THE OBJECTIVES OF THE MATRICULATION MATHEMATICS PROGRAM IN NEWFOUNDLAND AND LABRADOR, AS PERCIEVED BY SECONDARY AND POST-SECONDARY MATHEMATICS EDUCATORS

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THE OBJECTIVES OF THE MATRICULATION MATHEMATICS PROGRAM IN NEWFOUNDLAND AND LABRADOR, AS PERCEIVED BY SECONDARY AND POST-SECONDARY MATHEMATICS EDUCATORS

by

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ABSTRACT

The study was undertaken to investigate the perceptions of three groups of educators with respect to the relative importance of 18 objectives for the secondary school matriculation mathematics program in Newfoundland and Labrador. The three groups of educators were the instructors of first year mathematics at Memorial University, the instructors of mathematics at trade and vocational schools in Newfoundland and Labrador, and the teachers of matriculation mathematics at schools in Newfoundland and Labrador.

Attempts were made to ascertain if any differences existed among the three groups of educators in their perceptions of the relative importance of the objectives. It was also sought to determine if there were differences in the ranking of the objectives between those secondary school teachers who had completed a minimum of 10 university mathematics credits and those who had completed fewer than 10 such credits. Finally, a comparison was made between the rankings of the post-secondary instructors and those of similar groups of instructors in a study by Mercer (1975).

A questionnaire was developed comprising pair-wise comparisons of the objectives. Individual and test-retest

reliability checks resulted in acceptable levels of consistency.

From the data analysis it was concluded that there was a wide difference in opinion among the respondents, both within and between the three groups studied. Of the three groups, there was most agreement within the university group, and least within the group of matriculation mathematics teachers. Significant differences at the 0.05 level were found between the preference score correlations of the two post-secondary instructors, and also between those of the trade school group and the secondary school group. In general, the secondary school group exhibited a position "between" the two post-secondary groups in their perceptions of the objectives. No difference was found between the secondary school teachers who had completed 10 university mathematics credits and those who had completed fewer than 10 such credits, as to their perceptions of the objectives. Finally, general agreement was observed between the rankings of the post-secondary groups and those of the corresponding groups in Mercer's 1975 study.

Based on these results, recommendations concerning the involvement of the three groups in the curriculum development process were made. Also, it was recommended that teachers take care in considering the needs of all types of students in their classes.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM

Mercer's 1975 study compared the opinions of two groups of mathematics educators (namely, a group of 20 randomly selected mathematics instructors from the Newfoundland trade schools and a similar group of mathematics instructors at Memorial University of Newfoundland) with respect to their rank-orderings on a set of 18 objectives for secondary school mathematics. Comparisons were made on both cognitive and content dimensions. The 18 objectives comprised a pair of objectives from each of nine content areas, one of each pair being at a higher cognitive level and the other being at a lower cognitive level. It seems plausible that the information gained by comparison of the perceptions of these two groups should be enhanced by similar comparisons with the perceptions of high school mathematics teachers in Newfoundland and Labrador. Teachers, after all, "are ultimately responsible for curriculum reform" (Gearhart, p. 493). They implement the objectives of any curriculum. As Taba (1962) stated, "the functioning curriculum is in the hands of teachers" (p. 239). Indeed, the importance of teacher input in curriculum development is undeniable.

In a study by Robbins (1973) the opinions of secondary school geometry teachers in Newfoundland were compared to those of a group of university educators in Canada and the United States with respect to the objectives of deductive geometry in the secondary school. The respondents were presented with a list of 35 objectives and asked to rate each objective along a scale of 1 to 5, 1 being the most important and 5 being the least important. The 35 objectives encompassed a range of cognitive levels. The results of the studies by Mercer and Robbins indicated both similarities and differences in the perceptions of the objectives of high school mathematics courses among the groups studied.

It seems reasonable to assume that the comparison of certain subgroups of high school mathematics teachers would yield useful information if one bears in mind the diversity of this group of teachers. For instance, the opinions of teachers with different mathematics backgrounds might be compared.

In this study the intent was to compare the opinions of teachers of mathematics in Newfoundland and Labrador high schools with those of teachers of mathematics at the trade schools and at Memorial University, pertaining to the objectives of secondary school mathematics, using methods similar to Mercer (1975). However, a study which merely compared the opinions of high school mathematics teachers in 1980-81 with those of the post-secondary instructors in Mercer's 1975 study, pertaining to the objectives of high school mathematics, would have led to some difficulties. In Mercer's study the post-secondary mathematics instructors ranked the objectives based on their perceptions of the high school mathematics program as it existed in the academic year 1974-75. In the fall of 1975, a "tri-level" mathematics program was introduced into Newfoundland and Labrador high schools. Hence, it would not have been sufficient to inquire of the high school teachers as to their perceptions of the objectives of the high school program without being more specific with regard to the "level" within that program. Furthermore, the comparison of the opinions of post-secondary instructors in 1975 with those of high school teachers in 1980-81 would have led to questionable results and implications. Also, the list of objectives used in Mercer's study needed to be revalidated, and altered if considered necessary.

It is desirable, when studying the opinions of high school mathematics teachers pertaining to the objectives of the mathematics program, to consider all the courses offered in the high school. It is highly probable that the objectives of the three courses offered in Newfoundland and Labrador high schools (i.e., the honours, matriculation, and basic courses) would be perceived to be different, as well they should. It is, from a practical point of view, however, unrealistic to expect a group of post-secondary instructors to complete accurately a lengthy questionnaire in triplicate as to their opinions of the objectives of three different mathematics courses offered in the high school. Considering these factors, it was decided to compare the opinions of various groups of mathematics instructors as to the objectives of the high school mathematics program completed by most students who eventually enrol in mathematics courses at post-secondary institutions in Newfoundland and Labrador.

According to the Provincial Department of Education, 929 students in the province of Newfoundland and Labrador were registered in the grade XI honours mathematics course, 6076 were registered in the matriculation course, and 2036 were registered in the basic course during the academic year 1978-79. Hence, approximately 67% of the grade XI student population during that year were registered in the matriculation mathematics program. In the fall of 1979, 325 students out of a total of 1275 who were enrolled in first year mathematics courses at Memorial University came from an honours mathematics background in grade XI. Most of the remaining 950 students would have completed a grade XI matriculation mathematics course. Furthermore, since a purpose of the study was to investigate any differences that might occur in the opinions of teachers with varying mathematical backgrounds, the teachers of the honours course would have likely presented a biased group, since it was thought to be highly probable that only a few of these teachers would have what would be considered a weak mathematical background.

As for the basic course, very few students taking mathematics courses at the university level would have taken this route, even though some students at the trade schools would have a basic mathematics background at the high school level. Considering these facts, it was decided to compare the opinions of mathematics instructors from the high schools, trade schools, and Memorial University, as to their perceptions of the objectives of the secondary school matriculation mathematics course.

Mercer (1975) indicated that within the group of university instructors there seemed to be varying opinions as to the rankings of the objectives, and he suggested that this was possibly due in part to differences in the levels of mathematics being taught by these instructors. In other words, those who were teaching first year courses may have perceived the objectives of the high school program differently than those who were teaching higher level courses. Therefore, for purposes of this study, the respondents at Memorial University were limited to those who were currently teaching first year mathematics courses.

Statement of the Problem

A rank-ordering of a set of objectives for the secondary school matriculation mathematics program in Newfoundland and Labrador was established for three groups of mathematics instructors. This was done to determine the relative importance of each objective for the matriculation mathematics program, as perceived by (a) the instructors of first year mathematics courses at Memorial University of Newfoundland, (b) the mathematics instructors at the various trade schools throughout Newfoundland and Labrador, and (c) the teachers of the matriculation mathematics program throughout the province of Newfoundland and Labrador. The purposes of this study were:

(1) to compare the above rank-orderings in order to determine any similarities or differences relating to the perceptions of the three groups of educators on the relative importance of the objectives for the matriculation mathematics program.

(2) to compare the rank-orderings of those teachers of the matriculation mathematics group who had completed a minimum of 10 university mathematics semester credits with those of teachers of the matriculation mathematics group who had completed fewer than 10 such credits.

(3) to compare the rank-orderings of each group of post-secondary instructors in Mercer's 1975 study with

those of the corresponding group of post-secondary instructors in the present study.

More specifically, answers were sought to the following questions:

(1) How do instructors of first year mathematics at Memorial University rank a set of 18 objectives from the matriculation mathematics program?

(2) How do instructors of mathematics at trade schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

(3) How do teachers of matriculation mathematics at schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

(4) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

(5) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of first year mathematics at Memorial University with respect to the objectives of the matriculation mathematics program?

(6) Is there any significant difference between the rankings of instructors of first year mathematics at

Memorial University and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

(7) Is there any significant difference between the rankings of teachers of matriculation mathematics who have completed a minimum of 10 university mathematics credits and those of teachers of matriculation mathematics who have completed fewer than 10 such credits?

(8) How are the rankings of the post-secondary instructors in Mercer's 1975 study, pertaining to the objectives of secondary school mathematics, related to those of the post-secondary instructors in the present study, pertaining to the objectives of secondary school matriculation mathematics?

The methods of analysis used to provide answers to these questions are described in Chapter III.

Definition of Groups

For purposes of this study the groups whose opinions were studied were defined as follows:

1. Group of University Mathematics Instructors: the group of mathematics instructors at Memorial University of Newfoundland who were teaching at least one first year mathematics course during the fall semester of 1980.
2. Group of Trade School Mathematics Instructors:

the group of mathematics instructors at the College of Trades and Technology, the district vocational schools and the College of Fisheries, who were teaching at least one mathematics course during the fall of the academic year 1980-81.

3. Group of Matriculation Mathematics Teachers: the group of teachers of secondary school mathematics throughout the province of Newfoundland and Labrador who were teaching a minimum of one class in the grade X or XI matriculation mathematics program, as set down by the Newfoundland Department of Education, during the academic year 1980-81.

Limitations of the Study

Firstly, this study was limited to the opinions of educators with respect to the objectives of the matriculation mathematics program as it existed in the academic year 1980-81. No attempt was made to discuss the objectives of the basic or honours courses.

Secondly, the interpretation of the results of this study were limited to the groups taking part, namely, the teachers of matriculation mathematics in Newfoundland and Labrador schools, the instructors of first year mathematics courses at Memorial University of Newfoundland, and the mathematics instructors at the various trade schools throughout the province. No attempt was made to generalize beyond these groups.

Thirdly, the list of objectives used in the study was not exhaustive. The content areas represented a cross-section of those topics suggested in pertinent literature, and paralleled those listed by Mercer (1975). The list of objectives used by Mercer was validated by a group of mathematics educators in 1975, and the complete list of objectives used in the present study was revised and revalidated by a similar group of educators. Furthermore, it was not intended in this study to determine a definitive list of objectives for the matriculation mathematics program in the secondary school.

Finally, it was intended to compare the opinions of the three groups of mathematics educators as to the objectives of the existing matriculation mathematics program in Newfoundland and Labrador schools, and to compare the rankings of the groups of post-secondary instructors with those of the corresponding groups investigated in Mercer's 1975 study. It was not intended to make judgements as to which group's opinions were most valid, but only to compare the opinions. However, it is recognized that the lack of objectives concerned with topics such as statistics and probability and others relating to the use of calculators and computers constitute a limitation of the study.

Outline of Report

In this chapter the nature of the problem, together with a justification of the need for the study, were discussed. Some limitations of the study were also described. In Chapter II the literature pertinent to the study is reviewed. In Chapter III the methods employed in the collection of the data and in its analysis are summarized. In Chapter IV the results of the analysis of data are presented. Chapter V includes a summary of the conclusions reached based on the results of the study, together with some implications of these results.

CHAPTER II

REVIEW OF THE LITERATURE

In this chapter the literature is reviewed with respect to (1) the delineation of the broad goals of mathematics education; (2) the translation of these broad goals into more specific objectives in curriculum development; (3) considerations in the formulation of specific instructional objectives; (4) discussion of recent developments in mathematics education; and (5) consideration of the importance of teacher input into curriculum.

Background--The Question of Preparation of Students for University and for Society

Over the past 25 years there has been dissatisfaction in the engineering schools and university mathematics and science departments concerning the seemingly poor preparation of freshmen. The School Mathematics Study Group, for example, met in 1958 to consider the need to provide for an improved curriculum for the schools that would preserve mathematical skills and techniques and deepen the understanding of underlying mathematics. They also sought to wrestle with the problems of furnishing materials for the preparation of teachers and of making mathematics more interesting

(NCTM, 1970, p. 273). The Commission on Mathematics of the College Entrance Examination Board in 1959 used the following quote to express concern about the pressing need for mathematical manpower (Bidwell & Clason, 1970):

> We are moving with headlong speed into a new phase in man's long struggle to control his environment. . . . We need an ample supply of high caliber scientists, mathematicians and engineers. . . . We need quality and we need it in considerable quantity. (p. 677)

One of the major forces that contributed to the ideas expressed by the Cambridge Conference and other mathematical study groups in the early 1960's was the success of the Russian Sputnik experiments. This challenged the technological leadership hitherto accredited to the United States and in turn kindled new impetus on the importance of the study of mathematics and the natural sciences in the United States (NCTM, 1970, p. 135).

The "new mathematics" movement which began in the late 1950's evoked some negative reaction, notably from Kline (1958). From the outset of the movement he criticized many aspects of the newer programs, especially in the areas of rigor and abstraction.

Through the 1950's, the 1960's, and the 1970's the problem of preparing university freshmen for post-secondary mathematics and ultimately for society with its continually expanding needs has remained with us. The present matriculation mathematics course must prepare many Newfoundland

and Labrador students for university and for society.

The Overall Goals for Mathematics Education

The writings of a number of educators in the field of mathematics education were reviewed with the intent to illustrate from this literature what the overall goals, as they see them, should be for students of mathematics. Lists of goals were extracted from the writings of various educators, namely, Johnson and Rising (1967), Butler, Wren, and Banks (1970), Watson (1972), Bassler and Kolb (1971), and Krulik and Weise (1975). These lists may be found in Appendix A.

The lists of goals obtained from these sources have many similarities. For instance, each of the writers listed certain goals which may be described as utilitarian in that they describe outcomes which students should attain for everyday living; for example,

> The student should be familiar with basic concepts, operations and relationships, skills in manipulation and computation for vocational needs, intelligent citizenship and daily living. (Watson, 1972, p. 537)

Each list of goals also includes elements of understanding the nature of mathematics, and how effective mathematical thinking can help students to conceptualize and solve problems; for example,

> To develop proficiency in using mathematical models to solve problems. (Krulik & Weise, 1975, p. 13)

> The student should be able to interpret, apply and examine the relevance of using a specific mathematical model in a situation from the physical and intellectual environment. (Bassler & Kolb, 1971, p. 44)

There is also an element of the affective domain of behaviour in each list of goals, including ideas of appreciation of mathematics, both in its own right and as a tool for intellectual independence and achievement; for example,

> The student develops attitudes and appreciations which lead to curiosity, initiative, confidence and interests. (Johnson & Rising, 1967, p. 13)

> Development of cultural advancement through a realization of the significance of mathematics in its own right and in its relation to the total physical and social structure. (Butler, Wren & Banks, 1970, p. 43)

In short, there is relative agreement among the various educators concerning the broad goals of mathematics education. All lists of goals contain certain utilitarian and content-related elements, certain process and problem-solving features, and some aesthetic and affective aspects. A discussion of more specific objectives applied to curriculum development follows.

A Discussion of Objectives in Curriculum Development

The broad goals of mathematics education described above can be satisfied only if students acquire certain knowledge, skills, and techniques. Taba (1962) described specific objectives in the following manner:

> The chief function of the more specific platform of objectives is to guide the making of curriculum decisions on what to cover, what to emphasize, what content to select and which learning experiences to stress. This level, in other words, contains the heart of the educational objectives in their usual sense, and clarification of the functions of objectives on this level is essential to arriving at a serviceable guide to curriculum development. Naturally these more specific objectives should be consistent with the general overarching ones and in their totality express the vision of the general aims. (p. 197)

Perhaps the most important function of objectives is that of guiding the decisions pertaining to the selection of content and learning experiences. These objectives should reflect the more general broad goals of instruction, whether they be in mathematics, social studies, or any other subject area.

While it is generally agreed that there should be a framework of broad goals for mathematics, and there are many similarities in such lists given by different educators and writers on the subject of mathematics education with respect to the high school program, there is a wide difference in opinion with respect to the content necessary in secondary school mathematics courses to enhance the attainment of these goals.

In the outline for grades IX to XII put forward by the Cambridge Conference on School Mathematics (1963) such topics as geometry and topology of the complex plane, linear algebra, calculus, probability, and analysis were recommended. Although not advocating the accumulation of as many abstract concepts at the same level of abstraction as did the Cambridge Conference writers, Fehr (1974) recommended a very highly structured, theoretical course, comprising such topics as sets, relations, functions, operations, and a modern viewpoint of geometry as a study of spaces related to algebraic structures. The level of sophistication for students should be the variable, according to Fehr, and not the content, when considering different "levels" in secondary schools.

At the other end of the spectrum there are educators such as Eilber (1968), who advocated the inclusion of topics in the secondary mathematics curricula such as the historical growth of major mathematical concepts, mathematical forms in nature, computers and their social significance, and a unit on famous men of mathematics. Eilber was concerned with the impact of mathematics on the future historian, musician, teacher of English, or any other mathematical layman. He stated:

> These are—all too frequently—intelligent, educated, professional people admitting openly and sometimes proudly that they know nothing about civilized man's greatest achievement. (p. 49)

Educators such as Eilber advocate that college preparatory mathematics should contain topics taught from a cultural and historical approach. He emphasized:

> In producing such a situation we have been selling short the subject of mathematics by not including the effects of its cultural impact. We should strive for mathematical courses which are meaningful, relevant, and of lasting significance not only in their own right, but for the broadened insights they provide into almost every corner of human thought. (p. 49)

There are certainly wide differences in opinion on what should be the content of high school mathematics programs. It must be remembered, however, that while this disagreement exists today as it did years ago, many of the broad goals of mathematics instruction may be met with a wide variety of content, and hence a wide variety of specific objectives relating to the content of mathematics courses may enhance the attainment of these goals.

The Question of Relevance in Curriculum

Mathematics educators generally attempt to choose course content which is as relevant as possible for students. This is an appropriate consideration at this point, since there seems to be relative disagreement on the content that will be useful in the formulation of objectives which will help to achieve the overall goals of mathematics instruction.

Bruner (1970) alluded to relevance in curriculum when he wrote:

> What is taught should be self-rewarding by some existential criteria of being "real", or "exciting", or "meaningful". On the other hand, what is taught should have some bearing on the grievous problems facing the world . . . the solutions of which may affect our survival as a species. (p. 114)

This is a strong statement, but worthy of consideration in the total philosophy of education. How does "relevance" relate, however, to the more specific objectives and the content required to meet them?

It is appropriate to first define and discuss the term "relevance" before considering the relevance of any particular topic in the curriculum. According to Kleinjans (1971):

> Relevance is a link forged in the mind, not a natural attribute of facts. It is making knowledge out of information or experience by connecting it to something else in such a fashion that it becomes meaningful or consequenceful. (p. 8)

Kleinjans concluded that attempts must indeed be made to make our curricula more relevant, but it must be remembered that the idea of relevance has many properties. For example, relevance is individual in nature, which suggests that relevance cannot be given easily to students in general. This implies that the question "relevance to whom?" should be considered when attempts are made to make curricula relevant. Are educators considering relevance to the student, or relevance to society in general? Kleinjans described relevance as being fluid or transitory. This suggests the consideration of questions such as "relevance to when?" in the designing of relevant curricula. What was relevant to the past, for example, may not always be relevant to the future. Kleinjans described other properties of relevance, including its plurality, its intricacy, and its unpredictability, in portraying the task of educators to make courses relevant. It is important to consider these aspects of relevance when trying to make mathematics courses "relevant" for as many students as possible. It is worthy of note that making curriculum decisions based on relevance is a most complex process.

Russell (1974) argued that no information, and no discipline, can possibly be relevant to everything or everybody: information can only be relevant to some particular subject or to some particular question. He emphasized that attempts to find a universally accepted standard of relevance would probably, if pursued, put an end to almost all types of knowledge. He condemned interpreting relevance as anything which has a short term visible utility. He stated:

> It is necessary to the vitality of any society that it have room for some activities which are not immediately designed to increase our gross national product. (p. 62)

Marshall (1974) held a similar opinion. He concluded:

> Those who cry relevance . . . are children, ignoring an opportunity to concentrate on learning and understanding that will find a place not immediately, but later. It is virtually impossible to learn anything that will not be of use somewhere, sometime. No mature person worth his or her own salt will ever know half enough even about his own special field of work, to feel satisfied. (p. 375)

Such considerations of relevance are essential in order to keep in perspective the choices of content which will be used to formulate specific objectives for curricula.

Some Considerations in the Formulation of Specific Objectives

Taba (1962) stated various principles to guide the formulation of objectives. She noted, for example, that objectives should describe both the kind of behaviour expected and the content or the context to which that behaviour applies. Also, they need to be stated specifically enough so that there is no doubt as to the kind of behaviour expected, or to what the behaviour applies. Too often, she said, objectives lack the clarity and concreteness necessary to be translated into educational practice.

Tyler (1949) noted that in curriculum development, the most useful form of stating objectives is to express them in terms which identify both the kind of behaviour to be developed in the student and content in which this behaviour is to operate. He stated:

> It should be clear that a satisfactory formulation of objectives which indicates both the behavioural aspects and the content aspects provides clear specifications to indicate just what the educational job is. By defining these desired educational results as clearly as possible the curriculum-maker has the most useful set of criteria for selecting content, for suggesting learning activities, for deciding on the kind of teaching procedures to follow, in fact to carry on all the further steps of curriculum planning. (p. 62)

This leads to the problem of clarity and specificity. Krathwohl (1965) described three levels of detail in referring to educational objectives, the most general being most relevant to program planning, the intermediate level to curriculum development, and the most specific to instructional development. He noted that each level of analysis permits the development of the next more specific level, thus reinforcing the importance of the more general goals. He observed that it is usually possible to obtain agreement only on the more abstract levels. This is consistent with the literature reviewed earlier in this chapter, since there was relative agreement on the broad goals and relative disagreement concerning the specific content-related objectives of secondary school mathematics. Since the intermediate level of specificity has been recommended in the delineation of the objectives of a course or series of courses, this level was most applicable to the objectives which were used in this study. Mercer (1975) also used this level of specificity in delineating his list of objectives.

Krathwohl also recommended the use of Bloom's Taxonomy of Educational Objectives in the analysis of objectives at the intermediate curriculum-building level. Wood (1967) supported the use of Bloom's taxonomy in the cognitive domain. He pointed out:

> It is particularly relevant in mathematics where most significant behaviors appear to have cognitive origins. (p. 86)

Mercer incorporated the use of cognitive levels in accordance with Bloom's taxonomy in his list of 18 objectives for the 1975 study, and these objectives were revised for use in the present study.

Recent Developments in Mathematics Education

Recommendations included in the report of the Cambridge Conference and by Fehr (1974), resulting in a high-powered, theoretical, and abstract mathematics secondary school program, have not been totally implemented, but the mathematics upheaval of the 1960's has produced different mathematics courses (the "new mathematics"), and there are various opinions as to the strengths and weaknesses of these "modern" mathematics courses. For example, Carpenter, Coburn, Reys, and Wilson (1975) reported on the first National Assessment of Educational Progress

(NAEP) in which representative samples of nine-year-olds, thirteen-year-olds, seventeen-year-olds, and adults between the ages of 26 and 35 were assessed to determine their levels of attainment in mathematical concepts and skills. This assessment took place during the academic year 1972-73. The weaknesses of the thirteen and seventeen-year-olds tended to be in the area of problem-solving skills, and the habits of checking and estimating seemed to be lacking. The writers pointed out, however, that the popular belief, that newer mathematics programs result in a lower level of achievement in computation, was false. In fact, the thirteen and seventeen-year-old age groups did about as well as the adults on most computational tasks.

Carpenter, Corbitt, Kepner, Lindquist, and Reys (1980) reported on the second NAEP asesssment, carried out in the academic year 1977-78. The results of this assessment indicated an overall decline in performance for seventeen-year-olds since the 1972-73 assessment. They pointed out continuing weakness in the areas of problem-solving and estimation. Assessments such as these which have uncovered some disturbing weaknesses among students ultimately led to what is known as the "back to basics" philosophy.

The writers of the report on the first NAEP assessment cautioned that the "back to basics" philosophy along with retrenchment in mathematics education in the face of accountability procedures could very well lead to over-emphasis on number and symbol manipulation skills. Indeed, the "back to basics" philosophy has evoked a cautious reaction from a number of mathematics educators and organizations, including the National Council of Teachers of Mathematics (NCTM) (1978) who, in their reaction to this movement, stated:

> In a total mathematics program, students need more than arithmetic skill and understanding. They need to develop geometric intuitions as an aid to problem-solving. They must be able to interpret data. Without these and other mathematical understandings citizens are not mathematically functional.
>
> Yes, let us stress basics, but let us stress them in the context of total mathematics instruction. (p. 147)

The position of the NCTM concurred with an earlier position paper published by the National Council of Supervisors of Mathematics (1977). This group identified 10 basic skill areas which they felt were appropriate for mathematics curricula in schools. These were (1) problem-solving, (2) applying mathematics to everyday situations, (3) alertness to the reasonableness of results, (4) estimation and approximation, (5) appropriate computational skills, (6) geometry, (7) measurement, (8) reading, interpreting, and constructing tables, charts and graphs, (9) using mathematics to predict, and (10) computer literacy. They stressed that any effective program of basic mathematical skills must be directed not back, but forward to the essential needs of adults in the present and future.

Perhaps the most widely read report on mathematics education of the 1970's is the Overview and Analysis of School Mathematics, Grades K - 12, submitted by the National Advisory Committee on Mathematics Education (NACOME). The goal of the committee was to answer the following questions:

> 1. What are the predominant American patterns of curriculum content and instructional style, and to what extent do these current practices represent a realization of the goals of recent innovative efforts?
> 2. What do research and general achievement testing data say about the effectiveness of current programs in reaching their goals?
> 3. What are the challenges facing mathematics education in the near future, and what research development and implementation activity is needed to meet these challenges? (Hill, 1976, p. 441)

Hill (1976), who chaired the NACOME committee, described some of the major issues incorporated in it. One of the most critical issues, according to NACOME, was the "back to basics" philosophy. NACOME urged the mathematics education community to consider carefully the long-range impact if the pendulum swings back to skills without understanding, especially in the light of recent calculator availability. Furthermore,

> NACOME recommends that no later than the end of grade 8 all students should have access to a calculator for all mathematics work. (p. 443)

Hill also pointed out the concern of NACOME that students of mathematics should receive a much higher degree of statistical literacy in their mathematics education. The importance of pre-service and in-service teacher education was also emphasized.

The NACOME report evoked reaction from many mathematics educators. Taylor (1976) voiced his general agreement with the report, particularly in the areas of computer and calculator use in the secondary school mathematics curricula, even though he cautioned that some problems inherent in the use of calculators (availability, security, power sources, etc.) must be given consideration before their widespread use. He showed concern also about the unqualified nature of the recommendation that calculators be available for ALL students for ALL mathematical work from the ninth grade onwards. He pointed out that we should not be quick to over-react to the use of the mini-calculator because of its growing widespread availability, noting that we may tend to make students completely dependent on a machine that is not always immediately accessible.

Trimble (1976) suggested a follow-up to the NACOME report in the area of teacher education incorporating some of the ideas of Polya in "drafting the laws of learning and teaching" (p. 466). Trimble indicated his general agreement with the NACOME report, both in content and style.

Kline (1976), who has often criticized newer mathematics courses for their level of abstraction and rigor, voiced his general support. He did criticize recommendations concerning the inclusion of structure as an objective, and included some of his ideas that mathematics should be less theoretical and more a function of the real world from which it comes. He stated:

> I not only recommend the report but wish to express my agreement with it and to stress some major points made in it. (p. 449)

In the curriculum area, the NACOME report recommended an increased awareness of the importance of statistical and computer literacy, problem-solving skills, as well as caution concerning the "back to basics" philosophy. The most controversial and surprising recommendation concerned the use of the mini-calculator in schools. Although most educators tend to accept this recommendation with caution, as does Taylor, to whom earlier reference has been made, there exists a great challenge for all mathematics educators in the use of the mini-calculator.

Many other educators, such as Machlowitz (1976), Maor (1976), Hiatt (1979), Szetela (1979), and Bell (1978), showed how calculators can be used to help teach abstract mathematical concepts as well as to assist in the usual utilitarian functions of calculation. Usiskin (1978) summarized his feelings with respect to calculator use when he stated:

> Insisting that all children must be excellent pencil-and-paper calculators puts the emphasis in the wrong place— on the means, rather than on the ends, of calculation. The ability to use the

> results of calculation is what we should expect from those who have completed their study of arithmetic. (p. 413)

Many would agree with Taylor (1976) when he observed that "calculators are a fact of life, and instruction in mathematics must take full advantage of their potential" (p. 459).

The National Council of Teachers of Mathematics (NCTM) (1980) put forth the following recommendations for school mathematics in the 1980's:

> 1. problem solving be the focus of school mathematics in the 1980's;
> 2. basic skills in mathematics be defined to encompass more than computational facility;
> 3. mathematics programs take full advantage of the power of calculators and computers at all grade levels;
> 4. stringent standards of both effectiveness and efficiency be applied to the teaching of mathematics;
> 5. the success of mathematics programs and student learning be evaluated by a wider range of measures than conventional testing;
> 6. more mathematics study be required for all students and a flexible curriculum with a greater range of options be designed to accommodate the diverse needs of the student population;
> 7. mathematics teachers demand of themselves and their colleagues a high level of professionalism;
> 8. public support for mathematics instruction be raised to a level commensurate with the importance of mathematical understanding to individuals and society. (p. 1)

These recommendations by the NCTM supported the earlier ideas of NACOME and others, regarding emphasis on problem solving, the expanded definition of basic skills, as well as the use of computers and calculators in the mathematics curricula of the 1980's.

From the literature reviewed thus far, there is relative agreement on the broad goals of mathematics instruction, and relative disagreement on the choice of content which will best achieve these goals and make mathematics curricula "relevant" for as many students as possible. Recommendations for the mathematics curricula of the future include an increased emphasis on problem solving, estimation, and computer literacy. It is also suggested that the potential of the mini-calculator as a teaching aid should be further explored.

The Importance of Teacher Input in Curriculum Development

Since it was the intention of this study to compare the opinions of teachers with those of other groups, it was considered appropriate to discuss the importance of teacher input in curriculum.

Vaughn (1976) indicated clearly her views on the importance of teacher input in curriculum when she said:

> Although many elements are involved in curriculum development . . . only in recent years has serious consideration been given to the involvement of the key

> component of the education process, the classroom teacher. While publishing firms, parent organizations, community groups, and students can make and have made significant contributions toward including meaningful goals in the development of curriculum, those persons responsible for the effective implementation of curriculum goals—the teachers—have often been denied an opportunity to participate in curriculum development. (p. 21)

Taylor (1976) expressed his view that teachers are a functionally important group in making curriculum decisions when he asserted:

> The concerns of classroom teachers are influencing the shift in emphasis in mathematics curriculum development. I feel that in the future, significant teacher input will be an essential component in any successful curriculum development efforts. (p. 463)

Teachers have undeniable first-hand experience in what is functionally happening in the curriculum. They ultimately control what is taught and how it is taught. A teacher may change the approach of a particular textbook, for example, if he or she feels it is necessary in order to meet what he or she perceives to be an objective of the course being taught. In fact, textbooks are often criticized by teachers because of their lack of direction as to the objectives of the course they present. Egsgard (1978) alluded to this problem when he emphasized:

> It is unusual to find a junior high school teacher among the authors (of junior high school mathematics textbooks). The same is true for most texts for the senior high

> school level. . . . One of the main reasons why our textbooks are not more effective is that they are being written by people who do not know what is going on in the classrooms for which they are writing. (p. 555).

The Organisation for Economic Cooperation and Development (OECD) (1975) in its Handbook on Curriculum Development, published by the Centre for Educational Research and Innovation, placed a great deal of importance on the role of the teacher in curriculum development. As the handbook stated:

> In short, the underlying idea is as follows: curriculum development should go in line with teaching; it should be the task of the teachers themselves working as a team, with the assistance of experts and advisors. (p. 106)

Furthermore, it was emphasized:

> Teachers are a significant filter between materials and students. The teacher's selections, attitudes, postures and language are potentially capable of modifying not only the specific curriculum objectives but the curricular ends themselves. (p. 105)

The observations which were made by this group (OECD) stem from studies of curriculum development and curriculum change in various OECD countries, both in Europe and in the United States and Canada.

There is little doubt that teachers are deeply involved in curriculum development and are ultimately responsible for the implementation of curriculum reform and the meeting of curriculum objectives. As the National

Advisory Committee on Mathematics Education (NACOME) (1975) recommended, cooperation between teachers, colleges of education, and others is essential for continued improvement of mathematics curricula. The report stated:

> Colleges of education, professional mathematics organizations, accredited agencies of teacher certification, and the mathematics community must cooperate to produce mathematics teachers knowledgeable in mathematics, aware of, oriented to, and practised in a multitude of teaching styles and materials and philosophically prepared to make decisions about the best means to facilitate the contemporary, comprehensive mathematics education of their students. Further, the above bodies, together with local school boards and organizations representative of teachers must continually facilitate the maintenance of teachers' awareness of and input to current programs and issues. (p. 139)

Before any such cooperation can exist in curriculum improvement, these interested groups should be given the opportunity to show what their perceptions are with respect to the objectives of mathematics courses in our schools. This study can provide at least a starting point in the quest for such cooperation in curriculum development in Newfoundland and Labrador secondary schools, applied to the matriculation mathematics course.

Summary

In this chapter a review of literature relevant to the purposes of the study has been presented. Included in the discussions were considerations of the broad goals of mathematics education, the translation of these goals into more specific curricular objectives, some considerations in formulating these objectives, and a discussion of the role of the teacher in curriculum development. The methods used in the collection of data for the study, and an outline of the statistical procedures employed in the analysis of the results are described in Chapter III.

CHAPTER III

DESIGN OF THE STUDY

In this chapter a description of the instrument used, together with an outline of the sampling procedures, is presented. The methods and statistical analysis which were employed in an attempt to answer the questions put forth in the study are also described.

Sampling Procedures

In the study, comparisons were made between the rankings of three groups of educators. It was necessary to obtain a list of educators in each of the three groups from which to select a representative sample of respondents for each of the three groups. A description follows of the procedures utilized in acquiring these samples.

A list of instructors teaching first year mathematics courses was obtained through the Department of Mathematics at Memorial University of Newfoundland. Since the list comprised a total of 30 instructors it was decided that sampling was unnecessary, and each instructor was sent a questionnaire to complete. In the case of the trade school and high school groups, however, it was decided to obtain a sample of 50 instructors from each group using procedures described below.

A list of trade and vocational schools was obtained from the Provincial Department of Education. There were 19 in all. A letter was sent to the principal or academic head of each of these institutions, requesting the names of all instructors engaged in teaching at least one mathematics course at his or her institution. A stamped return envelope was enclosed. Responses were received from 18 of the 19 institutions, yielding a total of 81 trade school mathematics instructors. From this list of 81 a random sample of 50 instructors was selected using a table of random numbers. This sample included trade school instructors from institutions throughout Newfoundland and Labrador, including the College of Trades and Technology, the College of Fisheries, Navigation, Marine Engineering and Electronics, the Bay St. George Community College, and the various district vocational schools.

A list of schools which offered grade X and/or XI was also obtained from the Department of Education. From this list of 207 schools a random sample of 50 was chosen using a table of random numbers. A letter was then sent to the principal of each of these 50 schools (28 secondary schools and 22 all-grade schools), requesting a list of teachers on the staff of his or her school who were engaged in teaching at least one class of grade X or grade

XI matriculation mathematics. A stamped return envelope was enclosed, as with the letter to the trade school principals. Responses were received from 45 of the schools. Of the five schools from which no response was received, four were listed as offering K to X, and the other was listed as offering K to XI. It was assumed that the 93 teachers obtained by this procedure were representative of those teachers who were teaching matriculation mathematics in grade X or XI during the 1980-81 school year. The final sample of 50 teachers of matriculation mathematics was obtained from this list of 93 using a table of random numbers.

The List of Objectives

In Mercer's 1975 study an initial list of 35 objectives was obtained after reference to literature pertinent to the needs and abilities of secondary school mathematics students. After modification and validation by a group of mathematics educators at Memorial University of Newfoundland, a final list of 18 objectives was reached in an attempt to present as comprehensive a list as possible for purposes of the study.

The final list comprised two objectives from each of nine content areas, one being a low-cognitive objective and the other being a high-cognitive objective. The low-cognitive objectives related to the abilities to know, manipulate, compute, and translate, and the high-cognitive objectives related to the abilities to interpret, analyze, transfer, and synthesize. The content areas were (1) Systems of Numbers, (2) Measurement, (3) Geometry, (4) Graphs, (5) Algebraic Expressions and Sentences and their Solutions, (6) Relations and Functions, (7) Probability and Statistics, (8) Logic, and (9) Applications. The level of specificity chosen as being the most appropriate for these objectives was the intermediate level as described by Krathwohl (1965), to which earlier reference has been made in Chapter II of this report.

Since one of the aims of this study was to compare the rankings of the post-secondary mathematics instructors in Mercer's 1975 study with those of the post-secondary instructors in this study, it was thought to be desirable to use a list of objectives in this study which was similar to that used by Mercer. It was indicated, however, in the review of literature in Chapter II of this report that certain recommendations made during the mid-1970's and in 1980 ought to be considered in delineating the final list of objectives to be used in the study. More specifically, emphasis on the areas of statistics and computer literacy and calculator use were recommended by NCTM, as well as by the writers of the NACOME report and others.

Because of these recommendations certain alterations in Mercer's 1975 list of objectives were considered in order to incorporate these ideas into the final list of objectives to be employed in the study. There appeared to be two alternatives if this was to be done: (1) the addition of objectives to the list of 18 employed by Mercer to include content areas of computer literacy and calculator use; and (2) the alteration of some of the objectives in Mercer's list to incorporate the areas of computer literacy and calculator use.

If the first alternative had been chosen, some problems of instrumentation would have been encountered. Since a method of paired comparisons similar to that of Mercer was to be used in the analysis of data, each respondent was to make a choice for 153 distinct pairs of objectives if there were 18 objectives in the final list. If two more objectives had been added, the number of choices for each respondent would have been increased to 190. If four more objectives had been added, making a total of 22 objectives in the final list, there would have been 231 distinct pairs for each respondent to consider. This alternative was thereby thought to be unrealistic.

Consideration was also given to the second alternative, that of altering a number of the objectives in Mercer's list. After careful examination of the 18 objectives, it was thought that the objectives dealing with systems of numbers could have been altered to include the use of the calculator with respect to computation, and the objectives dealing with probability and statistics could have been altered to incorporate the areas of computers and computer literacy.

It was felt, however, that such alterations would have caused some difficulties in the analysis of the data. Firstly, changing the objectives dealing with systems of numbers to include the use of the calculator would have substantially changed the content area and the theme of these two objectives so that a comparison between the results of the study with those of Mercer's 1975 study would have been difficult to justify. Also, the computational advantages of a calculator are not the only advantages described by various writers, nor are they necessarily considered the most important advantages. It was suggested by Szetela (1979) and others that calculators ought to be used in the teaching of trigonometry and other abstract mathematics. To extend these other objectives to include calculator use, however, would have made them very lengthy. Also, it was thought that it should be left to the teacher what techniques are appropriate for the attainment of these objectives. Furthermore, since the calculator is a relatively new aid in the classroom, it was determined that any choices made by respondents involving objectives dealing with calculator use would likely have been superficial.

With respect to extending the objectives dealing with probability and statistics to include the areas of computers and computer literacy, it was thought that this would have caused problems of interpretation of the objectives; for example, statistics do not necessarily imply the use of computers. Again, as with the use of the calculator, computers are relatively new in the high school, and hence it was felt that decisions involving their use may have been almost irrelevant in the minds of many mathematics educators at the time the questionnaire was to be distributed.

It was therefore decided to leave unchanged the main ideas in the 18 objectives used by Mercer in his 1975 study. It should be noted that it was not intended in this study to provide a definitive list of objectives for a matriculation mathematics program. It was merely intended that the objectives employed be representative of those suggested from various sources to be appropriate for the matriculation mathematics program, in order to serve as a basis for comparison among the groups of educators questioned.

It was considered, however, since the questionnaire to be used in the study was to be administered largely by mail, that it was necessary to consolidate each of the objectives used by Mercer into a more concise statement, without appreciably altering its context. These revisions were made under the guidance of a group of educators from

Memorial University of Newfoundland, until the final list was obtained. This list was thought to maintain the context of those objectives used by Mercer, and was deemed to be the most appropriate for the purposes of the study. The objectives, comprising two objectives from each of nine content areas, the first being a low-cognitive objective and the second being a high-cognitive objective, are listed below:

Systems of Numbers

1. To acquire the basic computational skills related to the real number system and its subsets, including associated algorithms.
2. To develop efficiency in computations through understanding of the operations and properties of the number systems.

Measurement

1. To develop a facility for measurement of length, area, volume, etc.
2. To develop understanding of precision and estimation in measurement, and their effect in interpreting solutions to problems.

Geometry

1. To state geometric properties dealing with such topics as similarity, congruence

and right triangles.

2. To develop an understanding of the structure of geometry, including the generation of geometric relationships from basic assumptions.

Graphs

1. To take a set of data, tabulate it, and present it in meaningful graphical form.
2. To analyze, interpret, and draw inferences from data presented in graphs and tables.

Algebraic Expressions and Sentences

1. To develop algebraic skills such as the use of algorithms, simplification of expressions and the solving of equations and inequalities.
2. To justify the sequence of steps used in any algebraic algorithm.

Relations and Functions

1. To represent the relationship between sets of numbers by using graphs, tables and algebraic or trigonometric sentences.
2. To recognize the concept of function as being relevant and unifying for the various branches of mathematics.

Probability and Statistics

1. To apply the basic principles of probability and statistics such as mean, mode and standard deviation.
2. To interpret statistical data for the purpose of making inferences or drawing conclusions.

Logic

1. To follow the steps in a given proof by comprehending the sequence of the premises and conclusions involved.
2. To carry through a consistent argument to a valid conclusion.

Applications

1. To identify applications of mathematics to the physical sciences, industry, technology and consumerism.
2. To select appropriate mathematical procedures in order to help solve a specific real life problem.

The list of objectives used by Mercer in his 1975 study are included in Appendix B.

Description of the Questionnaire

Each of the 18 objectives was assigned a number, and each number from 1 to 18 was paired with each other number, yielding a total of 153 distinct pairs. These 153 pairs of numbers were listed on a sheet of paper, with the lower number in each pair first. Then every second pair of numbers was reversed so that the higher of the two numbers was listed first, thus yielding the list of pairs, 1,2; 3,1; 1,4; 5,1; etc. These pairs of numbers were then written on 153 small slips of paper. From this procedure a random list of the 153 pairs was obtained, which represented the order of presentation for the 153 pairs of objectives in the questionnaire. These pairs were assigned, nine to a page, to pages numbered 1 through 17. This procedure resulted in the 153 pairs of objectives arranged in random order, such that each of the 18 objectives was listed first in either eight or nine of the 17 pairs of objectives in which it appeared. Each respondent was presented with the pages in random order. An extra page, randomly chosen, was placed at the front of each questionnaire to serve as a check on internal consistency. The random order of the pages was altered to ensure that the duplicate of this first page was toward the end of the questionnaire. The data obtained from the second copy of the page were used in the analysis. An instruction and identification-data sheet was stapled to the front of the 18 pages of objectives, forming the 19-page instrument.

Each respondent was instructed to make a choice, for each pair of objectives, as to which of the two he or she considered to be the more important for the matriculation mathematics program in Newfoundland and Labrador, and to indicate that choice by writing a "1" or a "2" in a space provided to the right of each pair. A choice had to be made for each pair. The objectives were presented to the respondents as shown in this example:

1. To carry through a consistent argument to a valid conclusion. 2651

43 ___

2. To develop a facility for measurement of length, area, volume, etc. 7320

Respondents were asked to ignore the numbers typed after each objective and to the left of each answer blank, since they were for identification purposes only. The number after each objective was a disguised representation of the number associated with that particular objective in the original list, which may be found by reading the last and second digits respectively. Hence, the first objective above was objective 16 and the second was objective 3. The other two digits were varied each time the objective appeared in the questionnaire. The two digits to the left of each answer blank represented the computer card column on which the response was to be typed.

<u>Reliability of the Instrument</u>

Each respondent received a questionnaire containing one duplicate page, as described above in the discussion of the questionnaire. This provided one measure of response consistency. However, it was considered necessary to obtain more data with respect to the reliability of the questionnaire. Therefore, 13 high school mathematics teachers who were not members of the group of 50 selected as the sample of secondary school mathematics teachers were asked to complete the questionnaire twice, approximately four weeks apart. The two administrations were carried out during the week of December 10, 1980 and the week of January 12, 1981.

Collection of Data

Enclosed with each questionnaire was an explanatory letter, together with a stamped, return-addressed envelope. The 30 packages for the group of university instructors were delivered on November 21, 1980, to the Department of Mathematics at Memorial University for distribution. The remaining 100 were mailed on November 22, 1980, to the secondary school teachers and to the grade school instructors. During the week of December 10, 1980, an attempt was made to contact all those who had not responded. Those in the proximity of St. John's were contacted by telephone where possible, and the others around the province were sent a follow-up letter requesting their cooperation at their earliest convenience. Using the different methods of contacting people might have introduced a bias in the returns; however, it was felt that this possibility was preferable to that of a lower response rate. After allowing for some delay, the collection of questionnaires was terminated on January 23, 1981.

Methods of Analysis

Each completed questionnaire was unstapled, the pages put in order from 1-17, the duplicate first page of the original questionnaire was placed at the back, and then the questionnaire was restapled. The information from each questionnaire was typed on three computer cards, which were read into the computer for purposes of analysis.

The questions, previously listed in Chapter I, which this study sought to answer, were the following:

(1) How do instructors of first year mathematics at Memorial University rank a set of 18 objectives from the matriculation mathematics program?

(2) How do instructors of mathematics at trade schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

(3) How do teachers of matriculation mathematics at schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

(4) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

(5) Is there any significant difference between

the rankings of teachers of matriculation mathematics and those of instructors of first year mathematics at Memorial University with respect to the objectives of the matriculation mathematics program?

(6) Is there any significant difference between the rankings of instructors of first year mathematics at Memorial University and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

(7) Is there any significant difference between the rankings of teachers of matriculation mathematics who have completed a minimum of 10 university mathematics credits and those of teachers of matriculation mathematics who have completed fewer than 10 such credits?

(8) How are the rankings of the post-secondary instructors in Mercer's 1975 study, pertaining to the objectives of secondary school mathematics, related to those of the post-secondary instructors in the present study, pertaining to the objectives of secondary school matriculation mathematics?

A preference score for each objective was calculated for each respondent. The preference score for an objective represented the number of times that objective was chosen by the respondent over the other objectives. The maximum preference score was 17 and the minimum zero. The rankings for each group were obtained by using the following procedure:

(1) the preference scores for each objective were found for each respondent, (2) these 18 preference scores (one for each objective) were totalled for all respondents in each group of instructors, yielding a total group preference score for each of the 18 objectives, and (3) these scores provided the group rankings, rank number 1 representing the objective having the highest total group preference score, and rank number 18 representing the objective having the lowest total group preference score. Questions 1, 2, and 3 were answered with reference to these group rankings.

To answer questions 4, 5, and 6, pertaining to relationships between the rankings of the three groups of mathematics instructors, a correlation of the preference scores for each respondent with those for each other respondent was carried out. The correlational matrix describing this procedure is given in Figure 1. The procedure produces six distinct cells, enabling not only comparisons of the preference scores of each group of respondents with those of each other group, but also comparisons of scores within each group. A one-way analysis of variance was carried out on the correlations obtained in the six cells in order to determine any significant differences. An answer to question 7 was sought using procedures similar to the above, applied to the group of secondary school teachers, as described in Figure 2.

	2 3 4 . . . 18	19 20 . . . 49	50 51 . . . 73
1 2 3 . . . 18	Preference Scores by University Instructors correlated with each other (U X U)		
19 20 . . . 49	Preference Scores by Trade School Instructors correlated with those by University Instructors (T X U)	Preference Scores by Trade School Instructors correlated with each other (T X T)	
50 51 . . . 72	Preference Scores by Secondary School Teachers correlated with those by University Instructors (S X U)	Preference Scores by Secondary School Teachers correlated with those by Trade School Instructors (S X T)	Preference Scores by Secondary School Teachers correlated with each other (S X S)

FIGURE 1. Diagram of the correlational matrix for individual preference scores.

Note: Variables 1 to 18 represent individual preference scores by university instructors, variables 19 to 49 represent preference scores by trade school instructors, and variables 50 to 73 represent individual preference scores by secondary school teachers. (UXU), (TXU), (SXU), (TXT), (SXT), and (SXS) represent the various correlation comparisons in the respective cells.

	2 3 4 . . . 11	12 13 . . . 24
1 2 3 . . . 11	Preference Scores by Secondary School Teachers with 10 or more credits correlated with each other (S_1 X S_1)	
12 13 . . . 23	Preference Scores by Secondary School Teachers with fewer than 10 credits correlated with those by Secondary School Teachers with 10 or more credits (S_2 X S_1)	Preference Scores by Secondary School Teachers with fewer than 10 credits correlated with each other (S_2 X S_2)

FIGURE 2. Diagram of the correlational matrix for preference scores by secondary school teachers.

<u>Note</u>: Variables 1 to 11 represent individual preference scores by the group of secondary school teachers having completed a minimum of 10 university mathematics semester credits; variables 12 to 24 represent the preference scores by the group of secondary school teachers having completed fewer than 10 such credits. (S_1XS_1), (S_2XS_1), and (S_2XS_2) represent the various correlation comparisons in the respective cells of the matrix.

Because of the inherent differences in Mercer's 1975 study and the present study, comparisons between the corresponding groups of post-secondary instructors were made only in the light of the limitations involved. Spearman rank-order coefficients (ρ) were obtained from the ranks in order to make comparisons and to help provide an answer to question 8.

The results of the investigation described in Chapter III are presented in Chapter IV.

CHAPTER IV

ANALYSIS OF THE DATA

In this chapter the results of the data collection and the analytic procedures are presented. The questions listed in Chapter I are answered in relation to the results obtained.

Useable Data Received

Collection of the data took place between November 22, 1980 and January 23, 1981. Original samples consisted of 50 secondary school mathematics teachers, 50 trade school mathematics instructors, and 30 instructors of first year mathematics at Memorial University of Newfoundland. Thirty-two questionnaires were returned by the group of trade school instructors. However, one of these was not used, since the pages were restapled with the duplicate page omitted. Thus the questionnaires from 31 trade school instructors were utilized in the data analysis. Twenty-six secondary school teachers returned the questionnaire, but two of these questionnaires could not be used because of incompleteness. Eighteen questionnaires were received from the university mathematics instructors, all of which were useable in the data analysis.

Results of Reliability Testing

Test-retest correlations were found for the data received from 13 educators who completed the questionnaire on two occasions, approximately four weeks apart. These correlations were calculated using the preference scores that each individual placed on the objectives. The correlations, transformed by using the Fisher Z transformation, ranged from 0.68 to 1.00, with a mean of 0.90. This indicated a substantial agreement between the judgments over the four-week period. In the repeated-page individual consistency check, there was also substantial agreement. Out of a total of nine possible agreements, 10 of the 73 respondents had either four or five agreements, and the other 63 had between six and nine. The average was 7.3 agreements out of a possible 9, representing 81% agreement. It is worth noting that the respondents had to make a choice for each objective pair, even though in some cases such a choice was probably difficult to make. In these cases it is conceivable that choices were made almost arbitrarily, especially when the choice was between objectives which were considered by the respondent to be of almost equal importance. These consistency checks indicated an acceptable level of reliability for the instrument used in the study.

Overview of Analysis Procedures

The 73 questionnaires used in the data analysis yielded eight cases of skipped items out of a total of 11 169 judgments. A random response was made for each of these items for purposes of analysis.

Next, a set of preference scores was developed for each respondent. These consisted of a value for each objective from 0 to 17, corresponding to the number of other objectives over which each one was chosen. These data were combined for all members of each of the three groups of educators, and group mean preference scores were calculated for each of these groups, and for the entire sample of 73. These mean preference scores yielded the rankings for the list of objectives as perceived by each group. These rankings were used to provide answers to questions 1, 2, and 3.

The correlational procedure described in Figure 1 was applied to the preference scores, and analysis of variance procedures were employed to provide answers to questions 4, 5, and 6. Similar procedures as described in Figure 2 were used to provide an answer to question 7.

Finally, Spearman rank-order correlation coefficients (ρ) between the ranks obtained in this study and those obtained in Mercer's 1975 study were used to provide a basis for comparison in the discussion of question 8.

Results Pertaining to Questions 1, 2, and 3

Questions 1, 2, and 3 were stated as follows:

1) How do instructors of first year mathematics at Memorial University rank a set of 18 objectives from the matriculation mathematics program?

2) How do instructors of mathematics at trade schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

3) How do teachers of matriculation mathematics at schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

The sets of preference scores obtained from the respondents in each group were combined and averaged to yield the rankings of each of the three groups of educators described in questions 1, 2, and 3. In Table 1 the mean preference scores for each objective by each of the three groups of educators are presented. In Table 2 the corresponding rankings by the three groups are listed. A set of rankings with respect to content area was also obtained from the preference scores. These show how the respective groups of educators ranked each pair of objectives in the nine content areas. These ranks are given in Table 3.

In question 1 it was asked specifically how instructors of first year mathematics at Memorial University ranked the set of 18 objectives. From Table 2 it can be

TABLE 1

Mean Preference Scores for Each Objective for Each of the Three Groups

Objective	University (N = 18)	Trade School (N = 31)	Secondary School (N = 24)	Total Group (N = 73)
1. Number Systems - L	11.11	9.58	11.21	10.49
2. Number Systems - H	11.11	11.84	11.67	11.60
3. Measurement - L	4.11	9.52	7.96	7.67
4. Measurement - H	7.17	10.77	6.67	8.53
5. Geometry - L	7.28	5.35	6.75	6.29
6. Geometry - H	10.39	7.39	8.54	8.51
7. Graphs - L	6.17	8.74	7.75	7.78
8. Graphs - H	7.39	9.32	8.88	8.70
9. Algebra - L	14.22	8.94	11.79	11.18
10. Algebra - H	7.89	4.32	6.00	5.75
11. Functions - L	9.89	7.55	9.00	8.60
12. Functions - H	9.61	5.03	6.50	6.64
13. Probability - L	3.61	4.55	3.17	3.86
14. Probability - H	4.83	8.42	7.58	7.26
15. Logic - L	9.00	8.23	8.17	8.40
16. Logic - H	11.89	9.42	10.04	10.23
17. Applications - L	7.06	11.35	8.50	9.36
18. Applications - H	10.28	12.68	12.83	12.14
Mean - L	8.05	8.20	8.26	8.18
Mean - H	8.95	8.80	8.75	8.82

TABLE 2

Rankings of the Objectives by the Three Groups

Objective	University (N = 18)	Trade School (N = 31)	Secondary School (N = 24)	Total Group (N = 73)
1. Number Systems - L	3.5	5	4	4
2. Number Systems - H	3.5	2	3	2
3. Measurement - L	17	6	11	13
4. Measurement - H	13	4	15	9
5. Geometry - L	12	15	14	16
6. Geometry - H	5	14	8	10
7. Graphs - L	15	10	12	12
8. Graphs - H	11	8	7	7
9. Algebra - L	1	9	2	3
10. Algebra - H	10	18	17	17
11. Functions - L	7	13	6	8
12. Functions - H	8	16	16	15
13. Probability - L	18	17	18	18
14. Probability - H	16	11	13	14
15. Logic - L	9	12	10	11
16. Logic - H	2	7	5	5
17. Applications - L	14	3	9	6
18. Applications - H	6	1	1	1
Sum - L	96.5	90	86	91
Sum - H	74.5	81	85	80

TABLE 3

Rank Order of Preference Applied to Content Areas

Content Area	University (N = 18)	Trade School (N = 31)	Secondary School (N = 24)	Total Group (N = 73)
1. Number Systems	1	2	1	1
2. Measurement	8	3	8	6
3. Geometry	5	8	7	8
4. Graphs	7	4	5	5
5. Algebra	2	6	4	4
6. Functions	4	9	6	7
7. Probability	9	7	9	9
8. Logic	3	5	3	3
9. Applications	6	1	2	2

seen that the five highest-ranked objectives were, respectively, objective 9 (algebra, low-cognitive), objective 16 (logic, high-cognitive), objectives 1 and 2 (number systems), and objective 6 (geometry, high-cognitive). The lowest-rated objectives were, respectively, objective 13 (probability, low-cognitive), objective 3 (measurement, low-cognitive), objective 14 (probability, high-cognitive), objective 7 (graphs, low-cognitive), and objective 17 (applications, low-cognitive). With respect to content area, as illustrated in Table 3, the university instructors considered those objectives dealing with number systems, algebra, and logic to be most important, and those dealing with probability, measurement, and graphs to be least important. The sum of the ranks for the low-cognitive objectives was 96.5, and the sum of the ranks for the high-cognitive objectives was 74.5, thus indicating that the group of university instructors considered the high-cognitive objectives to be generally more important than the low-cognitive objectives.

In question 2 it was asked how the instructors of mathematics at the trade schools ranked the set of objectives. The five highest-ranked objectives were, respectively, objective 18 (applications, high-cognitive), objective 2 (number systems, high-cognitive), objective 17 (applications, low-cognitive), objective 4 (measurement, high-cognitive), and objective 1 (number systems, low-cognitive). The five lowest-rated objectives were, respectively, objective 10 (algebra, high-cognitive), objective 13 (probability, low-cognitive), objective 12 (functions, high-cognitive), objective 5 (geometry, low-cognitive), and objective 6 (geometry, high-cognitive). From Table 3 it can be seen that the trade school group of instructors considered those objectives dealing with applications, number systems, and measurement to be the most important, and those objectives dealing with functions, geometry, and probability to be the least important. The sum of the ranks of the low-cognitive objectives was 90, and the sum of the ranks of the high-cognitive objectives was 81, indicating that this group of instructors ranked the high-cognitive objectives higher overall than the low-cognitive objectives.

In Question 3 it was asked how the teachers of matriculation mathematics ranked the set of objectives. From Table 2 it can be seen that the five highest-ranked objectives were, respectively, objective 18 (applications, high-cognitive), objective 9 (algebra, low-cognitive), objective 2 (number systems, high-cognitive), objective 1 (number systems, low-cognitive), and objective 16 (logic, high-cognitive). The five lowest-ranked objectives were, respectively, objective 13 (probability, low-cognitive), objective 10 (algebra, high-cognitive), objective 12 (functions, high-cognitive), objective 4 (measurement, high-cognitive), and objective 5 (geometry, low-cognitive). From Table 3 it can be seen that the group of matriculation mathematics teachers considered those objectives dealing with number systems, applications, and logic to be the most important, and those objectives dealing with probability, measurement, and geometry to be the least important. The sum of the low-cognitive ranks was 86, and the sum of the high-cognitive ranks was 85, thus indicating no overall preference for either the high-cognitive objectives or the low-cognitive objectives.

Analysis Procedures Relating to Questions 4, 5, and 6

Questions 4, 5, and 6 were listed in Chapter I as follows:

4) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

5) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of first year mathematics at Memorial University with respect to the objectives of the matriculation mathematics program?

6) Is there any significant difference between the rankings of instructors of first year mathematics at

Memorial University and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

To provide answers to these questions, similarities and differences in the three sets of rankings presented in Tables 1, 2, and 3 were pointed out and a Spearman rank order correlation coefficient was then found for each pair of group rankings. These results are presented later in this Chapter in the sections dealing with questions 4, 5, and 6, respectively.

A more detailed analysis was carried out using the preference scores of each respondent. The correlational procedure described in Chapter III, and illustrated in Figure 1, was completed, enabling comparisons between groups as well as within groups. Firstly, after converting each correlation coefficient to a Fisher Z, the mean correlation within each group and between each pair of groups was calculated. These results are given in Table 4. The correlations generally were small, indicating that opinions varied substantially both within the three groups and between them. Nevertheless, the between-group correlations tended to be smaller than the within-group correlations, the smallest correlation being between the university group and the trade school group. The largest within-group correlation was among the university instructors and the smallest correlation occurred among the secondary

TABLE 4

Mean Correlations

	University Group	Trade School Group	Secondary School Group
University Group	0.35		
Trade School Group	0.08	0.27	
Secondary School Group	0.23	0.20	0.22

school teachers. In Table 5 a summary of a one-way analysis of variance, carried out using the Z-scores associated with the three sets of within-group correlation coefficients, is presented. These results indicated that there was a significant relationship between group membership and perception of the objectives.

Three analysis of variance procedures were then performed using the Z-scores associated with two sets of within-group correlations and the corresponding between-group correlations. More specifically, the Z-scores of the secondary school within-group correlations and those of the trade school within-group correlations were pooled, and were compared with the Z-scores of the between-group correlations for those two groups. The same procedure was

TABLE 5

Using the Z-scores of the Three Sets of Within-group Correlation Coefficients

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio	Probability
Between	1.90	2	0.95	7.08*	0.001
Within	119.8	891	0.13		

*reject at the 0.05 level of significance

repeated using the Z-scores between and within the secondary school group and the university group, and finally using the Z-scores between and within the trade school group and the university group. Essentially, this provided a pair-wise comparison among the three groups of mathematics instructors which could test for significant differences in perceptions of the objectives by each group. These results are presented in the next three sections.

Results Pertaining to Question 4

In question 4 it was asked if there is any significant difference between the rankings of the trade school instructors and those of the matriculation mathematics teachers. By observing the rankings of the two groups of instructors reported in Table 2, it can be seen that 12 of the 18 objectives differed by three or fewer ranks. This indicated that the two groups held similar perceptions as to the relative importance of these objectives. There was general agreement between these two groups on the relative importance of the objectives dealing with applications and number systems, and also on the relative non-importance of the objectives dealing with geometry and probability. On the other hand, there were also some marked differences in ranks. For example, objective 4 (measurement, high-cognitive) was ranked fourth by the trade school group and fifteenth by the secondary school group. From Table 3 it can be observed that the two objectives dealing with measurement, taken as a group, were ranked third by the trade school group, but were ranked eighth by the secondary school group. It can be seen from Table 2 that the trade school group showed more preference for the higher level objectives than did the secondary school group.

The Spearman rank-order coefficient (ρ) between the two sets of ranks was 0.65, indicating a significant positive correlation ($p < 0.01$) between the ranks of these two groups of instructors.

The results of the analysis of variance performed using the Z-scores of the within-group and between-group correlations are reported in Table 6. The preference scores by the group of trade school instructors differed significantly from those by the group of secondary school instructors ($p < 0.01$).

TABLE 6

ANOVA, Within vs Between, the Secondary School Group and the Trade School Group

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio	Probability
Between	0.853	1	0.853	6.76	0.01
Within	187.26	1483	0.1263		

These results indicated that there was a significant positive correlation between the ranks of these two groups, but analysis of the preference scores showed that there was significantly more agreement within these two groups than there was between them.

Results Pertaining to Question 5

In question 5 it was asked if there is any significant difference between the rankings of the matriculation mathematics teachers and those of the university mathematics instructors. By observing the rankings of the two groups, reported in Table 2, it can be seen that there was some commonality between these two groups of instructors, since 12 of the 18 objectives differed by three or fewer ranks. These two groups showed substantial agreement concerning the content areas, since it can be observed from Table 3 that in eight of the nine content areas, the ranks by the two groups differed by two or fewer ranks, and four of the content areas were ranked the same by the two groups.

There were also some noticable disagreements in the rankings. Objective 3 (measurement, low-cognitive) was ranked seventeenth by the university group and eleventh by the secondary school group. Objectives 17 and 18, dealing with applications, were ranked fourteenth and sixth by the university group, but were ranked ninth and first by the secondary school group. Objective 10 (algebra, high-cognitive) was ranked tenth by the university group and seventeenth by the secondary school group. It can be seen from Table 2 that the group of university instructors showed more preference for the high-cognitive objectives than did the group of secondary school teachers.

The Spearman rank-order coefficient (ρ) between the ranks by these two groups of instructors was 0.73, indicating a significant positive correlation ($p < 0.01$) between the two ranks.

The results of the analysis of variance performed using the Z-scores of the within-group and between-group correlations are reported in Table 7. The preference scores by the group of university instructors did not differ significantly from those by the group of secondary school teachers ($p < 0.05$).

TABLE 7

ANOVA, Within vs Between, the Secondary School Group and University Group

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio	Probability
Between	0.259	1	0.259	1.91	0.17
Within	116.30	859	0.1354		

These results indicated that there was a significant positive correlation between the ranks of these two groups, and analysis of the preference scores showed that there was no significant difference in the amount of agreement between the two groups and the amount of agreement within them.

Results Pertaining to Question 6

In question 6 it was asked if there is any significant difference between the rankings of the trade school instructors and those of the university mathematics instructors. By observing the rankings of the two groups of instructors, reported in Table 2, it can be seen that there was very little agreement between these two groups of instructors. Only six of the 18 objectives differed by three or fewer ranks. From the results reported in Tables 2 and 3 it can be observed that the groups agreed on the relative importance of the objectives dealing with number systems, and on the relative non-importance of those dealing with probability. The trade school group ranked those objectives dealing with applications and measurement much higher than did the university group. It can be seen from Table 2 that both groups generally preferred the high-cognitive objectives over the low-cognitive objectives, although more preference for the higher cognitive level was shown by the group of university instructors.

The Spearman rank-order coefficient (ρ) between the ranks by these two groups of instructors was 0.21, indicating that there was no significant agreement ($p < 0.05$) between the two sets of ranks.

The results of the analysis of variance performed using the Z-scores of the within-group and between-group correlations are reported in Table 8. The preference scores by the group of trade school instructors differed significantly from those by the group of university instructors ($p < 0.01$).

TABLE 8

ANOVA, Within vs Between, the Trade School Group and University Group

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio	Probability
Between	12.575	1	12.575	94.9	0.00
Within	155.529	1174	0.1325		

These results indicated that there was no significant correlation between the ranks of these two groups, and analysis of the preference scores showed that there was significantly more agreement within these two groups than there was between them.

Results Pertaining to Question 7

Question 7 was stated as follows:

7) Is there any significant difference between the rankings of teachers of matriculation mathematics who have completed a minimum of 10 university mathematics credits and those of teachers of matriculation mathematics who have completed fewer than 10 such credits?

It has already been indicated that the mean within-group correlations and between-group correlations were low. There was less agreement within the group of secondary school teachers than within either of the other two groups. In order to determine if there was any relationship between the number of mathematics semester credits completed by a teacher and the perceptions which that teacher had of the objectives of the matriculation mathematics program, a correlational procedure, similar to that utilized in testing for significant differences relative to questions 4, 5, and 6, was employed. The procedure is summarized in Figure 2.

The group of secondary school teachers was divided into two subgroups, the first consisting of 11 teachers who had completed a minimum of 10 university mathematics semester credits, and the second consisting of the remaining 13 teachers who had completed fewer than 10 such credits. Three distinct cells were used in the analysis: the preference scores of members of the first subgroup correlated with each other, the preference scores of members of the second subgroup correlated with each other, and the preference scores of members of the first subgroup correlated with those of members of the second subgroup. The Z-scores for the first two cells were pooled for comparison with those of the between-subgroup cell, using a one-way analysis of variance. The results of this procedure are summarized in Table 9. There was no significant difference between the correlations within the two subgroups and those across the subgroups. In other

TABLE 9

ANOVA, Within vs Between, Subgroups of Secondary School Teachers

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio
Between	0.0063	1	0.0063	0.17
Within	10.12	274	0.037	

words, those teachers who had completed 10 or more university mathematics semester credits did not differ in their perceptions with those who had completed fewer than 10 such credits. It should be noted, however, that there was little agreement within the group of secondary school teachers; in fact, the average correlation of preference scores for the total group of 24, after converting to Fisher Z's, was only 0.22. Hence, it was concluded that among the group of secondary school teachers, there was a substantial individual disagreement in perceptions of the objectives; no effect was observed resulting from the number of university mathematics credits completed by the respondents.

Results Pertaining to Question 8

Question 8 was stated as follows:

8) How are the rankings of the post-secondary instructors in Mercer's 1975 study, pertaining to the objectives of secondary school mathematics, related to those of the post-secondary instructors in the present study, pertaining to the objectives of secondary school matriculation mathematics?

It was possible to analyze this question only in the light of certain limitations. Firstly, this study encompassed objectives pertaining to secondary school matriculation mathematics, whereas Mercer's 1975 study did not specify a particular level (i.e., matriculation, honours, basic), since there was no distinction in this province between honours and matriculation mathematics until September 1975. Secondly, the group of university instructors who took part in Mercer's 1975 study were a random sample from the total group of university mathematics instructors (both senior and junior divisions) in the academic year 1974-75, while the group of university instructors who participated in this study included only those who were actively involved in teaching junior division mathematics in the 1980 fall semester. Thirdly, while the list of objectives used in this study closely paralleled that used by Mercer, each objective was rewritten using a more concise statement, and consequently certain objectives were altered in their scope and meaning. Nevertheless, each list comprised 18 objectives encompassing the same nine content areas, the first of each pair at a lower cognitive level than the second. Comparisons were made, within the framework of the limitations described, by using the Spearman rank-order coefficient of correlation (ρ), as well as by qualitative description.

The comparative rankings of the corresponding groups are presented in Table 10. The high-cognitive objectives dealing with algebra (objective 10 in each study) differed substantially in rank for both group comparisons, a difference of 13 ranks between the two groups of trade school instructors and a difference of seven ranks between the two groups of university instructors. The group of university instructors in 1975 ranked the low-cognitive objective dealing with measurement fifth, whereas the group of university instructors in the 1981 study ranked this objective seventeenth, a difference of 12 ranks. There was a nine-rank difference by the two university groups with respect to objective 12, the high-cognitive objective dealing with relations and functions. The two groups of trade school instructors exhibited a six-rank difference with respect to objective 5 (geometry, low-cognitive) and objective 16 (logic, high-cognitive). With the exception of these differences, the rankings of the corresponding groups in the two studies did not differ

TABLE 10

Comparative Rankings in Mercer's 1975 Study and the Present (1982) Study

Objective	Trade School Group 1975	Trade School Group 1982	University Group 1975	University Group 1982
1. Number systems - L	7.5	5	2	3.5
2. Number systems - H	6	2	6	3.5
3. Measurement - L	3	6	5	17
4. Measurement - H	4	4	15	13
5. Geometry - L	9	15	12	12
6. Geometry - H	14	14	10.5	5
7. Graphs - L	13	10	14	15
8. Graphs - H	10	8	7	11
9. Algebra - L	7.5	9	1	1
10. Algebra - H	5	18	3	10
11. Functions - L	12	13	9	7
12. Functions - H	15	16	17	8
13. Probability - L	18	17	18	18
14. Probability - H	17	11	16	16
15. Logic - L	16	12	10.5	9
16. Logic - H	11	7	4	2
17. Applications - L	2	3	13	14
18. Applications - H	1	1	8	6
Sum - L	88	90	84.5	96.5
Sum - H	83	81	86.5	74.5

$r_{\text{Trade School Groups}} = 0.67$ $r_{\text{Post-secondary, 1975}} = 0.49$

$r_{\text{University Groups}} = 0.64$ $r_{\text{Post-secondary, 1982}} = 0.21$

by more than four ranks with respect to each objective classification. The 36 corresponding group comparisons of the 18 objective classifications may be summarized as follows: seven corresponded exactly, six differed by one rank, eight differed by one-and-one-half or two ranks, four differed by two-and-one-half or three ranks, four differed by four ranks, and the remaining seven differed by more than five ranks. More generally, 25 of the 36 corresponding group comparisons (69.4%) differed by three or fewer ranks. The Spearman rank-order correlation coefficient between the rankings of the two trade school groups was 0.67, and between the rankings of the two university groups was 0.64, indicating a significant positive correlation ($p < 0.01$) in each case.

Upon calculation of Spearman rank-order coefficients between the ranks by the two 1975 groups of post-secondary instructors ($\rho = 0.49$) and between the ranks by the two 1981 groups of post-secondary instructors ($\rho = 0.21$), it was observed that a greater degree of agreement existed between the groups in 1975 than between the 1981 post-secondary groups. In 1975, for example, the two groups differed by three or fewer ranks with respect to 10 of the 18 objectives, whereas the two 1981 post-secondary groups differed by three or fewer ranks on only five of the 18 objectives.

These results indicated: 1) there was a degree of general agreement in rankings between the corresponding groups of post-secondary instructors who took part in the two studies, even though there were certain objective classifications which exhibited a relatively large rank difference; and 2) there was more agreement between the two post-secondary groups studied in 1975 by Mercer than between the two post-secondary groups who took part in this study. It should be remembered that these conclusions can be considered valid only in the light of the limitations previously described.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

In this chapter a summary of the study, including an outline of the problem investigated, the samples of educators involved, and the methods of data analysis, is given. Conclusions reached from the results of the study are listed, and some implications of these results are presented.

Outline of the Study

The study was undertaken to investigate the perceptions of three groups of educators with respect to the relative importance of 18 objectives for the secondary school matriculation mathematics program in Newfoundland and Labrador. The three groups of educators were the instructors of first year mathematics at Memorial University, the instructors of mathematics at trade schools in Newfoundland and Labrador, and the teachers of matriculation mathematics at schools in Newfoundland and Labrador. Attempts were made to determine differences in the perceptions of the relative importance of the objectives which existed among the three groups of educators. It was also sought to determine if there were differences in the ranking of the objectives between those secondary school teachers who had completed a minimum of 10 university mathematics credits and those who had completed fewer than 10 such credits. Finally, a comparison was made between the rankings of the post-secondary instructors and those of similar groups of instructors in a study by Mercer (1975). The questions to which answers were sought were as follows:

(1) How do instructors of first year mathematics at Memorial University rank a set of 18 objectives from the matriculation mathematics program?

(2) How do instructors of mathematics at trade schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

(3) How do teachers of matriculation mathematics at schools in Newfoundland and Labrador rank a set of 18 objectives from the matriculation mathematics program?

(4) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

(5) Is there any significant difference between the rankings of teachers of matriculation mathematics and those of instructors of first year mathematics at Memorial University with respect to the objectives of the matriculation

mathematics program?

(6) Is there any significant difference between the rankings of instructors of first year mathematics at Memorial University and those of instructors of mathematics at trade schools with respect to the objectives of the matriculation mathematics program?

(7) Is there any significant difference between the rankings of teachers of matriculation mathematics who have completed a minimum of 10 university mathematics credits and those of teachers of matriculation mathematics who have completed fewer than 10 such credits?

(8) How are the rankings of the post-secondary instructors in Mercer's 1975 study, pertaining to the objectives of secondary school mathematics, related to those of the post-secondary instructors in the present study, pertaining to the objectives of secondary school matriculation mathematics?

Mercer's list of 18 objectives, representing high and low cognitive levels from nine content areas, was revised and the new list validated. Each of these objectives was paired with each of the others, and the resulting 153 pairs of objectives were presented to the respondents on 17 pages, in random order. A randomly chosen duplicate page was included in each instrument as a check on response consistency. Respondents were asked to make a choice for each pair as to which objective he or she considered more important for the matriculation mathematics program in Newfoundland and Labrador.

The questionnaire was administered to 30 instructors of first year mathematics at Memorial University, 50 instructors of mathematics at trade schools in Newfoundland and Labrador, and 50 teachers of matriculation mathematics at schools in Newfoundland and Labrador. Useable data were received from 18 university instructors, 31 trade school instructors, and 24 secondary school teachers. As a further check on response consistency, 13 secondary school teachers, who were not members of the sample of 50 secondary school teachers, completed the questionnaire twice, approximately four weeks apart. The results of the individual repeated page consistency checks and the test-retest reliability checks indicated acceptable levels of consistency.

From the data analysis it was concluded that there was a wide difference in opinion among the respondents, both within and between the three groups studied. Of the three groups, there was most agreement among the university instructors and least among the secondary school teachers, and significant differences at the 0.05 level were found between the preference score correlations of the two groups of post-secondary instructors, and also between those of the trade school group and the secondary school group. The smallest correlations of preference scores and ranks occurred between the two groups of post-secondary instructors.

Some similarities among the three groups included relative agreement on the importance of the objectives dealing with number systems and on the non-importance of those dealing with probability and statistics. There was an overall trend to favour the high-cognitive objectives, varying from little effect for secondary teachers to a substantial effect for university instructors.

Virtually no difference was found between the group of secondary teachers who had completed at least 10 university mathematics credits and those who had completed fewer than 10 such credits, as to their perceptions of the relative importance of the objectives.

Finally, the comparison of the rankings of each post-secondary group with those of the corresponding group in Mercer's 1975 study indicated general agreement, despite some apparent dissimilarity in ranks, bearing in mind the inherent differences in the two studies. There was more agreement between the two post-secondary groups studied by Mercer (1975) than between the two post-secondary groups who took part in this study.

Discussion of Results, and Conclusions

In questions 1, 2, and 3 it was asked how the three groups of instructors ranked the objectives. The following conclusions were based on the three sets of rankings. The university group considered the objectives dealing with number systems, algebra, and logic to be most important, and those dealing with probability, measurement, and graphs to be least important. The trade school group considered the objectives dealing with applications, number systems, and measurement to be most important, and those dealing with functions, geometry, and probability to be least important. The secondary school group considered the objectives dealing with number systems, applications, and logic to be most important, and those dealing with probability, measurement, and geometry to be least important. There was an overall trend to favour the high-cognitive objectives over the low-cognitive objectives, varying from little preference by the secondary school group to a substantial preference by the university group.

It was not surprising that all three groups agreed on the relative importance of those objectives dealing with number systems, since underlying all mathematics there is a need for understanding the systems of numbers and their properties. One might conjecture that the agreement on the relative non-importance of probability and statistics was due to the absence of these concepts in current curricula in the high school and first year post-secondary courses.

It was not surprising that the university group ranked highly the objectives dealing with algebra and logic, considering the subject matter in university courses;

neither was it surprising that the university group ranked low the objectives dealing with measurement. It was expected that the objectives dealing with graphing might have been ranked higher by the university group, considering the content of first year mathematics courses at the university. Also, it was expected that the university group would have ranked higher those objectives dealing with relations and functions. It should be remembered, however, that the specific objectives included in the questionnaire were ranked, and not the objective categories. Different rankings might have occurred had different specific statements of objectives been used.

It might be concluded that the high ranking by the trade school group of the objectives dealing with applications and measurement was due at least in part to the content of the courses taught by these instructors. For example, in marine technology courses, calipers are used in order to determine areas and volumes. The low ranking by this group of those objectives dealing with geometry and functions could possibly be attributed to the fact that the statement of each of these objectives implied little or no sense of technical application, but rather described ideas or abstractions as ends in themselves.

By observation of the rankings of the objectives it appeared that, on the average, the opinions of the secondary school teachers seemed to be "between" the opinions of the two post-secondary groups, as to their perception of the relative importance of the objectives. In other words, the rankings of the secondary school group were closer to the rankings of the combined groups than were those of either of the two post-secondary groups of instructors. One might conjecture that this was due to the effect of the various influences on secondary teachers in preparing students for differing post-secondary institutions. One must also bear in mind that there were wide variations in the rankings by individual members of the group of secondary school teachers, thus possibly "averaging out" these wide differences.

It is also worthy of note that the university instructors generally ranked the high-cognitive objectives higher than either of the other two groups. The trade school group also showed a preference for the high-cognitive objectives, although the preference was not as marked as was indicated by the university group. One might have thought that the trade school group would have showed a preference for those objectives related to computation, knowledge, etc., in order to apply them directly to the trade and vocational courses. It was even more interesting to note that the secondary school teachers reflected almost no preference for the high-cognitive objectives. It would be very difficult to determine why this was the case, but a possible explanation was that secondary school teachers feel a need to teach "the facts" in order to help students pass the course, that they feel little time can be allotted to higher-level objectives, and perhaps this situation has an influence on their conceptualization of the objectives of the matriculation program. One must also bear in mind that post-secondary instructors, more particularly university instructors, were not dealing with as wide a range of student capability as were the secondary school teachers.

In questions 4, 5, and 6 it was asked whether there was any significant difference between the rankings of each pair of the three groups of instructors. Between each pair of ranks there were both general agreements and wide disagreements in the opinions of each group as to the relative importance of the objectives. The conclusions made on the basis of the rank-order correlations and analysis of variance of preference scores are summarized as follows.

With respect to the trade school instructors and the secondary school teachers, there was a significant positive correlation between the ranks of these two groups, but analysis of the preference scores showed that there was significantly more agreement within these two groups than there was between them.

With respect to the university instructors and the secondary school teachers, there was a significant positive correlation between the ranks of these two groups, and analysis of the preference scores showed that there was no significant difference in the amount of agreement between the two groups and the amount of agreement within them.

With respect to the two groups of post-secondary instructors, there was no significant correlation between the ranks of these two groups, and analysis of the agreement preference scores showed that there was significantly more agreement within these two groups than there was between them.

There was widespread general disagreement both within the groups and between the groups as to the perceptions of the relative importance of the objectives for matriculation mathematics, but the most agreement was among the university instructors, and the least agreement was between the two groups of post-secondary instructors.

Of the three between-group comparisons, most agreement was found between the university instructors and the secondary school teachers, since there was a significant positive correlation between the ranks of these two groups of instructors, and there was no significant difference between their preference scores. Neither of the other two between-group comparisons exhibited both of these results. By contrast, the two post-secondary groups showed the most disagreement, since there was no significant correlation between the ranks of these two groups of instructors, and there was a significant difference between their preference scores. This again shows the position of the secondary school teachers "between" the two post-secondary groups as to their perceptions of the objectives of the matriculation program. It could be conjectured that the closer relationship in the rankings between the group of university instructors and the group of secondary school teachers was possibly due to the university background of many of the secondary school teachers, and the lack of trade-oriented and practical applications in the present matriculation text books. The wide overall difference in perceptions suggested that there may have been many influences upon educators in conceptualizing the relative importance of the objectives of the matriculation mathematics program.

The fact that there was most agreement among the university instructors possibly resulted partly from the decision to use only the instructors of first year university mathematics courses. More disagreement might have been expected if these instructors had been selected from all the instructors of university mathematics.

In question 7 it was asked whether the secondary school teachers who had completed a minimum of 10 university mathematics credits ranked the objectives differently than those secondary school teachers who had not completed 10 such credits. By analysis of the preference scores it was concluded that there was no significant difference in the rankings by the two subgroups of secondary school teachers. It is worthy of note that of all the respondents considered in this study, both secondary and post-secondary, the group of secondary school teachers had the smallest within-group correlation of preference scores. In other words, they were the least homogeneous group of the three, even though no effect was observed with respect to the two subgroups described. This seemed to indicate that the number of mathematics credits completed by a teacher does not have a significant effect on that teacher's perception of the relative importance of the objectives of the matriculation mathematics course. It might have been expected that the opinions of these two subgroups would have differed, but the results of this study indicated the reverse. It should be remembered, however, that teachers are likely influenced by many factors in conceptualizing the objectives for a course, and the number of mathematics credits completed is only one of these factors.

In question 8 it was asked how the rankings of the post-secondary instructors in this study compared to those of the post-secondary instructors in Mercer's 1975 study. The following conclusions were reached: There was a degree of general agreement in rankings between the corresponding groups of post-secondary instructors who took part in the two studies, even though there were certain objective classifications which exhibited a relatively large difference. There was more agreement between the two post-secondary groups studied in 1975 than between the two post-secondary groups who took part in the present study. It should be remembered, however, that these conclusions can be considered valid only in the light of the differences in the two studies. The fact that the two post-secondary groups who took part in this study seemed to differ more in the rankings of the objective classifications than did those who took part in Mercer's 1975 study could possibly be due to the differences in the statements of the objectives in the two studies, rather than to a change in opinion of the post-secondary groups over the six-year period. Furthermore, those who took part in the present study ranked the objectives pertaining to the matriculation mathematics course, whereas those who took part in Mercer's study ranked them pertaining to a single secondary school mathematics program.

Implications and Recommendations

One significant aspect of the results of the study was that there was a wide difference in opinion among the respondents as to the relative importance of the objectives of secondary school matriculation mathematics. Overall, the group of secondary school teachers showed the most disagreement, and seemed to be "between" the two post-secondary groups with respect to the relative importance of the objectives. These results suggested that secondary school teachers have a wide difference in opinion among themselves, with respect to the relative importance of objectives for the matriculation mathematics program, and are likely influenced by a variety of very different factors in the conceptualization of these objectives. Some have opinions more like the "typical" trade school instructor whereas others are more like the "typical" university instructor.

Considering these results it is recommended firstly that individual secondary school teachers, whatever their personal opinions as to the objectives of the course, ensure that they attempt to meet the needs of all students enrolled in the matriculation mathematics program--those who will go to trade school, university, or elsewhere. Secondly, it is recommended that the Provincial Department of Education attempt to provide teachers with more specific guidelines as to the objectives of the matriculation mathematics course, in consultation with such groups as the trade school instructors and the university instructors. Thirdly, it is recommended that those committees responsible for mathematics curriculum and for giving advice to secondary school teachers concerning the mathematics curriculum include a variety of people to reflect the wide differences in opinion held by educators. These committee members must also attempt to express the various opinions of those they represent. A final recommendation is that studies be initiated concerning the objectives of the honours and basic mathematics programs.

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APPENDIX A

LISTS OF OVERALL GOALS OF MATHEMATICS EDUCATION

Johnson and Rising (1967) listed the following overall goals in the form of expected outcomes for the teaching of mathematics to the secondary student:

1. The student knows and understands concepts such as mathematical processes, facts and principles.

2. The student understands the logical structure of mathematics and the nature of proof.

3. The student performs computations with understanding, accuracy and efficiency.

4. The student has the ability to solve problems.

5. The student develops attitudes and appreciations which lead to curiosity, initiative, confidence and interests.

6. The student learns how to develop proper methods of learning mathematics and communicating mathematics, and also develops study habits essential for independent progress. (pp. 12-14)

Butler, Wren, and Banks (1970) indicated the following goals for mathematics education. We should strive for each student:

1. Competence in the basic skills and understanding for dealing with number and form.

2. Habits of effective thinking - a broad term involving analytical, critical and postulational thinking, as well as reasoning by analysis and the development of intellectual curiosity.

3. Communication of thought through symbolic expression and graphs.

4. Development of the ability to make relevant judgements through discrimination of values.

5. Development of ability to distinguish between relevant and irrelevant data.

6. Development of intellectual independence.

7. Development of aesthetic appreciation and expression.

8. Development of cultural advancement through a realization of the significance of mathematics in its own right and in its relation to the total physical and social structure. (p. 43)

The following overall goals were listed by Watson (1972):

1. The student should be familiar with basic concepts, operations and relationships, skills in manipulation and computation for vocational needs, intelligent citizenship and daily living.

2. The student should understand the nature of mathematics and appreciate the ability of human intelligence to invent and discover useful mathematical relationships.

3. The student should gain confidence and skill in using mathematical processes to interpret situations in his environment.

4. The student should have a familiarity with the internal nature of mathematics.

5. The student should be able to communicate with precise mathematical language.

6. The student should gain independence in learning mathematics and reading its literature.

7. The student should enjoy and have appreciation of intellectual pursuit and imaginative thinking. (p. 537)

Bassler and Kolb (1971) listed goals for mathematics education in three categories - content, process, and affective goals. They listed the following as content goals:

1. The student should have a knowledge of mathematical models that would permit manipulation and understanding of the learner's physical and intellectual environment.

2. The student should have skills in manipulation and computation of operations and relations in mathematical models which will be useful in his, the learner's, environment.

3. The student should have a language to clearly communicate with precision ideas about mathematical models which will be useful in his environment. (pp. 43-44)

The following are the process goals put forward by Bassler and Kolb which they saw as appropriate for all high school students:

1. The student should be able to interpret, apply and examine the relevance of using a specific mathematical model in a situation from the physical and intellectual environment.

2. The student should be able to abstract, idealize and formulate a mathematical model from a situation in the physical and intellectual environment.

3. The student should be able to discover new relationships or deduce new abstractions in an existing mathematical model and test its validity by logical inference.

4. The student should be able to transfer to other disciplines and successfully apply a repertoire of behaviors such as abstraction,

> formulation, induction, deductive proof, analysis, synthesis, and application of models. (p. 44)

These were followed by a list of four broad, affective goals:

> 1. Students should be made aware of the ability of human intelligence to invent and discover relationships whose application permits man to influence and order his environment.
>
> 2. Students should appreciate the ability of human intelligence to go beyond the known and observable part of his physical environment and engage in imaginative thinking.
>
> 3. Students should experience the enjoyment that can result from intellectual pursuit and a love of knowledge.
>
> 4. Students should see mathematics and mathematical activity as a substantial part of the cultural heritage of the human race that deserves the support and encouragement of society. (p. 44)

Krulik and Weise (1975) also listed some broad goals of mathematics education:

> 1. To achieve for each individual student mathematical knowledge appropriate for him.
>
> 2. To prepare each individual student for adult life, recognizing that some students will require more mathematical instruction than others.
>
> 3. To foster an appreciation of the fundamental usefulness of mathematics in our society, particularly with reference to understanding and improving man's environment.
>
> 4. To develop proficiency in using mathematical models to solve problems. (pp. 12-13)

APPENDIX B

LIST OF OBJECTIVES USED BY MERCER (1975)

Systems of Numbers

1. To acquire the basic computational skills related to the real number system and the subsets thereof, including various algorithms associated with these numbers.

2. To be able to achieve economy in computations by making use of available electronic calculators together with one's understanding of the structure and operations of the real number system.

Measurement

3. To develop a facility for measurement, with respect to determining length, area, volume, etc., and to the terminology and relations of various measurement systems.

4. To develop an understanding of the nature of measurement, relative to the notions of precision, accuracy, and estimation, and their effects in interpreting the meaning of a solution to a problem.

Geometry

5. To be able to apply the properties of geometric figures, such as similarity, congruency, the Pythagorean Theorem, etc., in the solution of a problem.

6. To develop an understanding of the structure of geometry, which includes the basic assumptions upon which geometry is built and how geometric facts and relations can be generated from these assumptions.

Graphs

7. To be able to take a set of data, tabulate it, and present it in meaningful graphical form.

8. To be able to analyze and interpret data as presented in graphs and tables and to draw inferences relevant to the solution of the problem under consideration.

Algebraic Expressions and Sentences, and their Solutions

9. To develop elementary skills in Algebraic manipulations, including the solution of inequalities and linear, quadratic, simultaneous, polynomial, logarithmic and exponential sentences, and the use of algebraic algorithms.

10. To be able to analyze and select the appropriate algebraic processes in problem solving.

Relations and Functions

11. To be able to represent the relationship between two sets of numbers by using coordinate graphs, tables, algebraic or trigonometric sentences.

12. To be able to recognize the concept of function as a relevant and unifying notion throughout the mathematical knowledge that one has acquired.

Probability, Statistics and Computer Literacy

13. To develop the ability to apply basic concepts and principles of probability, statistics and computer programming.

14. To develop the ability to interpret statistical data and computer programming for the purpose of making inferences or drawing conclusions.

Logic

15. To acquire the ability to follow proofs by comprehending the sequence of the premises and conclusions involved.

16. To be able to carry through a consistent argument to a valid conclusion.

Applications

17. To acquire familiarity with the applications of mathematics to the fields of the physical sciences, industry and technology, and consumerism.

18. To be able to select from his mathematical knowledge the necessary mathematics which can be applied to a specific real life situation.