1	15	23.3	6	25.0	3	9.7	25	16.6
26 - 30	0	0.0	5	7.8	4	16.7	8	25.8	17	11.3
31 - 35	0	0.0	0	0.0	4	16.7	13	47.0	19	12.6
Over 35	0	0.0	0	0.0	1	4.1	5	16.1	6	3.9
Total	32	100.0%	64	100.0%	24	100.0%	31	100.0%	151	100.0%
MATH. 21										
20 or less	4	100.0%	12	80.0%	7	77.8%	4	23.5%	27	60.0%
21 - 25	0	0.0	3	20.0	2	22.2	5	29.4	10	22.2
26 - 30	0	0.0	0	0.0	0	0.0	3	17.6	3	6.7
31 - 35	0	0.0	0	0.0	0	0.0	2	11.9	2	4.4
Over 35	0	0.0	0	0.0	0	0.0	3	17.6	3	6.7
Total	4	100.0%	15	100.0%	9	100.0	17	100.0%	45	100.0%

TABLE VI (continued)

Class Size	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers		Total Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 30										
20 or less	30	100.0%	60	95.2%	15	68.2%	3	10.4%	108	75.0%
21 - 25	0	0.0	1	1.6	3	13.6	7	24.1	11	7.6
26 - 30	0	0.0	1	1.6	3	13.6	9	31.0	13	9.0
31 - 35	0	0.0	1	1.6	0	0.0	8	27.6	9	6.3
Over 35	0	0.0	0	0.0	1	4.6	2	6.9	3	2.1
Total	30	100.0%	63	100.0%	22	100.0%	29	100.0%	144	100.0%
MATH. 31										
20 or less	3	100.0%	24	96.0%	13	86.6%	14	56.0%	54	79.4%
21 - 25	0	0.0	1	4.0	1	6.7	3	12.0	5	7.3
26 - 30	0	0.0	0	0.0	1	6.7	3	12.0	4	5.9
31 - 35	0	0.0	0	0.0	0	0.0	4	16.0	4	5.9
Over 35	0	0.0	0	0.0	0	0.0	1	4.0	1	1.5
Total	3	100.0%	25	100.0%	15	100.0%	25	100.0%	68	100.0%

The mathematics courses numbered 10, 20 and 30 form the college entrance pattern. Almost all schools offer these courses. In the one to three teacher category, 32 of the 35 schools give mathematics 10; 32 give mathematics 20; and 30 give mathematics 30. The pattern of class size in the three courses is similar: in the smaller schools almost all classes have fewer than 20 students. For mathematics 30, all schools in one to three teacher class had fewer than 20 students, while in the four to six teacher class over 95 per cent of schools report classes of such size.

This tendency changes as schools become larger. For example, in the 11 or more teacher category, the pattern is this: for mathematics 10 over 80 per cent of schools have classes larger than 25 students; for mathematics 20, almost 85 per cent had classes larger than 25 students; and for mathematics 30, about 65 per cent had such classes. In noting "Total Schools" there appears to be no general tendency to resort to the very large class of over 35 students--2.1 per cent of the schools reported classes of that size in mathematics 30.

For the general program--mathematics 11 and mathematics 21--some differences appear: (1) about 60 per cent of all schools maintained classes with 20 or fewer students for both courses--one reason for this presumably was certainly small registration; and (2) fewer schools offer these courses.

In mathematics 31 (Trigonometry) the prevailing pattern is the small class. Only one school reported a class larger than 35 while 54 schools reported classes of 20 or fewer students. About one-half the schools of the province offer Trigonometry, but only eight per cent of those having three or fewer teachers offer it.

Time Distribution

Instruction time. All the mathematics courses listed in the handbook for high schools, are "5-credit" courses. "One credit corresponds to a minimum of thirty-five minutes of instruction time per week."[2] If a school considers it advantageous to provide more it may do so. Furthermore, class periods may be of unequal length, but the common practice is five equal periods per week for a five-credit course. It should be noted further, that for schools having fewer teachers than grades, some allowance is made for instruction time less than the minimum noted above.

Every school responding to the questionnaire answered this item. Table VII gives a detailed analysis of the results. There were a few schools--six in all, or 3.9 per cent--alloting 105 minutes or less time per week to a five-credit course. In addition, there were nine schools or 5.9 per cent giving from 106 to 140 minutes time. The most common time category was the 141 to 175 minutes per week. Forty-nine per cent of the schools reported this. Most of these schools might well have been offering the so-called minimum instruction time. It may be noted further that 63 schools or 41.2 per cent of them reported giving time in excess of 175 minutes per week, to a five-credit mathematics course.

Time given was in direct proportion to size of the school. The two largest school size categories-- more than eleven teachers-- all gave

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[2]Regulations Pertaining to the Operation of Alberta Senior High Schools, (Edmonton: The Department of Education, 1959), p. 10.

TABLE VII

NUMBERS AND PERCENTAGES OF HIGH SCHOOLS REPORTING INSTRUCTION TIME GIVEN TO A 5-CREDIT MATHEMATICS COURSE, BY SIZE OF SCHOOL*

Teaching Time	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 - 15 Teachers		Over 15 Teachers		All Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
105 minutes or less . . .	2	5.7%	2	2.9%	2	8.7%	0	0.0%	0	0.0%	6	3.9%
106-140 minutes . . .	3	8.6	6	8.8	0	0.0	0	0.0	0	0.0	9	5.9
141-175 minutes . . .	21	60.0	32	47.1	11	47.8	6	42.8	5	38.5	75	49.0
Over 175 minutes . . .	9	25.7	28	41.2	10	43.5	8	57.2	8	61.5	63	41.2
Total . . .	35	100.0%	68	100.0%	23	100.0%	14	100.0%	13	100.0%	153	100.0%

* Time Per Week.

more than 140 minutes per week. It appears probable that they all gave 175 minutes or more time. Several schools reported by writing on the report, "We give 200 minutes per week." One school, operating on the quarter basis, said: "Time given is 600 minutes per week." Translated into a yearly basis, this fits into the greatest time class.

Figure 1 gives a graphical summary of these data on instruction time.

Homework time. The provision for out-of-class assignments or "homework" is an integral part of the mathematics program in Alberta high schools. To get this information teachers were asked to check one of three time areas: under 20 minutes; 20 to 29 minutes; and 30 minutes or more. This was done for each mathematics course. A summary of the data is given in Table VIII on pages 57-60.

There appear to be some general trends. In the low time class (under 20 minutes), there is an increasing percentage of the schools as the size increases. This is true for all the mathematics courses except mathematics 21, which remains about the same. In the high time class (30 minutes or more) there is a decreasing percentage of the schools as school size increases. This is true for all mathematics courses. In general the small schools ask their pupils to do more work out of class than do the larger schools. Since their instruction time is less, this latter conclusion follows quite normally.

Another pattern emerges. For the matriculation program, which includes mathematics 9, 10, 20 and 30, homework time increases with the grade. This is true for every size of school and hence for the total schools. For the general program, which includes mathematics 9, 11

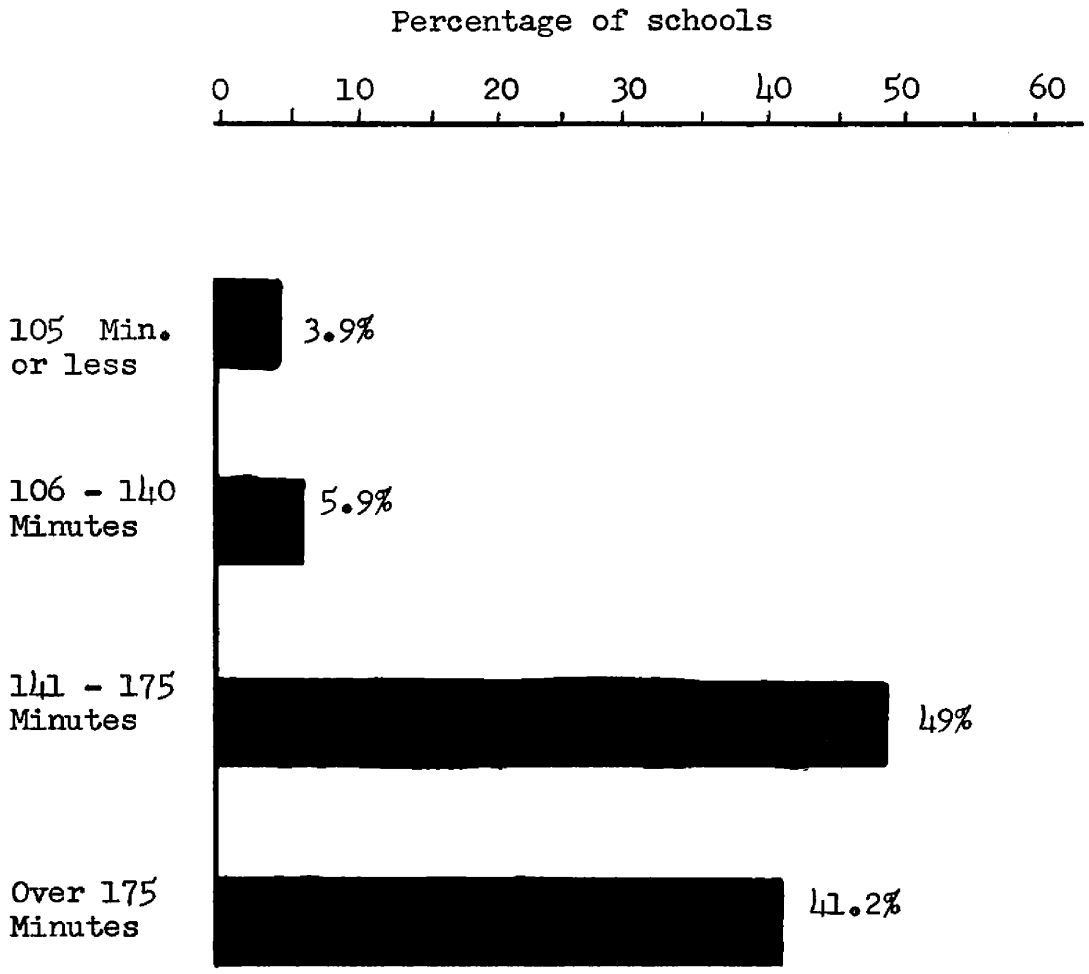

FIGURE 1

GRAPH SHOWING THE AMOUNT OF INSTRUCTION TIME GIVEN TO A 5-CREDIT MATHEMATICS COURSE, BY PERCENTAGES OF SCHOOLS

TABLE VIII

NUMBERS AND PERCENTAGES OF HIGH SCHOOLS REPORTING THE TIME TEACHERS EXPECT PUPILS TO GIVE TO HOME ASSIGNMENTS, PER CLASS, BY SUBJECT AND SIZE OF SCHOOL

	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or More Teachers		Total Schools	
Homework Time	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 9										
Under 20 Min.	4	13.8%	14	26.4%	3	30.0%	8	44.4%	29	26.4%
20 - 29	16	55.2	31	58.5	5	50.0	7	38.9	59	53.6
30 Min. or more	9	31.0	8	15.1	2	20.0	3	16.7	22	20.0
Total	29	100.0%	53	100.0%	10	100.0%	18	100.0%	110	100.0%

TABLE VIII (continued)

Homework Time	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or More Teachers		Total Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 10										
Under 20 Min.	1	3.3%	5	8.1%	2	10.0%	9	34.6%	17	12.3%
20 - 29 Min.	17	56.7	33	53.2	12	60.0%	12	46.1	74	53.6
30 Min.or more	12	40.0	24	38.7	6	30.0	5	19.3	47	34.1
Total	30	100.0%	62	100.0%	20	100.0$	26	100.0%	138	100.0%
MATH.11										
Under 20 Min.	4	33.3%	13	30.9%	6	37.5%	10	41.7%	33	35.1%
20 - 29 Min.	4	33.3	19	45.3	7	43.7	10	41.7	40	42.6
30 Min. or more	4	33.3	10	23.8	3	18.8	4	16.6	21	22.3
Total	12	100.0%	42	100.0%	16	100.0%	24	100.0%	94	100.0%

TABLE VIII (continued)

Homework Time	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or More Teachers		Total Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 20										
Under 20 Min.	0	0.0%	4	6.1%	1	4.8%	4	16.6%	9	6.2%
20 - 29 Minutes	12	35.3	24	36.3	10	47.6	10	41.7	56	38.6
30 Min. or more	22	64.7	38	57.6	10	47.6	10	41.7	80	55.2
Total	34	100.0%	66	100.0%	21	100.0%	24	100.0%	145	100.0%
MATH. 21										
Under 20 Min.	2	33.3%	10	25.0%	3	27.3%	6	31.6%	21	27.6%
20 - 29 Minutes	2	33.3	23	57.5	6	54.6	11	57.9	42	55.3
30 Min. or more	2	33.3	7	17.5	2	18.3	2	10.5	13	17.1
Total	6	100.0%	40	100.0%	11	100.0%	19	100.0%	76	100.0%

TABLE VIII (continued)

Homework Time	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or More Teachers		Total Schools	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
MATH. 30										
Under 20 Min.	0	0.0%	0	0.0%	1	5.0%	1	4.0%	2	1.4%
20 - 29 Minutes	2	6.7	14	20.3	3	15.0	6	24.0	25	17.4
30 Min. or more	28	93.3	55	79.7	16	80.0	18	72.0	117	81.2
Total	30	100.0%	69	100.0%	20	100.0%	25	100.0%	144	100.0%
MATH. 31										
Under 20 Min.	0	0.0%	1	2.4%	1	6.3%	3	13.6%	5.	5.7%
20 - 29 Minutes	1	12.5	10	23.8	4	25.0	7	31.8	22	25.0
30 Min. or more	7	87.5	31	73.8	11	68.7	12	54.6	61.	69.3
Total	8	100.0%	42	100.0%	16	100.0%	22	100.0%	88	100.0%

and 21, no general pattern of increase appears. The stress on homework is considerably less in this general program, than for the college entrance program.

A few significant items are noted in all these courses. In grade nine, 20 per cent of schools require students to do one-half hour of homework in mathematics daily, while 73.6 per cent of the schools suggest 20 minutes or more time. In the next succeeding course--mathematics 10--one-third of the schools require 30 minutes or more time, and 87.8 per cent require 20 minutes or more time. This trend continues in mathematics 20 where 93.8 per cent of the schools request about 20 minutes or more time for homework. For mathematics 30, over 80 per cent of the schools require 30 minutes or more of homework time, and over 98 per cent of them suggest more than 20 minutes time. The amount of homework time expected by Alberta mathematics teachers appears to be high when it is noted that pupils are likely to be carrying five, and possibly six additional courses.

Mathematics 31 (Trigonometry) may be taken by students in the general program, if they have credit in mathematics 20, and it is required of all students in the matriculation pattern if they plan on taking engineering or a major in physics, chemistry or mathematics. The same trend of homework appears as for the other courses. It is noted, however, that the stress is somewhat less than on mathematics 30. One reason may be that credit in Trigonometry is awarded by local school officials while those taking mathematics 30 must be prepared to meet examinations prepared and evaluated on a provincial basis.

In summary these items are significant:

(1) Homework is an integral part of the program for secondary school mathematics.

(2) More time is required for the college entrance course than for general course.

(3) The time required increases with grade for college entrance course, but does not for the general course.

(4) The larger schools require less time than the smaller schools.

Figure 2 gives a graphical picture of data for homework in mathematics.

Total weekly time. Two factors are involved here: (1) Instruction time; and (2) Homework time. Take, for example, a one to three teacher school: the instruction time for 85.7 per cent of such schools was shown to have a range of 140 minutes per week (minimum) to over 175 minutes per week. In the same school size category for a grade nine class, the homework time was shown to be, for 86.2 per cent of teachers, 20 minutes daily minimum (or 100 minutes per week) to more than 30 minutes per day or over 150 minutes per week. This gives a total time of 240 minutes minimum to over 325 minutes per week. For a grade 12 class in the larger schools (11 teachers or more) about 60 per cent showed over 175 minutes of instruction time per week. In the same school size category, for a grade 12 class, over 70 per cent of the schools indicated 30 minutes or more time daily for homework. This is 150 minutes or more time weekly. The total time is 325 minutes or more per week for a large percentage of the schools.

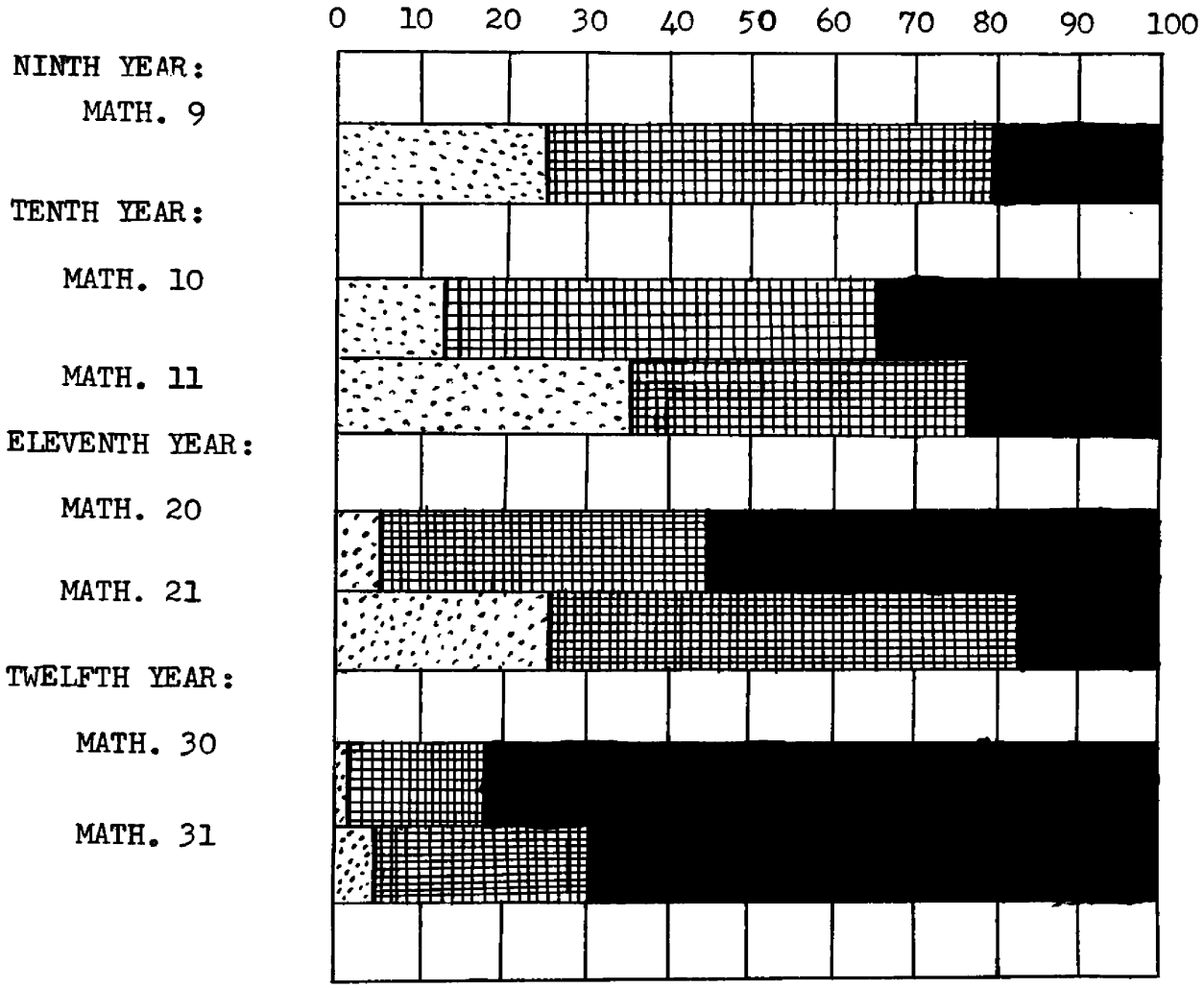

FIGURE 2

GRAPH SHOWING AMOUNT OF TIME (PER WEEK) TEACHERS EXPECT PUPILS TO SPEND ON HOME ASSIGNMENTS, BY SUBJECT AND PERCENTAGE OF SCHOOLS

II. ADMINISTRATIVE TECHNIQUES

Division of classes by ability. Homogeneous grouping of students is a practice that appears to be gaining popularity, where it is administratively possible. The subject appears with some regularity in the periodical literature. To get information on the situation in Alberta secondary schools, teachers were asked this question: "Do you divide mathematics classes by ability?" An analysis of replies is given in Table IX.

In respect to the number of schools it was noted that one school in four follows this practice. Obviously this could not be done in small schools with few students. One school in the smallest size category reported such a practice, but no explanation was given us to how it was feasible. As school size increases, so does this practice, but it is not the usual thing since the highest percentage shown was under fifty.

In the eleven or more teachers school size, 44 per cent reported division of classes by ability. This actually represents many more classes. Three of the largest schools, having an enrollment in excess of 3500 students, follow this plan.

Enrichment. Possibly no other topic in mathematics is receiving so much attention as this one. As a result, it seemed vital to find out something regarding provisions for enrichment in mathematics classes in Alberta. Teachers were asked to specify their provisions for enrichment or to indicate if nothing was being done.

These data are summarized in Table X. In the two smallest size categories of schools, no provision is made for about half of them. For

TABLE IX

NUMBERS AND PERCENTAGES OF HIGH SCHOOLS REPORTING DIVISION, OR LACK OF DIVISION, OF CLASSES BY ABILITY

	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers		All Schools	
Questionnaire	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
PART I, B - 3 Do you divide classes by ability										
1. Yes	1	3.0%	15	24.2&	11	47.8%	11	44.0%	38	26.5%
2. No	32	97.0	47	75.8	12	52.2	14	56.0	105	74.5
Total	33	100.0%	62	100.0%	23	100.0%	25	100.0%	143	100.0%

the largest group, no provision is made in 18.5 per cent of the schools. Province wide, about 44 per cent of the schools reported that no provision was made.

The most common practice related to enrichment was "advanced study in depth." This was reported by 56 schools--36.6 per cent of them. Just over one-half the larger schools made provision for this sort of enrichment, while about one-fourth of the smallest schools did. Nearly one-half (47 per cent) of the schools added additional topics. This, too, was of more common occurrence in the larger than the small schools. Six schools, in the 11 or more teachers category, have established special classes for the gifted. No doubt such students are few in number and hence only the larger schools would have a chance to provide such classes.

Teachers were asked to include any other provisions they had made relating to enrichment. A few teachers simply said: "I suggest to some students to attempt certain, more difficult exercises." In some instances, others said: "I include additional topics, if I have time." This part of mathematics enrichment appears to be on a rather informal and unplanned basis.

On Table X, an "Index of Enrichment" was computed to give an evaluative measure of school action. This index varies directly with the school size. This does not mean that only teachers in the large schools are concerned, but that they because of added numbers of students and staff, are able to do something about enriching the program.

Supervision. Any means through which mathematical instruction may be improved is a proper function of supervision. There are many aspects of supervision, but a selection had to be made to keep the size of the

TABLE X

NUMBERS OF SCHOOLS REPORTING SOME METHODS OF ENRICHMENT OF THE MATHEMATICS PROGRAM, BY SIZE OF SCHOOL

	1 - 3 Teachers	4 - 6 Teachers	7 - 10 Teachers	11 or More Teachers	Total
ENRICHMENT:					
1. Advanced study in depth	9	23	10	14	56
2. Additional topics added	7	14	10	16	47
3. Transfer to special classes	0	0	0	6	6
4. Others	2	3	0	1	6
5. No provision made:	17	36	10	5	68
Total	35	76	30	42	183
NUMBER OF SCHOOLS[b] RESPONDING	35	68	23	27	153
An Index of Enrichment*	0.45	0.54	0.87	1.33	0.75

*Found by $\frac{(1 + 2 + 3)}{b}$

questionnaire within reasonable bounds. Four aspects of supervision were included in the questionnaire. A fifth one--others--gave teachers a chance to add something they believed to be significant. The results of the respondents' replies are given in Table XI.

In total, 203 supervisory items were checked for the 153 schools. Since it was possible for a given school to carry out all the aspects of supervision that were mentioned, this number, in theory might have been 765 (= 5X 153). By way of comparison, the total possible supervising items, in each school size, were computed and this total divided by the number of schools in the same class. The results of these divisions are shown on Table XI as an index of supervision. There is a direct relationship between the size of this index and school size--the range is from 1.0 in the smallest schools to 2.3 in the largest.

The first item--principal supervises some classes--was checked by 46 schools. This means that 30 per cent of the schools participate to some degree in this basic supervisory practice. The large schools follow this practice to a greater degree than the smallest schools, but even here the reported participation was not significantly large--11 of the large schools--of the 27 that reported--or about 41 per cent. In regard to special planning meetings for mathematics teachers, the degree of participation is significantly greater in the larger than in the smaller schools. In the 11 or more teachers category, 16 of the 27 schools indicated that they follow this practice. This is about a 60 per cent activity for this item.

The provision for supplying professional magazines and books is considerably more common than the first two aspects mentioned. For these

TABLE XI

NUMBER OF SCHOOLS REPORTING SOME ASPECTS
OF SUPERVISION OF THE MATHEMATICS PROGRAM
BY SIZE OF SCHOOL

	1 - 3 Teachers	4 - 6 Teachers	7 - 10 Teachers	11 or More Teachers	Total
SUPERVISION:					
1. Principal supervises some classes*	11	19	5	11	46
2. Special meetings held for mathematics' teachers .	3	13	5	16	37
3. Professional magazines made available.	7	17	6	16	46
4. Related books supplied . .	11	19	10	17	57
5. Others	4	9	2	2	17
Total[a)]	36	77	28	62	203
Number of Schools[b)] Responding	35	68	23	27	153
Total Possible Responses = 5N	175	340	115	135	765
An Index of Supervision (a/b)	1.0	1.1	1.2	2.3	1.3

*Superintendent, Department Head, Principal.

two items combined, the total schools checked were 103. This is just about two-thirds of all the schools. In relation to the size of the schools, there were about one-half of the smallest ones that indicated they provide magazines or books, while the largest schools all provide magazines and/or professional books.

From the data two conclusions seem to appear:

(1) Actual supervisory practices are only a small percentage of the potential.

(2) The large schools more than double the small schools in these practices.

III. PRESENTATION OF THE MATERIALS OF MATHEMATICS TO STUDENTS

This part of the study is most directly concerned with methods of teaching mathematics to students in the classroom. The teachers, the department head, the principal and superintendent are all concerned here too, as they were with administrative provisions. It is realized that one method of presentation is not always employed by pre-arrangement on a given day, or in a given class, but rather the method is used that is most suited to the situation as it arises.

The assumption has been made here that there are certain well defined procedures, that are recognized freely in the literature of mathematics by which teachers may give direction to their work. It was the intent here to do some probing in an attempt to get a better picture of what is being done, and what teachers believe is desirable.

Four methods were suggested: (1) Lecture Method; (2) Heuristic Method; (3) Laboratory Method; and (4) Drill. Prior to each question

relating to these, a statement, of explanation was given so that there would be some uniformity in the minds of the respondents, respecting the questions asked.

Computation of Index.

An index was derived and is part of Tables XIII and XIV. Within each method category mentioned above there were four choices on a quantitative basis. Values ranging from one to four were assigned to these categories. A response of LESS THAN 25 PER CENT was given a weight of one, a response of 25 PER CENT TO 50 PER CENT was given two, a response of 50 PER CENT TO 75 PER CENT was given three, and a response of MORE THAN 75 PER CENT was given four. The index for each method was found--in each school size category and total schools--by multiplying the first of these responses by one, the second by two, the third by three, and the fourth by four, adding the four figures together and dividing by the total number of responses. For example, in the one to three teacher schools, and for the Lecture Method, computation of the index was as follows:

TABLE XII

COMPUTATION OF AN INDEX OF TEACHING TIME

Lecture Method

	Number	Weight Value	Product
1. Less than 25 per cent	10	1	10
2. 25 to 50 per cent	16	2	32
3. 50 to 75 per cent	9	3	27
4. More than 75 per cent	0	4	0
Total	35		69

Index = $\frac{69}{35}$ = 1.97

The possible range of the Index, under these conditions, is Index = 1 to 4. This index when compared with others should be interpreted as an index of the relative extent to which the particular method is employed.

The procedure indicated above was employed to get an Index for each of the fours methods suggested in each school size class and for total schools. Table XIII gives these data. The Lecture Method is used most in the first three school size classes, but ranks second to the Heuristic in the larger schools. This pattern appeared in the four to six teacher schools and the seven to ten teacher schools. The Laboratory Method ranked last for every school size category, having an Index just over one in all cases. This simply indicated that mathematics teachers in Alberta do not, to an appreciable extent, utilize these techniques. In a few instances teachers said: "Students must learn to think abstractly in Mathematics." The inference seemed to be that handling concrete objects did not assist in developing this ability. However, no special comment appeared on any of the returned questionnaires, in respect to the general courses.

The largest schools use the Heuristic Method most of the time, while the three smaller size school classes use the Lecture Method most. This usage may be related to time considerations--the smaller schools having less time in class, believe they can cover more material by lecturing. Time given to Drill was somewhat less in the largest schools than the others. This may well have resulted in the belief, that if additional time was given to questioning and explanation, less time would be required in drill.

TABLE XIII

METHODS USED IN TEACHING MATHEMATICS
BY SIZE OF SCHOOL

	SCHOOL SIZE							
	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or More Teachers	
	Index*	Rank	Index	Rank	Index	Rank	Index	Rank
1. Lecture Method	1.97	1	1.85	1	1.83	1	1.88	2
2. Heuristic Method	1.74	2	1.68	2.5	1.71	2	1.96	1
3. Drill	1.62	3	1.68	2.5	1.59	3	1.44	3
4. Laboratory Method	1.11	4	1.09	4	1.09	4	1.08	4

* See Text for an explanation - p. 71.

Some additional information is given in Table XIV--number of schools that reported time for each method and the Index and rank for "all schools." It was noted that of the four methods, fewest schools checked the "Less than 25 per cent" section under "Lecture Method," and most checked this section under "Laboratory Method." This is a good indication of the relative employment of these methods. Only two schools appeared to be rather extreme--one reported over 75 per cent of the time given to lecturing, and one other reported the same time devoted to the Heuristic Method. About one-half of the schools reported that they employ the Lecture Method, Heuristic Method and Drill, from 25 per cent to 50 per cent of the time.

Comparison of Lecture and Heuristic Methods

In comparing the Lecture and Heuristic Methods of teaching, an attempt was made to discover desirable features of each, undesirable features of each and then to find some reasons why teachers considered these features desirable or undesirable. In each instance, space was left for "others." A summary of the way teachers answered these four categories of questions for these two methods is given in Table XV.

Lecture Method. The most commonly reported strong feature of this was that it, "gives teachers an opportunity to deal with anticipated difficulties." This was indicated by a total of 118 schools. The feature checked least in this same area was that it was "valuable training to students in note taking and assimilation"--reported by 19 schools. Ninety-one schools reported that they could cover a greater scope of material by this method.

TABLE XIV

TIME GIVEN TO SOME
METHODS USED IN TEACHING MATHEMATICS

	All Schools		
	Number Schools Reporting	Index	Rank
LECTURE METHOD:		1.88	1
1. Less than 25%	47		
2. 25% - 50%	76		
3. 50% - 75%	27		
4. Over 75%	1		
Total	151		
HEURISTIC METHOD:		1.75	2
1. Less than 25%	57		
2. 25% - 50%	75		
3. 50% - 75%	17		
4. Over 75	1		
Total	150		
DRILL:		1.61	3
1. Less than 25%	69		
2. 25% - 50%	68		
3. 50% - 75%	11		
4. Over 75%	0		
Total	148		
LABORATORY METHOD:		1.09	4
1. Less than 25%	135		
2. 25% - 50%	10		
3. 50% - 75%	2		
4. Over 75%	0		
Total	147		

Some teachers made other suggestions of desirable features. Some examples are : (1) "There is too little material in text, so by lecturing I add other items." (2) "You give them (the students) your experience in mathematics." (3) "The lecture allows you to sell mathematics. You can thus create interest." (4) "It confines the lesson to the material at hand."

Teachers said there were undesirable features too. Ninety-six schools said, "Students allow statements to go unchallenged." This appeared to be considered a very great weakness in lecturing to high school students. The next weakness was that it allowed no immediate opportunity to clear up difficulties. In regard to "why" this method was weak, 59 schools indicated, "They have found it less effective as a basis of student learning."

There were other suggested items of weakness in the lecture: (1) "There is danger of rote learning without understanding." (2) "It (the lecture) stifles student initiative." (3) "It simply calls for too little exertion on the part of the student." (4) "Too many students fail to supplement the lecture with later application."

Heuristic Method. There were 379 responses checked under "desirable features." This appeared to be a most favorable reaction to this method. The response of most common occurrences was: "(It) brings students into active participation." In second place, 86 of the schools, indicated the feature: "It motivates by putting the student into the role of an investigator." These two features rated first and second place respectively in each school size class and in "total schools." In

TABLE XV

NUMBERS OF SCHOOLS REPORTING CERTAIN STRENGTHS AND WEAKNESSES OF THE LECTURE AND HEURISTIC METHODS IN TEACHING MATHEMATICS, BY SIZE OF SCHOOL

LECTURE METHOD	SIZE OF SCHOOL 1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS	TOTAL NO.	TOTAL PERCENT
NUMBER OF SCHOOL RESPONDING	35	68	23	27	153	
A. INDICATE FEATURES FOUND DESIRABLE:						
1. COVERS GREATER SCOPE OF MATERIAL	60%*	53%	61%	74%	91	59%
2. VALUABLE TRAINING TO STUDENTS IN NOTE TAKING AND ASSIMILATION	8	16	4	15	19	12
3. MAKES POSSIBLE THE INTRODUCTION OF ANECDOTES AND OTHER RELATED MATERIALS	31	31	52	26	51	33
4. GIVES TEACHERS AN OPPORTUNITY TO DEAL WITH ANTICIPATED DIFFICULTIES	83	76	78	67	118	77
5. OTHERS	3	16	0	15	16	10
					295	
B. INDICATE WHY YOU LIKE CERTAIN FEATURES OF LECTURE METHODS:						
1. BY OBSERVATION I HAVE SENSED STUDENT INTEREST	28	51	43	41	75	49
2. BY TESTING I HAVE NOTED STUDENT PROGRESS	51	51	47	55	79	52
3. OTHERS	14	22	22	19	30	19
					184	
C. INDICATE FEATURES FOUND UNDERSIRABLE:						
1. SECONDARY SCHOOL STUDENTS ARE SELDOM ABLE TO ASSIMILATE MATERIALS BY LECTURE	9	16	13	22	23	15
2. LECTURES DO NOT ALLOW AN IMMEDIATE OPPORTUNITY TO CLEAR UP DIFFICULTIES	43	57	26	41	71	46
3. STUDENTS ALLOW STATEMENTS TO GO UNCHALLENGED	66	62	70	56	96	63
4. OTHERS	3	15	9	7	15	9
					205	
D. INDICATE WHY YOU DO NOT LIKE THIS METHOD:						
1. I HAVE FOUND IT LESS EFFECTIVE AS A BASIS OF STUDENT LEARNING	34	44	30	37	59	39
2. HAVE FOUND IT DIFFICULT TO MAINTAIN STUDENT INTEREST	23	28	13	30	38	25
3. OTHERS	23	15	9	22	26	17
					123	

*THE NUMBER OF TIMES AN ITEM WAS CHECKED WAS COMPARED TO THE NUMBER OF SCHOOLS, TO GET THE PERCENTAGE.

TABLE XV (CONTINUED)

HEURISTIC METHOD	SIZE OF SCHOOL 1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS	TOTAL NO.	TOTAL PERCENT
A. INDICATE FEATURES FOUND DESIRABLE:						
1. BRINGS STUDENTS INTO ACTIVE PARTICIPATION	89%	78%	83%	81%	125	82%
2. MOTIVES, BY PUTTING THE STUDENT INTO THE ROLE OF AN INVESTIGATOR	60	51	61	59	86	56
3. GUIDES STUDENTS TOWARDS DISCOVERIES	60	50	43	70	84	55
4. GIVES TEACHERS AN OPPORTUNITY TO EMPHASIZE KEY POINTS	46	57	26	70	80	52
5. OTHERS	0	3	4	4	4	3
					379	
B. INDICATE WHY YOU LIKE CERTAIN FEATURES OF THIS METHOD:						
1. TESTS SHOW THAT IT IS EFFECTIVE FOR SOME TYPES OF WORK	40	31	31	44	54	35
2. AWAKENS IN THE STUDENT, THE SPIRIT OF SEEKING ANSWERS	66	72	78	73	109	71
3. STUDENTS DO IT THEMSELVES	40	51	78	41	68	44
4. OTHERS	6	7	0	4	8	5
					239	
C. INDICATE FEATURES YOU HAVE FOUND UNDESIRABLE:						
1. IT IS TOO TIME CONSUMING	57	41	61	44	74	48
2. IF NOT SKILLFULLY HANDLED, IT DEGENERATES INTO "YES" AND "NO" ANSWERS WITH LITTLE THOUGHT	49	51	61	55	81	53
3. IN UNSKILLED HANDS THE DISCUSSION BECOMES RANDOM	17	26	43	41	45	29
4. DANGER OF QUESTIONING ONLY THE BRIGHTER STUDENTS	66	51	48	59	85	56
5. OTHERS	6	7	4	4	9	6
					294	
D. INDICATE WHY YOU DO NOT LIKE THIS METHOD:						
1. MOST STUDENTS ARE NOT WILLING TO GIVE THE TIME NECESSARY TO DEVELOP SOLUTIONS	28	34	40	30	50	33
2. PUPILS TURN TO BOOKS TO FIND SOLUTIONS	6	3	0	4	5	3
3. BRIGHTER PUPILS DO NOT NEED ALL THE TIME GIVEN	57	60	43	48	84	55
4. OTHERS	3	6	0	4	6	4
					145	

regard to why teachers liked this method, 109 schools checked the item: "(It) awakens in the student the spirit of seeking answers."

There were some pitfalls cited, too. Three weak features were noted in about equal numbers: (1) There is danger of questioning only the brighter students: (2) If not skillfully handled, it degenerates into "yes" and "no" answers with little thought and(3) It is too time consuming.

In regard to why teachers do not like the Heuristic Method, all categories of schools concurred in checking the item most: "Brighter pupils do not need all the time." Several teachers added other reasons, for example: (1) "It allows students to practise errors, if left to discovery for themselves." (2) "In a large class the slower students are neglected."

Summary. Sections"A" and "B" from Table XV may be taken as a measure of favorable reaction in each of these methods. In total there were 479 items checked for the Lecture and 618 items checked for the Heuristic Method. Sections "C" and "D" from the same table indicate a measure of unfavorable reaction for each method. These totals for the Lecture and Heuristic Methods were 328 and 439 respectively. These data indicate, that although mathematics teachers see many strengths in both these methods, they point out many weakmesses, too.

Laboratory Method.

The meaning that has been attached to the "Laboratory Method" is that it is the method involving the development of new understandings and concepts through activities of measuring, constructing, drawing, representing data, handling objects, making models, taking field trips and

possibly other related ideas. Respondents were given this statement in order that all might have a similar basis upon which to make their judgments. Some data have been given--Tables XIII, XIV on pages 73 and 75--relative to the time devoted to different methods. Laboratory activities were noted and given a relative position. Other facets of this method are now considered.

Grade level. Teachers were requested to indicate the grade level at which they believed the laboratory method was most helpful. Over one-half of the schools in each size category reported that they had found these procedures most helpful at the grade nine level. This information is given in Table XVI. Somewhat fewer schools indicated it most helpful at the grade 10 level--22.1 per cent--while about one-sixth of those reporting said it was "about the same" for all grades. The pattern reported in each school size category is about the same as for "all schools," so there appeared to be general unanimity of thinking regarding this.

Activities. A list of items containing some of the usual activities was given and teachers were asked to check those that they found most helpful. Table XVII summarizes these. Measuring activities ranked first, this being reported by 108 schools. Item 4, "drawing to scale" and items 2 and 5, "construction activities--making models, etc.--and "making large graphs" respectively were reported with some regularity. The activity checked least was the "construction of solid models." This may be the result of there being no course in solid geometry on the secondary school program in Alberta. The gathering of data to be used for statistical treatment and the taking of field trips for the purpose of making surveys, maps and indirect measurements, are uncommon activities in Alberta high

TABLE XVI

NUMBERS AND PERCENTAGES OF RESPONSES IN RESPECT TO GRADE LEVEL WHERE LABORATORY METHOD MOST HELPFUL

	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		Over 11 Teachers		All Schools	
Responses	No.	P. Cent	No.	P. Cent	No.	P. Cent	No.	P. Cent	No.	P.Cent
Indicate the grade level you believe this method to be most helpful										
1. Grade 9	27	61.4%	41	52.6%	13	56.6%	18	66.7%	99	57.5%
2. Grade 10	12	27.3	16	20.5	5	21.7	5	18.5	38	22.1
3. Grade 11	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4. Grade 12	0	0.0	4	5.1	0	0.0	1	3.7	5	2.9
5. About the same	5	11.3	17	21.8	5	21.7	3	11.1	30	17.5
Total	44	100.0%	78	100.0%	23	100.0%	27	100.0%	172	100.0%

TABLE XVII

NUMBERS OF LABORATORY ACTIVITIES REPORTED IN MATHEMATICS

	School Size, by Teachers				
	1 - 3 Teachers	4 - 6 Teachers	7 - 10 Teachers	Over 11 Teachers	Total
INDICATE THOSE OF THE FOLLOWING ACTIVITIES FOUND MOST USEFUL.					
1. Measuring activities (length, wt. temp. angles, etc.)	29	50	12	17	108
2. Construction activities (making models, e.g., Pythagoras' Theorem)	11	32	7	12	62
3. Construction of solid models. . .	3	4	1	1	9
4. Drawing to scale.	19	39	15	13	86
5. Making large graphs	14	26	9	11	60
6. Field trips (surveys, maps, indirect measurement)	4	10	2	3	19
7. Gathering data (to treat statistically)	2	13	2	5	22
8. Others	2	2	2	1	7
Total	84	176	50	63	373
Schools responding	35	68	23	27	150
Index of Activity*	2.4	2.6	2.2	2.3	2.5

*Total items checked ÷ No. of Schools

schools.

There was no significant difference in the activities among the various school size classes. A simple index found by dividing the total numbered activities by the number of schools, was computed. For the "one to three teacher schools," the "four to six," the "seven to ten," the "over eleven," and "all schools," these indexes were 2.4, 2.6, 2.2, 2.3 and 2.5 respectively.

Strengths and Weaknesses. Some information has been given relating to the findings on mathematics activities. Table XVIII shows the extent of certain strengths and weakness in the practices of the schools sampled and in the thinking of their staffs. There was a strong belief that, "students visualize problems more readily after having had actual laboratory experience." One hundred one of the schools reported this. About the same number--98 schools-- said that, "mathematical concepts become more functional and meaningful when they are seen in relation to actual applications." These were certainly favorable reactions to laboratory teaching.

In opposition to these favorable reactions were indications of inherent weaknesses. "The laboratory method is too time consuming," one hundred four schools reported. And a smaller group--58 schools-- reported that, "it may become aimless manipulation."

Altogether there were recorded 318 responses favorable to the strengths of the laboratory method, and 236 related to certain weaknesses. These findings are weighted in favor of its strengths. Laboratory teaching ranked last of methods in respect to the time given to it, but it appears that these same teachers believe it cannot be completely abandoned.

TABLE XVIII

NUMBERS OF TEACHERS REPORTING CERTAIN STRENGTHS AND WEAKNESSES
OF THE LABORATORY METHOD OF TEACHING MATHEMATICS
BY SIZE OF SCHOOL

LABORATORY METHOD	SIZE OF SCHOOL				
	1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS	TOTAL
A. INDICATE WHAT HAS LED YOU TO BELIEVE THAT THE LABORATORY METHOD LEADS TO BETTER UNDERSTANDING. CHECK THOSE THAT APPLY:					
1. HAVE NOTED THAT STUDENTS, AFTER HAVING WORKED ON MODELS, GRAPHS, ETC., EXPLAIN THEM READILY TO THEIR PEERS	8	17	2	4	31
2. STUDENTS VISUALIZE CERTAIN PROBLEMS MORE READILY AFTER HAVING HAD ACTUAL LABORATORY EXPERIENCES	26	43	15	17	101
3. TEACHER CAN "PUT OVER" CERTAIN IDEAS BETTER BY DEMONSTRATION IN THE LABORATORY	16	48	15	9	88
4. MATHEMATICAL CONCEPTS BECOME MORE FUNCTIONAL AND MEANINGFUL WHEN THEY ARE SEEN IN RELATION TO ACTUAL APPLICATIONS	23	46	13	16	98
TOTAL	73	154	45	46	318
B. INDICATE WEAKNESSES THAT YOU HAVE FOUND WITH THE LABORATORY METHOD. CHECK THOSE THAT APPLY:					
1. THE LABORATORY METHOD IS TOO TIME CONSUMING	23	47	16	18	104
2. STUDENTS RELY TOO STRONGLY ON SEEING OR MEASURING	4	13	7	4	28
3. IT MAY BECOME AIMLESS MANIPULATION	13	29	5	11	58
4. IN HIGH SCHOOL MATHEMATICS, LABORATORY WORK DOES LITTLE TO DEVELOP AND CLARIFY MATHEMATICAL INTER-RELATIONSHIPS ITSELF	11	20	8	7	46
TOTAL	51	109	36	40	236

From these results it seems to be a fair conclusion that teachers have adopted a somewhat cautious attitude.

Drill in Mathematics

Drill must be recognized as an essential means of attaining some of the desired outcomes of mathematics. Many mathematical operations need to be performed correctly and with some speed if they are to be useful. The acquisition of facility in such operations can only be secured through repeated practice. On this basis, "drill" is a means of achieving desired outcomes.

Grade level. Table XIX shows the grade level at which teachers have found drill to be most useful. Each size class of schools and total schools reported drill to be most helpful at the grade nine level. Just 30 per cent of "total schools" reported thus. A somewhat greater number--41.8 per cent--said that drill was "about the same" for all grades of the secondary school. Somewhat lesser numbers said that "drill" was most effective in grade 10, or grade 11 or grade 12. The evidence here only indicates a tendency to say it is most effective at the lowest grade level, but the percentage of teachers reporting this does not seem large enough to get a conclusive opinion of this.

Several teachers reported this in respect to drill: "The grade level isn't as important as the topic." Since, as it was noted above, about 40 per cent of the schools reported that drill was equally applicable to all of the secondary school grades, it is logical to take a closer look at the question of drill in mathematics. To do this a series of twenty teaching topics were given to the questionnaire respondents and they were asked to indicate the degree of stress they placed on "drill"

TABLE XIX

NUMBERS AND PERCENTAGES OF SCHOOLS REPORTING ON DRILL IN MATHEMATICS

	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		Over 11 Teachers		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Indicate grade level in which you have found "drill" most useful:										
1. Grade 9	12	33.3%	24	32.0%	6	24.0%	7	41.2%	49	30.0%
2. Grade 10	3	8.3	14	18.8	3	12.0%	4	23.5%	24	14.7
3. Grade 11	3	8.3	5	6.5	4	16.0	1	5.9	13	7.9
4. Grade 12	2	5.6	2	2.7	3	12.0	2	11.8	9	5.6
5. About the same	16	44.5	30	40.0	9	36.0	13	17.6	68	41.8
Total	36	100.0%	75	100.0%	25	100.0%	27	100.0%	163	100.0%

for each of these topics.

Computation of the index. For each of the teaching topics given in Table XX, the respondents were asked to check them under LITTLE, SOME, or MUCH, relative to amount of drill they did on each. A response of LITTLE was given a weight of one, a response of SOME was given a weight of two, and a response of MUCH was given three. The index for each item was obtained by multiplying the total LITTLE responses by one, the SOME responses by two and the MUCH responses by three, adding the three figures and dividing by the total responses to the item. This index figure then is a relative value of the extent of drill on each topic. With the imposition of these conditions, the range of the index is from one to three.

Importance of drill on twenty selected topics in Mathematics. Table XX lists these items ranked according to the indexes computed for "all schools." The topic requiring most drill was, "operations with signed members." The index computed for this topic was 2.91. which indicates that almost all schools checked MUCH for this item. The teaching of signed numbers is presently introduced in grade nine, in the Alberta program. The factoring of algebraic expressions ranked second, with an index of 2.72. This topic is formally introduced in grade 10. One topic which is introduced in grade 12--computation by logarithms--ranked fifth on the basis of "drill" needed, while the topic on geometric constructions ranked twentieth and is introduced at the grade nine level. It appears, from an examination of these topics, drill may be somewhat more dependent on the topic than on the grade level.

TABLE XX

IMPORTANCE OF DRILL, ON A SELECTED LIST
OF TWENTY TOPICS FROM SECONDARY MATHEMATICS

	All Schools	
	Index	Rank
Indicate how important you have found drill to be:		
1. Operations with signed numbers	2.91	1
2. Factoring	2.72	2
3. Fundamental operations on algebraic fractions	2.51	3
4. Solving quadratic equations by formula	2.43	4
5. Computation of logarithms	2.42	5
6. Solutions of equations	2.40	6.5
7. Solutions of systems of equations	2.40	6.5
8. Grouping like terms	2.38	8
9. Operations in radicals	2.35	9
10. Solutions in linear equations	2.32	10
11. Problems in expansion of Binomial Theorem	2.30	11
12. Extracting square roots	2.28	12
13. Memorizing area and volume formulas	2.26	13
14. Graphing of quadratic functions	2.25	14
15. Finding the L.C.M. - H.C.F.	2.23	15
16. Finding areas of surfaces.	2.21	16
17. Graphing of linear functions	2.18	17
18. Solving equations by graphical methods	1.96	18
19. Learning propositions in geometry	1.91	19
20. Making geometric constructions	1.85	20

In order to get a more detailed picture of this facet of method, a more comprehensive tabulation was made, giving the indexes for the twenty teaching topics, in each school size category. Table XXI gives this information. The topics were arranged on the basis of rank for "all schools." Then for each of the school size classes the number indicating its rank was fitted in wherever it fell. In looking at this table, one gets some indication of the agreement of thinking in these different school size categories.

The first two items, "operations with signed numbers" and "factoring" ranked first and second in all school size classes. There were some discrepancies. The topic, "fundamental operations on algebraic fractions" ranked third in the two smallest school categories, and for "all schools," but it ranked fourth in the seven to ten teacher class and, ninth in the "over 11 teachers" class. For the topic, "finding the areas of surfaces," the rank was eighth in the "four to six teacher" class, but it was 15 or more for the other categories. These facts simply point out that there was not complete agreement of thinking.

However, some general agreement does appear. The five topics which ranked sixteenth to twentieth for "all schools," also ranked near the bottom in each other size category. The correlation, by the rank-difference method, of these data between the "one to three teacher" schools and the "four to six teacher" schools was found to be 0.715. Between the "four to six teacher" schools and the "11 or more teacher" schools, it was 0.752. This gives some indication of general agreement of thinking.

Evaluation in Mathematics

The evaluation of achievement in mathematics is important because

TABLE XXI

IMPORTANCE OF DRILL, ON A SELECTED LIST OF TOPICS IN SECONDARY SCHOOL MATHEMATICS, BY SIZE OF SCHOOL

	ALL SCHOOLS		1 - 3 TEACHERS		4 - 6 TEACHERS		7 - 10 TEACHERS		11 OR MORE TEACHERS	
	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK	INDEX	RANK
HERE IS A LIST OF 20 TOPICS COVERED IN SECONDARY MATHEMATICS. WILL YOU INDICATE IN EACH HOW IMPORTANT YOU HAVE FOUND DRILL TO BE. PLEASE CHECK THIS:										
1. OPERATIONS WITH SIGNED NUMBERS	2.91	1	2.81	1	2.94	1	2.78	1	2.88	1.5
2. FACTORING	2.72	2	2.74	2	2.69	2	2.59	2	2.88	1.5
3. FUNDAMENTAL OPERATIONS ON ALGEBRAIC FRACTIONS	2.51	3	2.51	3	2.57	3	2.57	4	2.33	9
4. SOLVING QUADRATIC EQUATIONS BY FORMULA	2.43	4	2.29	8	2.49	5	2.32	11	2.24	14
5. COMPUTATION BY LOGARITHMS	2.42	5	2.23	11	2.51	4	2.58	3	2.32	11
6. SOLUTIONS OF EQUATIONS	2.40	6.5	2.48	4	2.48	6	2.43	7	2.48	4.5
7. SOLUTIONS OF SYSTEMS OF EQUATIONS	2.40	6.5	2.25	10	2.33	14	2.54	5	2.67	3
8. GROUPING LIKE TERMS	2.38	8	2.39	5	2.38	10.5	2.36	8.5	2.35	8
9. OPERATIONS IN RADICALS	2.35	9	2.31	6.5	2.38	10.5	2.33	10	2.32	11
10. SOLUTIONS IN LINEAR EQUATIONS	2.32	10	2.18	12	2.29	15.5	2.48	6	2.43	6
11. PROBLEM IN EXPANSION OF BINOMIAL THEOREM	2.30	11	2.03	13.5	2.41	8	2.15	15	2.48	4.5
12. EXTRACTING SQUARE ROOTS	2.28	12	2.31	6.5	2.29	15.5	2.14	16	2.37	7
13. MEMORIZING AREA AND VOLUME FORMULAS	2.26	13	2.27	9	2.41	8	2.18	14	2.08	17
14. GRAPHING OF QUADRATIC FUNCTIONS	2.25	14	1.97	17	2.37	12	2.25	13	2.32	11
15. FINDING THE L. C. M. - H. C. F.	2.23	15	1.97	17	2.35	13	2.30	12	2.19	15
16. FINDING AREAS OF SURFACES	2.21	16	2.00	15	2.41	8	2.00	18	2.09	16
17. GRAPHING OF LINEAR FUNCTIONS	2.18	17	1.97	17	2.20	17	2.36	8.5	2.28	13
18. SOLVING EQUATIONS BY GRAPHICAL METHODS	1.96	18	1.87	19	1.97	19.5	2.05	17	2.00	18
19. LEARNING PROPOSITIONS IN GEOMETRY	1.91	19	2.03	13.5	1.97	19.5	1.78	19	1.69	20
20. MAKING GEOMETRIC CONSTRUCTIONS	1.85	20	1.84	20	2.03	18	1.52	20	1.87	19

it plays many roles. It should indicate something of the day to day progress of the pupil--his mastery or lack of mastery of certain ideas and concepts. Evaluation is a means of determining something of the effectiveness of methods of instruction. It may be the means of finding the slow and rapid learners and thus modify the methods of teaching such students. In this study an attempt was made to find some of the means of evaluation and to find the degree of importance attached to each. A second attempt was made to search out some of the purposes of evaluation.

Student performance. A list of ten evaluative items was given and teachers were asked to indicate a percentage (10 per cent, 20 per cent....more than 50 per cent) value which they attached to each, in making a final assessment of a student's work. Table XXII gave a summary of the reporting of the various schools. This table gives a classification of the data according to the school-size categories, by numbers of schools that checked each item.

There is general agreement among all school-size categories. The final examination is the most significant means of evaluating student performances in mathematics in Alberta. In the schools of one to three teachers, 22 of the 23 that reported, gave 50 per cent or more weight to it; in four to six teacher schools, 45 out of 66 gave over 50 per cent weight to it; for the seven to ten teachers schools, it was 15 out of 23 and for schools of 11 or more teachers, it was 15 out of 27. In total there were 97 of 149 schools that gave a 50 per cent or more weight to the final examination in evaluating student performance.

The term examinations ranked next in importance. About one-half

TABLE XXII

NUMBERS OF SCHOOLS GIVING A PERCENTAGE RATING TO SOME ASPECTS OF EVALUATION OF STUDENT PERFORMANCE

Evaluation	Schools - 1 - 3 Teachers						
	10% or less	20%	30%	40%	50%	Over 50%	Totals
1. Final examination	0	2	2	7	18	4	33
2. Term examination (Christmas and/or Easter and possibly others)	4	12	11	3	2	0	32
3. Short, teacher-made tests	19	10	2	0	0	0	31
4. Commercially prepared tests	8	0	0	0	0	0	8
5. Marks for notebooks	15	0	0	0	0	0	15
6. Marks for projects or other selected pieces of work	10	0	0	0	0	0	10
7. Pupils' daily class preparation . .	14	2	0	0	0	0	16
8. Pupils' class participation	14	1	0	0	0	0	15
9. Teachers' judgment	13	2	0	0	0	0	15
10. Others (Write in)	2	0	0	0	0	0	2

TABLE XXII (continued)

Evaluation	Schools 4 - 6 Teachers						
	10% or less	20%	30%	40%	50%	Over 50%	Totals
1. Final examination	1	4	1	15	36	9	66
2. Term examination (Christmas and/or Easter and possibly others	6	26	14	6	7	1	60
3. Short, teacher-made tests	24	10	2	3	1	0	40
4. Commercially prepared tests	12	1	0	1	0	0	14
5. Marks for notebooks . . .	25	3	0	0	0	0	28
6. Marks for projects or other selected pieces of work	22	0	0	0	0	0	22
7. Pupils' daily class preparation	25	3	1	0	0	0	29
8. Pupils' class participation	24	3	0	0	0	0	27
9. Teachers' judgment . . .	23	2	0	0	0	0	24
10. Others	2	0	0	0	0	0	2

TABLE XXII (continued)

Evaluation	Schools 7 - 10 Teachers						
	10% or less	20%	30%	40%	50%	Over 50%	Totals
1. Final examination	0	1	1	6	13	2	23
2. Term examination (Christmas and/or Easter and possibly others.)	0	3	5	10	4	1	23
3. Short, teacher-made tests.	10	4	1	0	1	0	16
4. Commercially prepared tests	5	0	0	0	0	0	5
5. Marks for notebooks	10	0	0	0	0	0	10
6. Marks for projects or other selected pieces of work	8	0	0	0	0	0	8
7. Pupils' daily class preparation	9	0	0	0	0	0	9
8. Pupils' class participation.	11	0	0	0	0	0	11
9. Teachers' judgment	8	0	0	0	0	0	8
10. Others	1	0	0	0	0	0	1

TABLE XXII (continued)

Evaluation	Schools 11 or over Teachers						
	10% or less	20%	30%	40%	50%	Over 50%	Total
1. Final examination	0	3	7	2	10	5	27
2. Term examination (Christmas and/or Easter and possibly others)	3	9	4	4	2	2	24
3. Short, teacher-made tests . .	9	1	2	5	2	0	19
4. Commercially prepared tests .	5	1	1	0	0	0	7
5. Marks for notebooks	11	1	0	0	0	0	12
6. Marks for projects or other selected areas of work . . .	10	0	0	0	0	0	10
7. Pupils' daily class preparation	10	1	0	0	0	0	11
8. Pupils' class participation .	10	2	0	0	0	0	12
9. Teachers' judgment	8	2	1	0	0	0	11
10. Others	0	0	0	0	0	0	0

TABLE XXII (continued)

Evaluation	All Schools						
	10% or less	20%	30%	40%	50%	Over 50%	Totals
1. Final examination	1	10	11	30	77	20	149
2. Term examination (Christmas and/or Easter and possibly others)	13	50	34	23	15	4	139
3. Short, teacher-made tests . . .	62	25	7	8	4	0	106
4. Commercially prepared tests . .	30	2	1	1	0	0	34
5. Marks for notebooks	61	4	0	0	0	0	65
6. Marks for projects or other selected pieces of work	50	0	1	0	0	0	51
7. Pupils' daily class preparation	58	6	1	0	0	0	65
8. Pupils' class participation . .	59	6	0	0	0	0	65
9. Teachers' judgment	52	6	1	0	0	0	59
10. Others	5	0	0	0	0	0	5

of each school size category gave 30 per cent or more weight to these rather comprehensive tests. In "all schools," 76 out of 139 reported thus on this item, while 50 schools weighted these examinations at 20 per cent of total.

The other eight evaluative items were given much smaller weight. The "short, teacher-made tests" were given 10 per cent or less weight by about one-half of the schools. Four of the schools said that these short tests determined 50 per cent or more of the value of a final assessment. This is only a small percentage of the schools. Commercially prepared tests were not reported as being used to any significant extent. Only 34 schools indicated any use and, of these, 30 placed a 10 per cent or less weight to them.

Some other items such as marks for notebooks, or projects or special pieces of work were almost all weighted at 10 per cent or less. A few schools gave these items 20 per cent or 30 per cent weight, but they represented only a small fraction of them. The "pupils daily class preparation" and "daily class participation" were not valued very heavily. The "teachers' judgment" apparently does not play a significant part. Fifty-two teachers said they weighted this means of evaluation at 10 per cent or less. A few teachers said: "The teacher's judgment is significant when other information is inconclusive."

It was noted above that there was general agreement among all size categories--the first two items weighted heavily and the last eight items rather lightly. There was noted a tendency for the largest schools not to weight the final examination as heavily as the smaller schools--just over 50 per cent of the largest schools gave 50 per cent or more

weight to it, while about two-thirds of the other schools gave this weight to it.

Purposes of evaluation. The respondents were asked to indicate the degree of importance which they attached to each of ten "purposes of evaluation." This was done by checking each purpose under SOME, LITTLE, or MUCH. An Index for each of these items was computed in the same manner as that on page 87. These ten items were then re-arranged by rank order and presented in two tables: Table XXIII for "all schools," and Table XXIV for each school size class.

With an index of 2.63 and ranking first among these purposes of evaluation was the item, "To serve as a basis for 'passing' or 'failing' a student." Since only six schools of the 143 responding to this item, checked this purpose, under LITTLE, it may be concluded that Alberta mathematics teachers believe this to be a significant purpose. In rank two was the statement, "To determine the strengths and weaknesses of students or of a class as a whole," while the purpose which ranked third was, "To provide a basis for reporting to parents." In the ninth place is the purpose, "To measure the ability of students to apply mathematical reasoning to non-mathematical situations." And finally the purpose of evaluation, which Alberta teachers think is least significant is the one, "To provide a basis for the appraisal of teachers."

All of the categories in Table XXIV concurred in granting the item, "To serve as a basis of 'passing' or 'failing' a student," rank one. All agreed in granting the item, "To provide a basis for the appraisal of teachers," rank ten, except one school size class and those teachers placed it in rank nine. There was a general concurrence in ranking all

TABLE XXIII

THE IMPORTANCE THAT MATHEMATICS' TEACHERS ATTACH TO THE PURPOSES OF EVALUATION, FOR ALL SCHOOLS

		All Schools	
		Index	Rank
1.	To serve as a basis for "passing" or "failing" a student	2.63	1
2.	To determine the strengths or weaknesses of students or of a class as a whole	2.61	2
3.	To provide a basis for reporting to parents	2.69	3
4.	To stimulate the improvement of teaching	2.23	4
5.	To maintain standards	2.19	5
6.	To provide an incentive to study	2.17	6
7.	To furnish data for educational guidance	2.06	7
8.	To assist in grouping of students	1.72	8
9.	To measure the ability of students to apply mathematical reasoning to non-mathematical situations	1.69	9
10.	To provide a basis for the appraisal of teachers	1.50	10

TABLE XXIV

A MEASURE OF THE IMPORTANCE MATHEMATICS TEACHERS ATTACH TO PURPOSES OF EVALUATION, BY SCHOOL SIZE

	School Size							
	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		11 or more Teachers	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
1. To serve as a basis for "passing" or "failing" a student	2.38	1	2.66	1	2.78	1.5	2.72	1
2. To determine the strengths or weaknesses of students or of a class as a whole	2.26	2	2.59	2	2.78	1.5	2.68	2
3. To provide a basis for reporting to parents	2.16	4	2.23	3	2.45	3	2.52	3
4. To stimulate the improvement of teaching	2.17	5	2.22	4	2.21	4	2.25	5
5. To maintain standards	2.13	6	2.20	5	2.14	5	2.30	4
6. To provide an incentive to study	2.09	7	2.18	6	1.96	7	2.24	6
7. To furnish data for educational guidance	2.19	3	1.95	7	2.10	6	2.08	7
8. To assist in grouping of students	1.58	9	1.74	8	1.82	8	1.82	8
9. To measure the ability of students to apply mathematical reasoning to non-mathematical situations	1.87	8	1.69	9	1.35	10	1.77	9
10. To provide a basis for the appraisal of teachers	1.52	10	1.44	10	1.71	9	1.50	10

items, with a few exceptions. The ranking was done from data from "all schools," but it was identical in the four to six teacher schools, and almost so in the seven to ten teacher schools, and the 11 or more teacher schools. No detailed statistical analysis could be made, but the pattern of thinking appears to be quite uniform.

Teaching For Transfer

An assessment on the teaching of mathematics could hardly ignore some inquiry about "transfer of training" or "teaching for transfer." Many claims have been made respecting the disciplinary values of mathematics that are unwarranted. Many claims have been made for "no transfer," too. Both have been made from limited observations and insufficient data.

Theory and practice. It was the purpose of this part of the study (1) to find out how significant mathematics' teachers believed transfer of training to be (from their readings and discussions); and (2) to find out how significant transfer of training appeared to be in actual practice. Two explicit questions were directed to the respondents and they were asked to indicate their beliefs and findings by checking, LITTLE, SOME, or MUCH to each. An index was computed, similarly to that on page 71. The data are given in Table XXV, for "all schools" and for each size class.

The indexes for item 1, "from readings and discussions of transfer of training, indicate how significant you believe proper instruction in mathematics can contribute to this goal," are all respectively higher than those for item 2, "from experience and observations in teaching mathematics, indicate the importance you place on transfer in actual practice."

TABLE XXV

DIFFERENCES BETWEEN THEORY AND PRACTICE IN RESPECT TO TEACHING FOR TRANSFER, IN MATHEMATICS BY SIZE OF SCHOOL

	School Size									
	1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		Over 11 Teachers		Total	
	Index	Rate	Index	Rate	Index	Rate	Index	Rate	Index	Rate
1. From your readings and discussions of transfer of training, indicate how significant you believe proper instruction in mathematics can contribute to this goal. Check one.	2.32	1	2.15	1	1.91	1	2.00	1	2.13	1
2. From your experience and observations in teaching mathematics, indicate the importance you place on transfer of training in actual practice. Check one.	1.82	2	1.93	2	1.73	2	1.91	2	1.94	2

In theory then, transfer of training in mathematics seems somewhat greater than it was found to be in actual practice. For "all schools," these indexes were 2.13 and 1.94 respectively. Since the range of the index computed under these restrictionss, is one to three, there appears to be a genuine belief that transfer of training is an actuality. There was a measure of caution exercised in that the indexes would both have been much nearer the "one." Regarding the two indexes given above, the indication appears to be that Alberta teachers exercise somewhat greater caution regarding transfer than they seem to gather from the literature on the subject.

Some teaching techniques for transfer. To find out how teachers try to present the materials of mathematics, so that pupils may transfer these learnings, a list of six techniques was given to the respondents with a request that they indicate those that they used. An opportunity was given them to write in "others." These itens were ranked as they were checked for "all schools" and are given in Table XXVI. Items one, two and three appear in the first three ranks for all school size categories. The most commonly checked technique was, "teacher points out general applications of fundamental mathematical operations." This was done by 122 of the schools. The item checked least was, "mathematics and science teachers confer and pose this question: 'How can we facilitate transfer?'"

These results indicate an awareness of this problem, and an attempt to do something about it. Since there were a total of 454 items checked then each school, on the average, has been using three of these techniques. The fact that few use the technique, item six, leaves something to be desired.

TABLE XXVI

TECHNIQUES USED IN TEACHING MATHEMATICS
SO THAT TRANSFERS MAY OCCUR BY SIZE OF SCHOOL

	School Size									
	All Schools		1 - 3 Teachers		4 - 6 Teachers		7 - 10 Teachers		Over 11 Teachers	
	Number	Rank	Number	Rank	Number	Rank	Number	Rank	Number	Rank
1. Teacher points out general applications of fundamental mathematical operations	122	1	25	1	54	1	19	1	24	1
2. Teacher points relationships of preceding and subsequent parts in order to build up whole picture	109	2	22	3	52	2	17	2	18	3
3. Teacher indicates the wide applications which certain generalizations have, e.g. Pythagorean Theorem, angle-sum relationship, and Sine Law...	102	3	23	2	41	3	16	3	22	2
4. Teacher simply points out to students to be on the lookout for similarities between new situations and familiar ones--habitually searching for elements or relationships	48	4	9	5	22	4	5	4.5	12	4
5. Teacher and students bring wide variety of materials to the classroom (e.g. graphs from newspapers) to see practical applications	42	5	15	4	16	5	5	4.5	6	6
6. Mathematics and Science teachers confer and pose this question: "How can we facilitate transfer?"	25	6	6	6	9	6	3	6	7	5
7. Others (write in)	6	7	1	7	3	7	1	7	1	7

IV. THE MATHEMATICS LIBRARY, TEACHING FACILITIES AND EQUIPMENT

What is the current status of the mathematics library? How adequate are the materials and equipment? Are the secondary schools of Alberta developing regular mathematics laboratories? Two recommendations related to these problems have been made by the Royal Commission on Education: (1) "That models and other aids to the teaching of mathematics be used more extensively in classrooms;" (2) "that efforts be made to develop the mathematics laboratory in all schools of adequate enrollment."[3] Some investigation of these problems seemed timely.

Mathematics books available. This section of the report was designed to find out something of the numbers of mathematics books available in the high school libraries. Many and varied books on mathematics, of interest to both pupils and teachers, are available. Several of these lists are available.[4] A restricted list of books was compiled and respondents were asked to indicate those that they had available in their libraries. In making the list, standard texts were not included, and only a few professional books were listed. Four main classes were listed: (1) History and Biography; (2) Recreational and Popular Accounts of Mathematics; (3) Surveys and those of a general nature; and (4)

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[3] Report of the Royal Commission on Education in Alberta, 1959. (Edmonton: The Queen's Printer, 1959), p. 110.

[4] Schaaf, William L., "The High School Mathematics Library." Reprint from The Mathematics Teacher, Vol. XLVII, Nos. 2 and 3. February and March, 1954.

Mathematics in the Trades and Professions. Teachers were invited to list others and spaces were left for them to do so.

Table XXVII lists the numbers of books in each of the categories mentioned, by school size. The total number of books indicated was 436. This number is indeed small, since it represents an average of about three books per school. If allowance is made for the person who did not bother to check his books, the numbers are still very small and surveying all the schools, there is a general consistency that few of these books are available.

There is no category in which the schools are well supplied, nor is there any single book widely available. The little booklet, "Why Study Mathematics"[5] was available in 25 schools, while the text: "The Teaching of Secondary School Mathematics,"[6] was available in 21 schools. Some copies of every book listed were available in some of the schools.

Some reasons for such few books may be advanced. First, mathematics has been largely a text book course of a fairly comprehensive nature. As a result teachers probably have concentrated their mathematical activities on the given text. Secondly, there are many small schools, whose book budget has probably gone for "free reading" books, social studies books and others where there seemed to be a greater need. A third reason may be related to the fact that 65.7 per cent of the mathematics teaching force have only two (or fewer) university courses in

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[5]The Canadian Mathematical Congress, Why Study Mathematics, (Montreal: The Cambridge Press).

[6]Butler, C. H. and Wren, F. Lynnwood, The Teaching of Secondary Mathematics, (New York: McGraw Hill Book Co., Inc. 1951).

TABLE XXVII

NUMBERS OF BOOKS IN THE HIGH SCHOOL
MATHEMATICS LIBRARY, BY SIZE OF SCHOOL

	1 - 3 Teachers	4 - 6 Teachers	7 - 10 Teachers	Over 11 Teachers	All Schools
	Numbers				
1. History and Biography	3	19	13	18	53
2. Recreational and Popular Accounts of Mathematics	6	25	16	31	78
3. Surveys and General Accounts	17	136	48	54	255
4. Mathematics in the Trades and Professions	2	20	15	13	50
Totals	28	200	92	116	436
Number of schools	35	68	23	27	153

mathematics.

Some teachers commented on the mathematics library. Quite a number said: "We have some old books, but very few of the new ones." One principal (who was also the mathematics teacher) reported: "I have my own mathematics' library of about fifty books, which are available to all students." Some other teachers simply wrote: "None."

The mathematics room. The modern secondary-school mathematics program, requires that a specially planned room be available, that contains appropriate cupboards, benches, and equipment. To assess the extent to which such facilities are available in Alberta the respondents were asked: "Do you have a special mathematics room (laboratory) in your school? The results appear in Table XXVIII.

One hundred fifty-three schools responded to the questionnaire and 151 of them to this item. Of these, 145 said they had no special mathematics room, and six reported, "Yes." Four schools in the four to six teachers school size reported having such a room and two of the larger schools reported similarly. This number represents about four per cent of the schools, having a distinctly planned and equipped mathematics room.

It may be that there are many schools having rooms with some or most of the equipment desirable for a mathematics room. There may be some rooms re-arranged to accommodate a demonstration desk for setting up certain experimental apparatus. The study did not get this particular information. Some teachers, undoubtedly, improvise and make good use of some materials to do certain laboratory activities. It cannot be concluded, then, that because schools have no special mathematics room,

TABLE XXVIII

NUMBERS OF SCHOOLS HAVING (OR NOT HAVING)
A MATHEMATICS ROOM (LABORATORY)

	School Size				
	1 - 3 Teachers Numbers	4 - 6 Teachers	7 - 10 Teachers	11 or over Teachers	all Schools
1. Do you have a special Mathematics Room (Laboratory) in your School?					
Yes	0	4	0	2	6
No	35	63	23	24	145
Totals	35	67	23	26	151
Schools Responding to Questionnaire	35	68	23	27	153

that no laboratory teaching is done.

Equipment. A list of thirty-four items of equipment and apparatus was given and the respondents were asked to check those that they had available in their schools. This list included: (1) general equipment; (2) chalkboard equipment; (3) instruments; and (4) models. The list was confined to those items that might be most commonly used or that were considered essential. Table XXIX gives a listing of these things and a summary of the items contained in Alberta high schools.

The four items of highest incidence on the list gave the pencil sharpner, meter and yard sticks, wooden compasses and the demonstration protractor. The next three items were the motion picture projector, the duplicator and bulletin boards. The radio appeared in 97 of the schools and ranked tenth on the list. The first four inexpensive items were present in most of the schools. The cost factor is certainly not the sole criterion by which a choice of equipment is made.

If one looks again at these seven items of equipment of highest incidence, it is noted that there is no appreciable difference in the percentages of schools possessing them, in each school size category. Eighty-three per cent of the smallest schools have a motion picture projector and a duplicator, while 85 per cent of the largest schools possess these items. Since these pieces of equipment serve the entire school needs, it may have been that all of the large schools actually had them, but did not list them, if the mathematics department did not actually possess them.

Some pieces of apparatus appeared in few instances. The five items of lowest incidence were the proportional dividers, surveyor's level,

TABLE XXIX

EQUIPMENT

		1 - 3 Teachers	4 - 6 Teachers	7 - 10 Teachers	11 or over Teachers	Total
1.	Pencil Sharpner	33	63	23	25	144
2.	Meter and yard stick	33	63	22	24	142
3.	Wooden compass	33	62	23	23	141
4.	Demonstration protractor	32	61	23	23	139
5.	Motion picture projector	30	59	21	23	133
6.	Duplicator	30	55	21	23	129
7.	Bulletin boards	32	50	20	22	122
8.	Balances and weights	27	54	18	16	115
9.	Triangle 30^{o} - 60^{o}	25	47	17	19	108
10.	Triangle 45^{o} - 90^{o}	19	46	13	19	97
11.	Radio	28	42	16	11	97
12.	Shelves	20	40	15	21	96
13.	Cupboards	19	39	15	19	92
14.	Projection lantern	17	42	17	16	92
15.	Calipers	11	31	11	13	68
16.	T - square, large	12	29	9	15	65
17.	Magazine rack	13	29	11	9	62

TABLE XXIX (continued)

EQUIPMENT

		1 - 3 Teachers	4 - 6 Teachers	7 - 10 Teachers	11 or over Teachers	Total
18.	Liner	16	30	7	8	61
19.	Micrometer screw	9	28	11	12	60
20.	Tape, 50' or 100'	9	22	9	11	51
21.	Models (Ellipsoid, etc.)	8	18	5	10	41
22.	Drawing sets	5	19	3	7	34
23.	Demonstration bench	6	12	2	6	26
24.	Demonstration slide rule, 4'	3	10	4	8	25
25.	Slated globe	6	11	2	5	24
26.	Miscellaneous charts related to mathematics	2	8	4	6	20
27.	Parallel rulers	1	6	5	4	16
28.	Pantograph	5	7	2	2	16
29.	French curves	0	9	1	3	13
30.	Exhibit cases	1	4	1	6	26
31.	Chart case (s)	2	3	3	1	11
32.	Pictures (of mathematicians)	1	3	2	1	7
33.	Surveyor's level	0	0	0	2	2
34.	Proportional dividers	1	1	0	0	2
	Number of schools	35	68	23	27	153

pictures of mathematicians, chart cases and exhibit cases. About one-quarter of the largest schools have exhibit cases. Here, again, the price of the item doesn't appear to be a factor.

There are some unanswered questions in regard to equipment in mathematics rooms. Why is the slated globe present in only five of the large high schools? Why are there only eleven chart cases and twelve exhibit cases in all the schools reporting? Why is it that only one school in six provides a demonstration slide rule? How can one account for the fact that the incidence of equipment is as high in the small schools as the large ones?

Obviously many secondary schools in Alberta are not equipped adequately for an overall program of mathematics instruction. Since the most expensive items are commonly available, it does not appear to be a question of finances. Possibly the answer is that a program calling for a mathematics laboratory and a variety of equipment, has not seemed significant enough to call for some provincial direction.

CHAPTER IV

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Problem Restated

The purpose of this study was to gather data and other related information on the teaching of mathematics in the secondary schools of Alberta, and to make a systematic analysis of these materials. This serves as a means of looking at the methods of teaching and noting certain provisions that are made in the mathematics program. Some of the related literature in recent professional books, periodicals, government publications and the national yearbooks were examined in order to get an overall look at the secondary school program, nationally. A summary of this material was made.

A sample of mathematics teachers and administrators in Alberta high schools were given questionnaires as a means of gathering data in Alberta. These questionnaires inquired into (1) administrative provisions closely related to the teaching of mathematics; (2) methods of presenting, fixing and evaluating the materials of mathematics; and (3) books, equipment and facilities available in the schools.

Mathematics education is a basic part of the program for all high school students in Alberta. For the general program, students are all required to take mathematics in grade nine plus one additional course in grade 10, 11 or 12. Those taking the University Matriculation program must take mathematics in grades nine, ten and eleven. In addition to this, for most faculties, mathematics 30 is required, and for some of the

science and engineering programs, mathematics 31 (Trigonometry) is also required.

Summary and Conclusion

Personnel. Two out of three reporting schools were staffed by six teachers or fewer. These may be classified as small schools. Twelve of the 161 public schools polled, and five of the nine private schools were located in the cities. The student enrollments varied from under 25 pupils to well over 1,500 pupils. Over one-half of the schools had fewer than 100 students and about 80 per cent of them had under 200 students. Three schools reported enrollments greater than 1,000 and six had more than 800 pupils.

One teacher in five had taken four or more university courses in mathematics, which may be considered quite adequate preparation, if these courses were taken in recent years. Somewhat more than one teacher in three had taken no mathematics beyond that in high school.

Class size. Two in three mathematics classes (totals) had twenty-five or fewer students. Thirty schools reported classes of more than 35 students, which was about 4 per cent of the classes. Most of the small classes--especially in the smaller schools--were the result of small enrollments.

Time distribution. About two schools in five gave more than 175 minutes per week instruction time, and nine out of ten gave over 140 minutes per week. About 4 per cent reported giving 105 minutes or less per week of instruction time. Nine classes in twenty required students to give one-half hour or more to home assignments, per class. The remaining 11 out of 20 classes ask somewhat less. Generally this appeared

to be rather heavy.

Enrichment. Some provisions for the gifted were reported, but this study did not get sufficient evidence on this topic. Six schools have established special classes for the gifted. Some additional schools reported other informal provisions such as assigning more questions.

Supervision. The supplying of professional magazines and books were the most commonly reported aspects of supervision. About one-third of the schools did this. In total, one in three schools said that the Principal supervised some classes. The larger schools were much more actively engaged in these activities than were the smaller schools.

Teaching methods. There was no single method of teaching that all mathematics teachers preferred. More time was devoted to the Lecture Method than to any other, but the difference between it and the Heuristic Method was not great. The largest schools generally favored the Heuristic Method but only by a small margin. There was little use being made by laboratory techniques. The reports indicated that in a typical classroom there was lecturing, questioning, drilling, evaluating and developmental teaching.

The study was concerned with determining the situation, as it existed. There is a possibility that the type of method is related to school size, class size, of IQ level of the students, but the evidence here was inconclusive. It is noted also that the results obtained were of a subjective nature--the teachers believed certain things without having a lot of factual evidence to bolster that belief.

Evaluation. Information on two main aspects was sought: student performance and purposes of evaluation. Over 65 per cent of the schools reported that they weighted the final examination at one-half or more as a measure of student progress. Five in six schools said that it determined 40 per cent or more of a student final grade in mathematics. Somewhat less stress was given to term tests, student projects, daily preparation etc. Rather small significance was placed upon the classroom teacher's judgment as an evaluative procedure.

Teachers were generally opposed to evaluation as a means of appraising themselves. Of the ten "purposes of evaluation," this one ranked last for "all schools" and in each size category. There was almost unanimous agreement that the first "purpose of evaluation" was to serve as a basis for "passing" or "failing" a student.

Transfer of training. Alberta teachers said there was a transfer of learning from mathematics to other areas, but this reaction was a cautious one. They believed that somewhat greater significance was attached to the transfer of training, in the literature on the subject, than is true in actual practice.

The mathematics library. Most of the high schools in Alberta were not adequately supplied with mathematics books--other than their basic texts. The larger schools generally reported higher incidence of supplementary books than did the smaller schools, but they had more students to use the books, too. Only 436 such books were reported in all schools. This appeared to be a most meagre selection.

Facilities and equipment. Some basic items of equipment were available in nearly all schools, while other essential items were almost

lacking. Thirteen in fifteen schools had a motion picture projector and a duplicator. One school in six had a demonstration bench, a large slide rule and a slated globe, for their mathematics work. Only one in thirty had a special room for mathematics. The larger schools had a higher incidence of items of equipment than the small schools.

Conclusion. In general, it may be said that there is a direct relationship between school size and the overall adequacy of instruction. The larger schools devote more time to instruction, and make better provision for the exceptionally bright students. They also provide a broader mathematics program for those students who are not college bound. Their libraries contain a greater variety of books, and they have more facilities and equipment for teaching mathematics.

It is a likely conclusion that teachers in the larger schools had an overall higher level of academic training in mathematics, and that they teach their subject full time or a large portion of that time. These conclusions are not inherent in the data of this report.

Few generalizations have no exceptions. That appeared to be true respecting the secondary school mathematics program in Alberta. From reading the returned questionnaires it was noted that there were exceptional schools in all size categories. These were usually associated with the personality, enthusiasm and dedication of the administrators and teachers. There were, also, some deficiences. Both of these exceptions do have some relationship to the physical provisions or lack of them. But one does get the impression that there is much worthwhile and sincere effort given to the teaching of mathematics to Alberta's youth.

Recommedations

1. That a study be made of means to more effectively provide for the gifted student.

2. That efforts be made to stimulate School Boards and teachers to develop more fully the mathematics laboratory.

3. That study be given to the feasibility of giving mathematics teachers continued education in some of the newer phases of the subject. Some areas of the United States are now actively carrying on such programs.

4. That consideration be given to the use of tests such as the Preliminary Scholastic Aptitude Test, and the Scholastic Aptitude Test, in order to compare Alberta students (and hence the program) with those of many other areas. These tests are distributed and scored by the College Entrance Examination Board.

5. That some research be done in Alberta on evaluation in mathematics related to development of interests, attitudes, appreciations, and the application of mathematical learning to new situations.

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APPENDIX A

THE QUESTIONNAIRE

QUESTIONNAIRE

A STUDY OF METHODS OF TEACHING SECONDARY SCHOOL MATHEMATICS

To the Principal:

1. Will you direct this to your mathematics teacher(s)?
2. Please note there are three parts to be answered.
3. Most of the items can be answered by a check (✓).
4. Please answer every item. Thank you.

PART I

A. 1. Your present position:

....Teacher ....Vice-Principal ....Principal

2. Number of years teaching experience....

3. Sex: ....Male ....Female

4. Number of full time teachers in your school including the principal.....

5. Grades included in your school.....

B. 1. What is the time given to a 5-credit mathematics course per week in your school? Check one.

1. ....105 minutes or less
2. ....106-140 minutes
3. ....141-175 minutes
4. ....over 175 minutes

2. What do you consider the upper limit, as to the number of students in a mathematics class, before a division is made? Check one.

1. ....30 students
2. ....35 students
3. ....40 students
4. ....45 students
5. ....over 45 students

3. Do you divide the classes by ability? Check one.

1. ....Yes
2. ....No

4. Indicate about how much time you expect students to spend on home assignments per class. Check time in each class.

	20 min. or less	20-29 min.	30 min. or more
1. Math 9	.....	.....	.....
2. Math 10	.....	.....	.....
3. Math 11	.....	.....	.....
4. Math 20	.....	.....	.....
5. Math 21	.....	.....	.....
6. Math 30	.....	.....	.....
7. Math 31	.....	.....	.....

5. What are your methods of enrichment? Check those that apply.

1. .....Advanced study in depth
2. .....Additional topics added
3. .....Transfer to special classes
4. .....No provision made
5. .....Others (Write in) . . . . . .

. . . . . .

6. Indicate aspects of supervision, as applied to mathematics that are practised in your school. Check those that apply.

1. .....Primcipal supervises some classes
2. .....Special meetings are held for mathematic teachers
3. .....Professional magazines are made available
4. .....Related books are supplied
5. .....Others (Write in) . . . . . .

. . . . . .

7. Do you have a special mathematics room (laboratory)? Check one.

1. .....Yes
2. .....No

8. What is the present enrollment of your school?

1. .....Grade 9
2. .....Grade 10
3. .....Grade 11
4. .....Grade 12
5. .....Total

9. Please indicate present class (math) size. Check for each course.

	Under 20	21-25	26-30	31-35	over 35
1. Math 9	.....	.....	.....	.....	.....
2. Math 10	.....	.....	.....	.....	.....

3. Math 11 ....
4. Math 20 ....
5. Math 21 ....
6. Math 30 ....
7. Math 31 ....

PART II

METHODS OF PRESENTATION

A. THE LECTURE METHOD: By the Lecture Method is meant the "telling method" or of giving a discussion of a topic. It is not assumed that it is the only method. Check one.

1. What percentage of class time do you give to the Lecture Method? Check one.

   1. .....Less than 25%
   2. .....25%-50%
   3. .....50%-75%
   4. .....More than 75%

2. Indicate any feature of the Lecture Method that you have found desirable. Check those that apply.

   1. .....Covers a greater scope of material
   2. .....Valuable training to students in note taking and assimilation
   3. .....Makes possible the introduction of anecdotes and other related materials
   4. .....Gives the teacher an opportunity to deal with anticipated difficulties
   5. .....Others (Write in) . . . . . .
      . . . . . .

3. Indicate why you like certain features of the Lecture Method. Check those that apply.

   1. .....By observation I have sensed student interest
   2. .....By testing I have noted student progress
   3. .....Others (Write in) . . . . . .
      . . . . . .

4. Indicate features of the Lecture Method that you have found undesirable. Check those that apply.

   1. .....Secondary school students are seldom able to assimilate materials by lecture.
   2. .....Lectures do not allow an immediate opportunity to clear up difficulties.

3. .....Students allow statements to go unchallenged
4. .....Other (Write in) . . . . . .
. . . . . .

5. Indicate why you do not like the Lecture Method. Check those that apply.

1. .....Have found it less effective as a basis of student learning
2. .....Have found it difficult to maintain student interest
3. .....Others (Write in) . . . . . .
. . . . . .

B. HEURISTIC METHOD: By the Heuristic Method I mean the leading of the student (class) by well chosen questions and illustrations to discover facts and relationships.

1. What percentage of class time do you give to the Heuristic Method? Check one.

1. .....less than 25%
2. .....25%-50%
3. .....50%-75%
4. .....More than 75%

2. Indicate any features of the Heuristic Method that you have found desirable. Check those that apply.

1. .....Brings student into active participation
2. .....Motivates, by putting the student into the role of an investigator
3. .....Guides students towards discoveries
4. .....Gives the teacher an opportunity to emphasize key points
5. .....Others (Write in) . . . . . .
. . . . . .

3. Indicate why you like certain features of the Heuristic Method. Check those that apply.

1. .....Tests show that it is effective for some types of work
2. .....Awakens in the students the spirit of seeking answers
3. .....Students do it themselves
4. .....Other (Write in) . . . . . .
. . . . . .

4. Indicate features of the Heuristic Method that you have found to be weak. Check those that apply.

1. .....It is too time consuming
2. .....If not skillfully handled, it degenerates into "Yes" and "No" answers with little thought

3. .....In unskilled hands the discussion becomes random.
4. .....Danger of questioning only the brighter students.
5. .....Others (Write in) . . . . . .
. . . . . .

5. Indicate why you do not like the Heuristic Method. Check those that apply.

1. .....Most students are not willing to give the time necessary to develop solutions.
2. .....Pupils turn to other books to find solutions.
3. .....The brighter pupils do not generally need all the time given by this method.
4. .....Others (Write in) . . . . . .
. . . . . .

C. LABORATORY METHOD: By the laboratory Method I mean the method involving the development of new understandings and concepts through activities of measuring, constructing, drawing, representing data, handling objects, making models, field trips, etc.

1. What percentage of class time do you give to the Laboratory Method? Check one.

1. .....Less than 25%
2. .....25%-50%
3. .....50%-75%
4. .....Over 75%

2. Indicate the grade level you believe this method to be most helpful. Check one.

1. .....Grade 9
2. .....Grade 10
3. .....Grade 11
4. .....Grade 12
5. .....About the same

3. Indicate those of the following statements that you have found most useful. Check those that apply.

1. .....Measuring activities (length, weight, temperature, angles, etc).
2. .....Construction activities (making of models, e.g. Pythagoras' Theorem).
3. .....Construction of solid models.
4. .....Drawing to scale.
5. .....Making large graphs
6. .....Field trips (surveys, maps, indirect measurement).
7. .....Gathering data (to treat statistically).
8. .....Others (Write in) . . . . . .
. . . . . .

4. Indicate what has led you to believe that the Laboratory Method leads to better understanding. Check those that apply.

   1. .....Have noted that students, after having worked on models, graphs, etc., explain them readily to their peers.
   2. .....Students visualize certain problems more readily, after having had actual laboratory experiences.
   3. .....Teacher can "put over" certain ideas better by demonstration in the Laboratory.
   4. .....Mathematical concepts become more functional and meaningful when they are seen in relation to actual applications.

5. Indicate weaknesses that you have found with this method. Check those that apply.

   1. .....The Laboratory Method is too time consuming.
   2. .....Students rely too strongly on seeing or measuring.
   3. .....It may become aimless manipulation.
   4. .....In High School mathematics, laboratory work does little to develop and clarify mathematical inter-relationships itself.

D. DRILL: By Drill is meant the repeated application or practice to fix certain skills in the memory.

1. What percentage of class time do you give to Drill?

   1. .....Less than 25%
   2. .....25%-50%
   3. .....50%-75%
   4. .....Over 75%

2. Indicate the grade level you have found this most useful. Check one.

   1. .....Grade 9
   2. .....Grade 10
   3. .....Grade 11
   4. .....Grade 12
   5. .....About the same

3. Here is a list of 20 topics covered in Secondary Mathematics. Will you indicate in each how important you have found drill to be. Please check thus:

	Little	Some	Much
1. Operations with signed numbers	_____	_____	_____
2. Grouping like terms	_____	_____	_____

		Little	Some	Much
3.	Graphing of linear functions	____	____	____
4.	Graphing of quadratic functions	____	____	____
5.	Learning propositions in geometry	____	____	____
6.	Extracting square roots	____	____	____
7.	Finding areas of surfaces	____	____	____
8.	Factoring	____	____	____
9.	Making geometric constructions	____	____	____
10.	Memorizing area and volume formulas	____	____	____
11.	Solutions of equations	____	____	____
12.	Fundamental operations on algebraic fractions	____	____	____
13.	Finding the L.C.M - H.C.F.	____	____	____
14.	Operations in radicals	____	____	____
15.	Solutions of systems of equations	____	____	____
16.	Solutions of linear equations	____	____	____
17.	Solving quadratic equations by formula	____	____	____
18.	Computation by logarithms	____	____	____
19.	Solving equations by graphical methods	____	____	____
20.	Problems in expansion of Binomial Theorem	____	____	____

E. EVALUATION of student performance. Check those that apply.

Please indicate what percent each of the following counts on your final assessment:

		Less than 10%	20%	30%	40%	50%	More
1.	Final examination	____	____	____	____	____	____
2.	Term examinations (Christmas and/or Easter and possibly others)	____	____	____	____	____	____
3.	Short, teacher-made tests	____	____	____	____	____	____
4.	Commercially prepared tests	____	____	____	____	____	____
5.	Marks for notebooks	____	____	____	____	____	____
6.	Marks for projects or other selected pieces of work	____	____	____	____	____	____
7.	Pupils' daily class preparation	____	____	____	____	____	____
8.	Pupils' class participation	____	____	____	____	____	____
9.	Teachers' judgment	____	____	____	____	____	____
10.	Others (Write in)	____	____	____	____	____	____

2. Please indicate the degree of importance that you attach to each of the following purposes of evaluation. Check thus:

	Little	Some	Much
1. To furnish data for educational guidance	____	____	____
2. To assist in grouping of students	____	____	____
3. To stimulate the improvement of teaching	____	____	____
4. To serve as a basis for "passing" or "failing" a student	____	____	____
5. To determine the strengths or weaknesses of students or of a class as a whole	____	____	____
6. To provide an incentive to study	____	____	____
7. To provide a basis for reporting to parents	____	____	____
8. To afford a basis for the appraisal of teachers	____	____	____
9. To measure the ability of students to apply mathematical reasoning to non-mathematical situations	____	____	____
10. To maintain standards	____	____	____

F. TEACHING FOR TRANSFER

1. From your readings and discussions of transfer of training, indicate how significant you believe proper instruction in mathematics can contribute to this goal. Check one.

Little Some Much

2. From your experience and observation in teaching mathematics, indicate the importance you place on transfer of training in actual practice. Check one.

Little Some Much

3. Indicate any techniques you use in teaching mathematics so that transfer may occur. Check those that apply.

1. .....Teacher points out general applications of fundamental mathematical operations.
2. .....Teacher points relationships of preceding and subsequent parts in order to build up whole picture.
3. .....Teacher and students bring wide variety of materials to classroom (e.g. graphs from newspapers) to see practical applications.

4. .....Teacher indicates the wide application which certain generalizations have, e.g. Pythagorean Theorem, angle-sum relationship, the Sine Law.
5. .....Teacher simply points out to students to be on the look-out for similarities between new situations and familiar ones--habitually searching for elements or relationships.
6. .....Mathematics and Science teachers confer and pose this question: "How can we facilitate transfer?"
7. .....Others (Write in) . . . . . .
. . . . . .

PART III

THE HIGH SCHOOL MATHEMATICS LIBRARY:

This part of the questionnaire is concerned only with a survey of mathematics books that are available at your school. Please check those you have for the use of teachers and students. Where indicated please list others of a similar nature.

1. History and Biography:

1. .....Bell, W. W. R., "A Short Account of the History of Mathematics."
2. .....Hart, Ivor B., "Makers of Science, Mathematics, Physics, and Astronomy."
3. .....Hooper, Alfred, "Makers of Mathematics."
4. .....Sanford, Vera, "A Short History of Mathematics."
5. .....Bell, E. T., "Men of Mathematics."
6. .....Bishop, Morris, "Pascal, the Life of Genius."
7. .....Philip, Frank, "Einstein, His Life and Work."
8. .....Sullivan, J. W. N., "Isaac Newton, 1642-1727."
9. .....Others . . . . . .
. . . . . .

2. Recreational and Popular Accounts of Mathematics

1. .....Dudenay, H. E., "The Canterbury Puzzles."
2. .....Jones, S. I., "Mathematical Clubs and Recreations."
3. .....Brandes, L. G., "Geometry Can Be Fun."
4. .....Steinhaus, Hugo, "Mathematical Snapshots."
5. .....Northrop, R. P., "Riddles Is Mathematics."
6. .....Bell, E. T., "Mathematics, Queen and Servant of Science."
7. .....Dantizig, Tobias, "Number: the Language of Science."
8. .....Dubisch, Roy, "The Nature of Number."
9. .....Kasner, E. and J. Newman, "Mathematics and the Imagination."
10. .....Others (Please write in) . . . . . .
. . . . . .

3. Surveys and General

1. .....Boyers, Lee E., "An Introduction to Mathematics for Teachers."
2. .....Hogben, L., "Mathematics for the Million."
3. .....Butler, C. H. and Wren, F. R., "The Teaching of Secondary Mathematics."
4. .....Canadian Mathematical Congress. "Why Study Mathematics?"
5. .....National Council of Teachers of Mathematics, "Emerging Practices in Mathematics Education."
6. .....A Report of the Incorporated Association of Assistant Masters in Secondary School, "The Teaching of Mathematics."
7. .....Ravielli, Anthony, "An Adevnture in Geometry."
8. .....Schorling, Raleigh, "Mathematics to the Consumer."
9. .....National Council of Teachers of Mathematics, "Multi-Sensory Aids in Teaching Mathematics."
10. .....Others (Please write in) . . . . . .

4. Mathematics in Trades and Professions

1. .....Axeland, Aaron, "Machine Shop Mathematics."
2. .....Cooke, Nelson, M., "Mathematics Essential to Electricity and Radio."
3. .....Slade, S., "Mathematics for Technical and Vocational Schools."
4. .....Shuster, C. M. and Bedford, F. L., "Field Work in Mathematics."
5. .....Progressive Education Association, "Mathematics in General Education."
6. .....Others (Please write on). . . . . .

THE MATHEMATICS ROOM (LABORATORY):

This is a room for mathematics classes and for certain practical work and experiments.

1. Do you have a special mathematics room (s) in your school?

_____Yes. _____No.

2. Indicate the items of equipment or apparatus you have available for use in your room or school. Check those that apply.

1. .....Chart case (s)
2. .....Shelves
3. .....Magazine rack
4. .....Cupboards
5. .....Bulletin boards
6. .....Exhibit cases

2. Equipment and Apparatus (Continued)

7. .....Demonstration bench
8. .....Duplicator
9. .....Motion picture projector
10. .....Projection lantern
11. .....Pencil sharpner
12. .....Radio
13. .....Wooden compass
14. .....Demonstration protractor
15. .....Demonstration slide rule, 4'
16. .....Liner
17. .....Meter and yard stick
18. .....Slated globe
19. .....Triangle 30° - 60°
20. .....Triangle 45° - 90°
21. .....T - square, large
22. .....Balances and weights
23. .....Calipers
24. .....Tape, 50' or 100'
25. .....Drawing sets
26. .....French curves, set of 6 or 8
27. .....Micrometer screw
28. .....Parallel rulers
29. .....Pantograph
30. .....Proportional dividers
31. .....Surveyer's level
32. .....Models (Ellipsoid, etc.)
33. .....Pictures (of Mathematicians)
34. .....Miscellaneous charts related to mathematics

APPENDIX B

ACCOMPANYING LETTERS

MAGRATH JUNIOR-SENIOR HIGH SCHOOL

MAGRATH, ALBERTA

January 11, 1960

Dear Fellow Principal (Teacher):

Although there are certainly numerous demands on your time, will you be kind enough to assist me in a task that may be of some significance to mathematics teachers?

At present I am working on a little research problem entitled, "A Study of Methods of Teaching Secondary School Mathematics." (Grades 9, 10, 11 and 12). This study is being made in connection with graduate work in Education.

Your school has been selected at random from a list of Secondary Schools in the province. I am hoping for your assistance and cooperation to successfully complete this task. Will you complete the enclosed questionnaire and return it to me in the stamped, self-addressed envelope provided for your use? The questionnaire appears to be lengthy, but since most of the questions require only that you check a response, it will not take a great deal of time to complete.

As you know, in a study of this nature, it is essential to have a large percentage of the questionnaires returned--I hope all of them. So I shall be most grateful to you for your assistance.

No teacher, school or system will be identified in the results of this study.

Some time during the next school year, when the data have been analyzed, I shall send you a summary of the results.

Thank you for your assistance.

Sincerely yours,

R. E. Blumell

Richard Emerson Blumell
Principal

MAGRATH JR. - SR. HIGH SCHOOL

Magrath, Alberta
January 25, 1960

Dear Fellow Principal:

A few weeks ago I sent you a questionnaire with a request that you and/or your mathematics teacher(s) complete it and return it to me. Up to this date the response has been good, but I have not received a sufficient number of completed questionnaires to enable me to continue the study. Would you kindly complete this questionnaire, or if you have given it to one of your mathematics teachers, would you, on my behalf, ask him if he will complete it and return it to me.

Thank you and please convey my appreciation to any teacher on your staff who has or who may assist in this.

Sincerely yours,

R. E. Blumell

Richard E. Blumell

APPENDIX C

ORIGINAL DATA TABLES

TABLE XXX

ORIGINAL DATA TABLE

QUESTIONNAIRE:	School Size Category: 1-3 Teachers	4-6 Teachers	7-10 Teachers	Over 11 Teachers	Total Teachers
1. What is the time given to a 5-credit mathematics course per week in your school? Check one.					
1. 105 minutes or less	2	2	2	0	6
2. 106 - 140 minutes	3	6	0	0	9
3. 141 - 175 minutes	21	32	11	11	75
4. Over 175 minutes	9	28	10	16	63
2. What do you consider the upper limit, as to the number of students in a mathematics class, before a division is made?					
1. 30 students	21	39	14	11	85
2. 35 students	8	18	5	14	45
3. 40 students	3	8	3	2	16
4. 45 students	0	1	0	0	1
5. Over 45 students	0	0	1	0	1
3. Do you divide classes by ability? Check one.					
1. Yes	1	15	11	11	38
2. No	32	47	12	14	105
4. Indicate about how much time you expect students to spend on home assignments, per class. Check time in each class.					
1. Mathematics 9 .. -20 minutes or less	4	14	3	8	29
-20 - 29 minutes	16	31	5	7	59
-30 minutes or more	9	8	2	3	22
2. Mathematics 10 .. -20 minutes or less	1	5	2	9	17
-20 - 29 minutes	17	33	12	12	74
-30 minutes or more	12	24	6	5	47
3. Mathematics 11 .. -20 minutes or less	4	13	6	10	33
-20 - 29 minutes	4	19	7	10	40
-30 minutes or more	4	10	3	4	21
4. Mathematics 20 .. -20 minutes or less	0	4	1	4	9
-20 - 29 minutes	12	24	10	10	56
-30 minutes or more	22	38	10	10	80

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
4. CONTINUED.					
5. MATHEMATICS 21 .. -20 MINUTED OR LESS	2	10	3	6	21
-20 - 29 MINUTES	2	23	6	11	42
-30 MINUTES OR MORE	2	7	2	2	13
6. MATHEMATICS 30 .. -20 MINUTES OR LESS	0	0	1	1	2
-20 - 29 MINUTES	2	14	3	6	25
-30 MINUTES OR MORE	28	55	16	18	117
7. MATHEMATICS 31 .. -20 MINUTES OR LESS	0	1	1	3	5
-20 - 29 MINUTES	1	10	4	7	22
-30 MINUTES OR MORE	7	31	11	12	61
5. WHAT ARE YOUR METHODS OF ENRICHMENT?					
1. ADVANCED STUDY IN DEPTH	9	23	10	14	56
2. ADDITIONAL TOPICS ADDED	7	14	10	16	47
3. TRANSFER TO SPECIAL CLASSES	0	0	0	6	6
4. NO PROVISION MADE	17	36	10	5	68
5. OTHERS	2	3	0	1	6
6. INDICATE ASPECTS OF SUPERVISION, AS APPLIED TO MATHEMATICS, THAT ARE PRACTISED IN YOUR SCHOOL					
1. PRINCIPAL SUPERVISES SOME CLASSES	11	19	5	11	46
2. SPECIAL MEETINGS ARE HELD FOR MATH. TEACHERS	3	13	5	16	37
3. PROFESSIONAL MAGAZINES ARE MADE AVAILABLE	7	17	6	16	46
4. RELATED BOOKS ARE SUPPLIED	11	19	10	17	57
5. OTHERS	4	9	2	2	17
7. WHAT IS THE PRESENT ENROLLMENT OF YOUR SCHOOL?					
1. GRADE 9					
2. GRADE 10					
3. GRADE 11					
4. GRADE 12					

TABLE XXX (CONTINUED)

QUESTIONNAIRE		SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
8. PLEASE INDICATE PRESENT CLASS SIZE.						
1. MATHEMATICS 9	- UNDER 20	24	19	0	0	43
	- 21 - 25	8	12	7	6	33
	- 26 - 30	0	15	0	11	26
	- 31 - 35	1	7	2	6	16
	- OVER 35	0	6	5	0	11
2. MATHEMATICS 10	- UNDER 20	28	30	4	3	65
	- 21 - 25	4	16	9	4	33
	- 26 - 30	0	7	7	12	26
	- 31 - 35	0	8	3	11	22
	- OVER 20	0	3	5	4	12
3. MATHEMATICS 11	- UNDER 20	13	24	8	7	52
	- 21 - 25	2	1	3	6	12
	- 26 - 30	0	2	2	6	10
	- 31 - 35	0	1	3	5	9
	- OVER 35	0	1	1	3	5
4. MATHEMATICS 20	- UNDER 20	31	42	9	2	84
	- 21 - 25	1	15	6	3	25
	- 26 - 30	0	5	4	8	17
	- 31 - 35	0	2	4	13	19
	- OVER 35	0	1	1	5	7
5. MATHEMATICS 21	- UNDER 20	4	12	7	4	27
	- 21 - 25	0	3	2	5	10
	- 26 - 30	0	0	0	3	3
	- 31 - 35	0	0	0	2	2
	OVER 35	0	0	0	3	3
6. MATHEMATICS 30	- UNDER 20	30	60	15	3	108
	- 21 - 25	0	1	3	7	11
	- 26 - 30	0	1	3	9	13
	- 31 - 35	0	1	0	8	9
	- OVER 35	0	0	1	2	3
7. MATHEMATICS 31	- UNDER 20	3	24	13	14	54
	- 21 - 25	0	1	1	3	5
	- 26 - 30	0	0	0	3	4
	- 31 - 35	0	0	0	4	4
	- OVER 35	0	0	0	1	1

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II					
A. THE LECTURE METHOD: BY THE LECTURE METHOD IS MEANT THE "TELLING METHOD" OR OF GIVING A DISCUSSION OF A TOPIC. IT IS NOT ASSUMED THAT IT IS THE ONLY METHOD.					
1. WHAT PERCENTAGE OF CLASS TIME DO YOU GIVE TO THE LECTURE METHOD.					
1. LESS THAN 25%	10	22	8	7	47
2. 25% - 50%	16	34	9	17	76
3. 50% - 75%	9	10	6	2	27
4. MORE THAN 75%	0	1	0	0	1
2. INDICATE ANY FEATURE OF THE LECTURE METHOD THAT YOU HAVE FOUND DESIRABLE.					
1. COVERS A GREATER SCOPE OF MATERIAL	21	36	14	20	91
2. VALUABLE TRAINING TO STUDENTS IN NOTE TAKING AND ASSIMILATION..	3	11	1	4	19
3. MAKES POSSIBLE THE INTRODUCTION OF ANECDOTES AND OTHER RELATED MATERIALS	11	21	12	7	51
4. GIVES THE TEACHER AN OPPORTUNITY TO DEAL WITH ANTICIPATED DIFFICULTIES	30	52	18	18	118
5. OTHERS	1	11	0	4	16
3. INDICATE WHY YOU LIKE CERTAIN FEATURES OF THE LECTURE METHOD.					
1. BY OBSERVATION I HAVE SENSED STUDENT INTEREST	19	35	10	11	75
2. BY TESTING I HAVE NOTED STUDENT PROGRESS	18	35	11	15	79
3. OTHERS	5	15	5	5	30
4. INDICATE FEATURES OF THE LECTURE METHOD THAT YOU HAVE FOUND DESIRABLE					
1. SECONDARY SCHOOL STUDENTS ARE SELDOM ABLE TO ASSIMILATE MATERIALS BY LECTURE	3	11	3	6	23

TABLE XXX (CONTINUED)

QUESTIONNAIRE	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II, A. - CONT'D.					
2. LECTURES DO NOT ALLOW AN IMMEDIATE OPPORTUNITY TO CLEAR UP DIFFICULTIES	15	39	6	11	71
3. STUDENTS ALLOW STATEMENTS TO GO UNCHALLENGED	23	42	16	15	96
4. OTHERS	1	10	2	2	15
5. INDICATE WHY YOU DO NOT LIKE THE LECTURE METHOD					
1. HAVE FOUND IT LESS EFFECTIVE AS A BASIS OF STUDENT LEARNING	12	30	7	10	59
2. HAVE FOUND IT DIFFICULT TO MAINTAIN STUDENT INTEREST	8	19	3	8	39
3. OTHERS	8	10	2	6	26
B. HEURISTIC METHOD:					
1. WHAT PERCENTAGE OF CLASS TIME DO YOU GIVE TO THE HEURISTIC METHOD?					
1. LESS THAN 25%	13	26	11	7	55
2. 25% - 50%	17	35	9	14	75
3. 50% - 75%	4	5	4	4	17
2. INDICATE ANY FEATURES OF THE HEURISTIC METHOD THAT YOU HAVE FOUND DESIRABLE					
1. BRINGS STUDENT INTO ACTIVE PARTICIPATION	31	53	19	22	125
2. MOTIVES, BY PUTTING THE STUDENT INTO THE ROLE OF AN INVESTIGATOR	21	35	14	16	86
3. GUIDES THE TEACHER TOWARDS DISCOVERIES	21	34	10	19	84
4. GIVES THE TEACHER AN OPPORTUNITY TO EMPHASIZE KEY POINTS	16	39	6	19	80
5. OTHERS	0	2	1	19	22

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II, B. - (CONT'D)					
3. INDICATE WHY YOU LIKE CERTAIN FEATURES OF THE HEURISTIC METHOD.....					
1. TESTS SHOW THAT IT IS EFFECTIVE FOR SOME TYPES OF WORK	14	21	7	12	54
2. AWAKENS IN THE STUDENTS THE SPIRIT OF SEEKING ANSWERS.....	23	49	18	19	109
3. STUDENTS DO IT THEMSELVES	14	35	8	11	68
4. OTHERS	2	5	0	0	7
4. INDICATE FEATURES OF THE HEURISTIC METHOD THAT YOU HAVE FOUND TO BE WEAK.					
1. IT IS TOO TIME CONSUMING	20	28	14	12	74
2. IF NOT SKILLFULLY HANDLED, IT DEGENERATES INTO "YES" AND "NO" ANSWERS WITH LITTLE THOUGHT.....	17	35	14	15	81
3. IN UNSKILLED HANDS THE DISCUSSION BECOMES RANDOM.....	6	18	10	11	45
4. DANGER OF QUESTIONING ONLY THE BRIGHTER STUDENTS	23	35	11	16	85
5. OTHERS	2	5	1	1	9
5. INDICATE WHY YOU DO NOT LIKE THE HEURISTIC METHOD.					
1. MOST STUDENTS ARE NOT WILLING TO GIVE THE TIME NECESSARY TO DEVELOP SOLUTIONS.....	10	23	9	8	50
2. PUPILS TURN TO OTHER BOOKS TO FIND SOLUTIONS	2	2	0	1	5
3. THE BRIGHTER PUPILS DO NOT GENERALLY NEED ALL THE TIME GIVEN BY THIS METHOD	20	41	10	13	84
4. OTHERS	1	4	0	1	6

TABLE XXX (CONTINUED)

QUESTIONNAIRE	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II, C. - CONT'D.					
C. LABORATORY METHOD:					
1. WHAT PERCENTAGE OF CLASS TIME DO YOU GIVE TO THE LABORATORY METHOD,					
1. LESS THAN 25%	32	60	20	23	135
2. 25% - 50%	2	4	2	2	10
3. 50% - 75%	1	1	0	0	2
4. OVER 75%	0	0	0	0	0
2. INDICATE THE GRADE LEVEL YOU BELIEVE THIS METHOD TO BE MOST HELPFUL.					
1. GRADE 9	27	41	13	18	99
2. GRADE 10	12	16	5	5	38
3. GRADE 11	0	0	0	0	0
4. GRADE 12	0	4	0	1	5
5. ABOUT THE SAME	5	17	5	3	30
3. INDICATE THOSE OF THE FOLLOWING STATEMENTS THAT YOU HAVE FOUND MOST USEFUL.					
1. MEASURING ACTIVITIES (LENGTH, WEIGHT, TEMPERATURE, ANGLES, ETC.)	29	50	12	17	108
2. CONSTRUCTION ACTIVITIES (MAKING OF MODELS, E.G. PYTHAGORAS' THEOREM)	11	32	7	12	62
3. CONSTRUCTION OF SOLID MODELS	3	4	1	1	9
4. DRAWING TO SCALE	19	39	15	13	86
5. MAKING LARGE GRAPHS	14	26	9	11	60
6. FIELD TRIPS (SURVEYS, MAPS, INDIRECT MEASUREMENT)	4	10	2	3	19
7. GATHERING DATA (TO TREAT STATISTICALLY)	2	13	2	5	22
8. OTHERS	2	2	2	1	7

TABLE XXX (CONTINUED)

QUESTIONNAIRE	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II, C. CONT'D					
4. INDICATE WHAT HAS LED YOU TO BELIEVE THAT THE LABORATORY METHOD LEADS TO BETTER UNDERSTANDING					
1. HAVE NOTED THAT STUDENTS, AFTER HAVING WORKED ON MODELS, GRAPHS, ETC., EXPLAIN THEM READILY TO THEIR PEERS	8	17	2	4	31
2. STUDENTS VISUALIZE CERTAIN PROBLEMS MORE READILY, AFTER HAVING HAD ACTUAL LABORATORY EXPERIENCES	26	43	15	17	101
3. MATHEMATICAL CONCEPTS BECOME MORE FUNCTIONAL AND MEANINGFUL WHEN THEY ARE SEEN IN RELATION TO ACTUAL APPLICATIONS	16	48	15	9	88
4. TEACHER CAN "PUT OVER" CERTAIN IDEAS BETTER BY DEMONSTRATION IN THE LABORATORY	23	46	13	16	98
5. INDICATE WEAKNESS THAT YOU HAVE FOUND WITH THIS METHOD.					
1. THE LABORATORY METHOD IS TOO TIME CONSUMING	23	47	16	18	104
2. STUDENTS RELY TOO STRONGLY ON SEEING OR MEASURING	4	13	7	4	28
3. IT MAY BECOME AIMLESS MANIPULATION	13	29	5	11	58
4. IN HIGH SCHOOL MATHEMATICS, LABORATORY WORK DOES LITTLE TO DEVELOP AND CLARIFY MATHEMATICAL INTERRELATIONSHIPS ITSELF	11	20	8	7	46

TABLE XXX (CONTINUED)

QUESTIONNAIRE	SCHOOL SIZE CATEGORY 1-3 TEACHERS	4-6 TEACHERS	7-10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II, CONT'D					
D. DRILL:					
1. WHAT PERCENTAGE OF CLASS TIME DO YOU GIVE TO DRILL?					
1. LESS THAN 25%	16	28	10	15	69
2. 25% - 50%	15	30	11	12	68
3. 50% - 75%	3	7	1	0	11
4. OVER 75%	0	0	0	0	0
2. INDICATE THE GRADE LEVEL YOU HAVE FOUND THIS MOST USEFUL					
1. GRADE 9	12	24	6	7	49
2. GRADE 10	3	14	3	4	24
3. GRADE 11	3	5	4	1	13
4. GRADE 12	2	2	2	2	9
5. ABOUT THE SAME	16	20	9	13	68

3. HERE IS A LIST OF 20 TOPICS COVERED IN SECONDARY MATHEMATICS.

	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH
1. OPERATIONS WITH SIGNED NUMBERS	0	2	29	0	4	59	1	3	19	0	3	22	1	12	129
2. GROUPING LIKE TERMS	1	17	13	1	36	24	0	14	8	2	10	11	4	77	56
3. GRAPHING LINEAR FUNCTIONS	6	22	5	6	36	18	2	10	10	3	12	10	17	80	43
4. GRAPHING OF QUADRATIC FUNCTIONS	5	21	4	5	31	27	1	13	6	4	9	12	15	74	49
5. LEARNING PROPOSITIONS IN GEOMETRY	11	8	12	14	34	12	11	6	6	12	6	5	48	54	45
6. EXTRACTING SQUARE ROOTS	4	14	14	8	29	26	5	9	8	3	9	12	20	61	60
7. FINDING AREAS OF SURFACES	6	19	6	3	34	31	5	13	5	5	9	7	19	65	49
8. FACTORING	1	7	27	0	20	45	3	3	16	0	3	22	4	33	110
9. MAKING GEOMETRIC CONSTRUCTIONS	9	18	4	11	39	13	8	9	4	7	13	4	35	79	25
10. MEMORIZING AREA AND VOLUME FORMULAS	3	18	12	10	18	36	5	8	9	7	11	9	25	55	66

TABLE XXX (CONTINUED

QUESTIONNAIRE	SCHOOL SIZE CATEGORY															
	1-3 TEACHERS			4-6 TEACHERS			7-10 TEACHERS			OVER 11 TEACHERS			TOTAL TEACHERS			
	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	LITTLE	SOME	MUCH	
PART II, CONT'D																
3. CONTINUED - LIST COVERED IN SECONDARY MATHEMATICS																
11. SOLUTIONS OF EQUATIONS	3	11	19	4	23	33	1	10	10	5	3	17	13	47	79	
12. FUNDAMENTAL OPERATIONS ON ALGEBRAIC FRACTIONS	0	16	17	1	26	38	0	9	12	5	8	14	6	59	81	
13. FINDING THE L.C.M. - H.C.F.	6	20	5	3	34	25	1	12	7	4	13	9	14	79	46	
14. OPERATIONS IN RADICALS	1	20	11	2	34	26	1	10	7	5	7	13	9	71	57	
15. SOLUTIONS OF SYSTEMS OF EQUATIONS	0	24	8	4	35	25	1	9	14	1	6	17	6	74	64	
16. SOLUTIONS OF LINEAR EQUATIONS	3	21	9	4	36	22	0	11	10	3	7	13	10	75	54	
17. SOLVING QUADRATIC EQUATIONS BY FORMULA	3	14	13	4	24	35	1	11	7	4	11	10	12	60	65	
18. COMPUTATION BY LOGARITHMS	5	16	13	4	19	32	0	8	11	6	5	19	15	48	75	
19. SOLVING EQUATIONS BY GRAPHICAL METHODS	9	17	5	13	37	11	3	15	4	6	11	6	31	80	26	
20. PROBLEMS IN EXPANSION OF BINOMIAL THEOREM	4	22	5	2	30	26	2	13	5	3	8	16	11	73	52	

TABLE XXX (CONTINUED)

QUESTIONNAIRE	SCHOOL SIZE CATEGORY											
	1 - 3 TEACHERS						4 - 6 TEACHERS					
	10%	20%	30%	40%	50%	MORE	10%	20%	30%	40%	50%	MORE
PART II, CONT'D.												
E. EVALUATION OF STUDENT PERFORMANCE.												
1. PLEASE INDICATE WHAT PERCENT OF THE FOLLOWING COUNTS ON YOUR FINAL ASSESSMENT:												
1. FINAL EXAMINATION	0	2	2	7	18	4	1	4	1	15	36	9
2. TERM EXAMONATIONS, ETC	4	21	11	3	2	0	6	26	14	6	7	1
3. SHORT, TEACHER-MADE TESTS	19	10	2	0	0	0	24	10	2	3	1	1
4. COMMERCIALLY PREPARED TESTS	8	0	0	0	0	0	12	1	0	1	0	0
5. MARKS FOR NOTEBOOK	15	0	0	0	0	0	25	3	0	0	0	0
6. MARKS FOR PROJECTS, ETC	10	0	0	0	0	0	22	0	1	0	0	0
7. PUPILS' CLASS PARTICIPATION	14	2	0	0	0	0	25	3	1	0	0	0
8. PUPILS' DAILY CLASS PREPARATION	14	1	0	0	0	0	24	3	0	0	0	0
9. TEACHERS' JUDGMENT	13	2	0	0	0	0	23	2	0	0	0	0
10. OTHERS	2	0	0	0	0	0	2	0	0	0	0	0
	7 - 10 TEACHERS						11 OR MORE TEACHERS					
1. FINAL EXAMINATION	0	1	1	6	13	2	0	3	7	2	10	5
2. TERM EXAMINATIONS ETC.	0	3	5	9	6	0	3	9	4	4	2	2
3. SHORT, TEACHER-MADE TESTS	10	4	1	0	1	0	9	1	2	5	2	0
4. COMMERCIALLY PREPARED TESTS	5	0	0	0	0	0	5	1	1	0	0	0
5. MARKS FOR NOTEBOOK	10	0	0	0	0	0	11	1	0	0	0	0
6. MARKS FOR PROJECTS ETC.	8	0	0	0	0	0	10	0	0	0	0	0
7. PUPILS' CLASS PARTICIPATION	9	0	0	0	0	0	10	1	0	0	0	0
8. PUPILS' DAILY CLASS PREPARATION	11	0	0	0	0	0	10	2	0	0	0	0
9. TEACHERS' JUDGMENT	8	0	0	0	0	0	8	2	1	0	0	0
10. OTHERS	1	0	0	0	0	0	0	0	0	0	0	0

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	School Size Category: 1 - 3 Teachers			4 - 6 Teachers			7 -10 Teachers			Over 11 Teachers			Total Teachers		
	Little	Some	Much	Little	Some	Much	Little	Some	Much	Little	Some	Much	Little	Some	Much
PART II, CON'T.															
E. 2. PLEASE INDICATE THE DEGREE OF IMPORTANCE THAT YOU ATTACH TO EACH OF THE FOLLOWING PURPOSES OF EVALUATION.															
1. TO FURNISH DATA FOR EDUCATIONALGUIDANCE	9	13	7	15	36	12	4	12	5	5	12	7	33	60	31
2. TO ASSIST IN GROUPING OF STUDENTS	14	16	1	22	29	6	5	11	2	8	10	4	49	66	13
3. TO STIMULATE THE IMPROVEMENT OF TEACHING	4	17	9	9	32	23	4	11	9	5	8	11	22	68	52
4. TO SERVE AS A BASIS FOR "PASSING" OR "FAILING" A STUDENT	5	11	18	1	21	45	0	5	18	0	7	18	6	44	99
5. TO DETERMINE THE STRENGTHS OR WEAKNESSES OF STUDENTS OR OF A CLASS AS A WHOLE	1	15	18	0	27	39	0	5	18	0	8	17	1	55	92
6. TO PROVIDE AN INCENTIVE TO STUDY	3	23	6	6	34	22	5	14	4	3	13	9	17	84	41
7. TO PROVIDE A BASIS FOR REPORTING TO PARENTS	4	19	8	6	41	20	0	12	10	0	11	12	10	83	50
8. TO AFFORD A BASIS FOR THE APPRAISAL OF TEACHERS	17	9	3	35	19	3	8	6	3	10	10	0	70	44	9
9. TO MEASURE THE ABILITY OF STUDENTS TO APPLY MATHEMATICAL REASONING TO NON-MATHEMATICAL SITUATIONS	10	14	6	26	28	7	14	5	1	9	9	4	59	46	18
10. TO MAINTAIN STANDARDS	4	20	8	7	34	19	4	10	7	4	8	11	19	72	45
F. TEACHING FOR TRANSFER.															
1. FROM YOUR READINGS AND DISCUSSIONS OF TRANSFER OF TRAINING, INDICATE HOW SIGNIFICANT YOU BELIEVE PROPER INSTRUCTION IN MATHEMATICS CAN CONTRIBUTE TO THIS GOAL	3	19	13	6	45	16	6	13	4	5	15	5	20	92	38
2. FROM YOUR EXPERIENCE AND OBSERVATIONS IN TEACHING MATHEMATICS, INDICATE THE IMPORTANCE YOU PLACE ON TRANSFER OF TRAINING IN ACTUAL PRACTICE	9	23	2	13	46	8	9	10	4	5	15	3	36	94	17

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS	TOTAL TEACHERS
PART II, CONT'D.					
F. 3. INDICATE ANY TECHNIQUES YOU USE IN TEACHING MATHEMATICS SO THAT TRANSFER MAY OCCUR.					
1. TEACHER POINTS OUT GENERAL APPLICATIONS OF FUNDAMENTAL MATHEMATICAL OPERATIONS	25	54	19	24	122
2. TEACHER POINTS REALTIONSHIPS OF PRECEDING AND SUBSEQUENT PARTS IN ORDER TO BUILD UP WHOLE PICTURE	22	52	17	18	109
3. TEACHER AND STUDENTS BRING WIDE VARIETY OF MATERIALS TO THE CLASSROOM (E.G. GRAPHS FROM NEWSPAPERS) TO SEE PRACTICAL APPLICATIONS	15	16	5	6	42
4. TEACHER INDICATES THE WIDE APPLICATIONS WHICH CERTAIN GENERALIZATIONS HAVE, E.G. PYTHAGOREAN THEOREM, ANGLE-SUM RELATIONSHIP, THE SINE LAW	23	41	16	22	102
5. TEACHER SIMPLY POINTS OUT TO STUDENTS TO BE ON THE LOOKOUT FOR SIMILARITIES BETWEEN NEW SITUATIONS AND FAMILIAR ONES--HABITUALLY SEARCHING FOR ELEMENTS OR RELATIONSHIPS	9	22	5	12	48
6. MATHEMATICS AND SCIENCE TEACHERS CONFER AND POSE THIS QUESTION: "HOW CAN WE FACILITATE TRANSFER?"	6	9	3	7	25
7. OTHERS	1	3	1	1	6
PART III					
THE HIGH SCHOOL MATHEMATICS LIBRARY:					
THIS PART OF THE QUESTIONNAIRE IS CONCERNED ONLY WITH A SURVEY OF MATHEMATICS BOOKS THAT ARE AVAILABLE AT YOUR SCHOOL. PLEASE CHECK THOSE YOU HAVE FOR THE USE OF TEACHERS AND STUDENTS. WHERE INDICATED, PLEASE LIST OTHERS OF A SIMILAR NATURE.					
1. HISTORY AND BIOGRAPHY:					
1. BALL, W.W.R., "A SHORT ACCOUNT OF THE HISTORY OF MATHEMATICS...	0	2	2	1	
2. HART, IVOR B., "MAKERS OF SCIENCE, MATHEMATICS, PHYSICS, AND ASTRONOMY."	1	3	2	2	
3. HOOPER, ALFRED, "MAKERS OF MATHEMATICS."	0	0	1	2	

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS
PART III, CONT'D.				
1. HISTORY AND BIOGRAPHY, CONT'D.				
4. SANFORD, VERA, "A SHORT HISTORY OF MATHEMATICS	0	1	2	1
5. BELL, E. T., "MEN OF MATHEMATICS"	0	3	4	3
6. BISHOP, MORRIS, "PASCAL, THE LIFE OF GENIUS"	0	2	0	0
7. PHILIP, FRANK, "EINSTEIN, HIS LIFE AND WORK"	2	2	0	2
8. SULLIVAN, J.W.N., "ISAAC NEWTON, 1642-1727"	0	5	2	1
9. OTHERS	0	1	0	6
2. RECREATIONAL AND POPULAR ACCOUNTS OF MATHEMATICS.				
1. DUDENAY, H.E., "THE CANTERBURY PUZZLES."	0	0	0	1
2. JONES, S.I., "MATHEMATICAL CLUBS AND RECREATIONS."	0	2	0	4
3. BRANDES, L.G., "GEOMETRY CAN BE FUN"	3	7	5	2
4. STEINHAUS, HUGO, "MATHEMATICAL SNAPSHOTS"	0	1	1	2
5. NORTHROP, R. P., "RIDDLES IS MATHEMATICS"	1	3	2	2
6. BELL, E. T., "MATHEMATICS, QUEEN AND SERVANT OF SCIENCE"	0	0	1	1
7. DANTIZIG, TOBIAS, "NUMBER: THE LANGUAGE OF SCIENCE"	0	0	0	0
8. DUBISCH, ROY, "THE NATURE OF NUMBER"	1	3	3	3
9. KASNER, E. AND J. NEWMAN, "MATHEMATICS AND THE IMAGINATION"	0	4	1	6
10. OTHERS	1	5	3	10
3. SURVEYS AND GENERAL.				
1. BOYERS, LEE E., "AN INTRODUCTION TO MATHEMATICS FOR TEACHERS".	1	1	1	1
2. HOGBEN, L., "MATHEMATICS FOR THE MILLION"	4	4	4	3
3. BUTLER, C.H. AND WREN, F.R., "THE TEACHING OF SECONDARY MATHEMATICS"	2	11	6	4
4. CANADIAN MATHEMATICAL CONGRESS. "WHY STUDY MATHEMATICS?"	2	10	7	6
5. NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS, "EMERGING PRACTICES IN MATHEMATICS EDUCATION"	0	4	2	3
6. A REPORT OF THE INCORPORATED ASSOCIATION OF ASSISTANT MASTERS IN SECONDARY SCHOOL, "THE TEACHING OF MATHEMATICS"	0	3	1	2
7. RAVIELLI, ANTHONY, "AN ADVENTURE IN GEOMETRY"	0	2	2	1

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS
3. SURVEYS AND GENERAL, CONTINUED.				
8. SCHORLING, RALEIGH, "MATHEMATICS TO THE CONSUMER"	4	19	9	6
9. NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS, "MULTI-SENSORY AIDS IN TEACHING MATHEMATICS"	2	5	2	5
10. OTHERS	5	26	14	21
4. MATHEMATICS IN TRADES AND PROFESSIONS.				
1. AXELROD, AARON, "MACHINE SHOP MATHEMATICS"	0	3	3	3
2. COOKE, NELSON M., "MATHEMATICS ESSENTIAL TO ELECTRICITY AND RADIO"	0	4	1	0
3. SLADE, S., "MATHEMATICS FOR TECHNICAL AND VOCATIONAL SCHOOLS"	0	5	5	5
4. SHUSTER, C.M. AND BEDFOR, F.L. "FIELD WORK IN MATHEMATICS"	0	3	2	3
5. PROGRESSIVE EDUCATION ASSOCIATION, "MATHEMATICS IN GENERAL"	0	1	1	0
6. OTHERS	2	4	3	2
THE MATHEMATICS ROOM (LABORATORY):				
THIS IS A ROOM FOR MATHEMATICS CLASSES AND FOR CERTAIN PRACTICAL WORK AND EXPERIMENTS.				
1. DO YOU HAVE A SPECIAL MATHEMATICS ROOM(S) IN YOUR SCHOOL?				
YES	0	4	0	2
NO	35	63	23	24

TABLE XXX (CONTINUED)

QUESTIONNAIRE:	SCHOOL SIZE CATEGORY 1 - 3 TEACHERS	4 - 6 TEACHERS	7 - 10 TEACHERS	OVER 11 TEACHERS
PART III, CONT'D.				
2. INDICATE THE ITEMS OF EQUIPMENT OR APPARATUS YOU HAVE AVAILABLE FOR USE IN YOUR ROOM OR SCHOOL.				
1. CHART CASE (S)	2	3	3	1
2. SHELVES	20	40	15	21
3. MAGAZINE RACK	13	29	11	9
4. CUPBOARDS	19	39	15	19
5. BULLETIN BOARDS	32	50	20	22
6. EXHIBIT CASES	1	4	1	6
7. DEMONSTRATION BENCH	5	12	2	6
8. DUPLICATOR	30	55	21	23
9. MOTION PICTURE PROJECTOR	30	59	21	22
10. PROJECTION LANTERN	17	42	17	15
11. PENCIL SHARPENER	33	63	23	25
12. RADIO	28	42	16	12
13. WOODEN COMPASS	33	62	23	23
14. DEMONSTRATION PROTRACTOR	32	61	23	23
15. DEMONSTRATION SLIDE RULE, 4'	3	10	4	8
16. LINER	16	30	7	8
17. METER AND YARD STICK	33	63	23	23
18. SLATED GLOBE	6	11	2	5
19. TRIANGLE 30^0 - 60^0	25	47	17	19
20. TRIANGLE 45^0 - 90^0	19	46	13	19
21. T - SQUARE, LARGE	12	29	9	15
22. BALANCES AND WEIGHTS	27	54	18	19
23. CALIPERS	11	30	11	13
24. TAPE, 50' OR 100'	9	22	9	11
25. DRAWING SETS	5	19	3	7
26. FRENCH CURVES SET OF 6 OR 8	0	9	1	3
27. MICROMETER SCREW	9	28	11	12
28. PARALLEL RULERS	1	6	5	4
29. PANTOGRAPH	5	7	2	2
30. PROPORTIONAL DIVIDERS	1	1	0	0
31. SURVEYOR'S LEVEL	0	0	0	2
32. MODELS (ELLIPSOID, ETC.)	8	18	5	10
33. PICTURES (OF MATHEMATICIANS)	1	3	2	1
34. MISCELLANEOUS CHARTS RELATED TO MATHEMATICS	2	8	4	6