THE UNIVERSITY OF ALBERTA

THE OBJECTIVES OF TEACHING MATHEMATICS IN THE JUNIOR HIGH SCHOOL

by

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A THESIS

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ABSTRACT

The purpose of this study was to investigate the perceptions of teaching mathematics in the junior high school by professors of secondary education at the universities in Alberta and secondary mathematics supervisors in Edmonton and Calgary; junior high school mathematics teachers in Ponoka, Lacombe and Red Deer counties; and a random sample of Grade IX students and parents of Grade IX students in the same counties. A questionnaire containing a list of fifteen objectives was prepared from the related literature. These objectives were ranked in the order of their importance by each person in the above groups.

All of the questionnaires that were returned by professors, supervisors, and teachers were used, but, from the parent and student questionnaires, stratified random samples were prepared.

The consensus rankings of the objectives by each of the groups and subgroups were obtained by summing the ranks of each objective for each group. The smallest sum of the ranks indicated the most important objective, and the next smallest sum indicated the second most important objective, and so on. Students, parents and teachers chose the same six objectives as being most important. Students and parents ranked these six in the same order which follows: mathematics in daily life, fundamental processes of mathematics, process

skills of mathematics, mathematical concepts, problem solving techniques, and developing the student's confidence in his ability. Teachers ranked them as follows: process skills of mathematics, mathematical concepts, problem solving techniques, fundamental processes of mathematics, mathematics in daily life, and tied in sixth place were developing the student's confidence in his ability and critical thinking. The six objectives which professors ranked most important were: process skills of mathematics, mathematical concepts, to foster enjoyment of mathematics, problem solving techniques, to develop the student's confidence in his ability, and structure. In all cases the cultural objectives seemed to be of secondary importance.

The Kendall coefficient of concordance W was used to determine the agreement within the groups and subgroups. In all cases the agreement was greater than it would have been by chance.

The Mann-Whitney U test was used to determine the significant differences among the rankings of the different groups and subgroups. The analysis showed significant differences in the rankings by the following pairs of groups: professors and students, professors and parents, professors and teachers, parents and teachers, parents and students, and teachers and students. The following pairs of student subgroups showed significant differences: students who liked mathematics and students who disliked mathematics, students who had chosen a vocation and students who had not chosen a vocation, and students who had chosen senior high school mathematics programs and those who had not. However, there were no significant differences among the rankings of objectives by boys and girls.

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CHAPTER I

INTRODUCTION

During the past two decades, a knowledge explosion has taken place and seems to be continuing at an accelerating pace. One of the most important factors contributing to this explosion is the unprecedented advance in the uses of mathematics. Theoretical mathematicians have produced new ideas, new theories, and new potential for breakthroughs in all branches of science. The astounding accomplishments in the physical sciences are creating new interpretations and new uses of mathematics. Perhaps of just as great importance are the "demands" made by the new users of mathematics.

Among these new users are life sciences, business administration, and social sciences which make use of the principles of mathematics. Biology applies these principles to genetics; business and industry apply them to schedule production and distribution; human behavior analysis applies the principles and properties of game theory. These new users require an interpretation of mathematics which is not supplied by traditional programs. They emphasize the structure of mathematics and its use as "a language in which hypotheses may be set up and tested (*The Mathematics Teacher*, May, 1959, p. 392)." The mathematical method of solving problems is applied to these fields--namely, constructing a mathematical model and analysing its essentials.

Howard Fehr (1968), in the preface to Modern Mathematics by Papy, sums up the impact of the new uses of mathematics on education by stating:

> Today as never before, schools are under greater pressure to teach more mathematics at an earlier age because of the steady growth in the applications of mathematics (Papy, p. v).

This statement raises a number of questions. Should everyone know this additional mathematical knowledge? Should it be obtained in vocational schools or in the public schools? Since it seems possible for a child to learn more mathematics at an earlier age, is it appropriate to teach the child more? What are the opinions of parents regarding introducing more mathematics earlier? How do students relate to the introduction of more mathematics earlier? What mathematics should be taught in schools to prepare students for a rapidly changing world? These are some of the questions raised by the impact of the new uses.

The Problems of the Study

It is the purpose of this study:

(1) to construct a list of objectives for teaching mathematics in the junior high school from the related literature;

(2) to determine the perception of these objectives as to relevancy and importance by groups of university secondary mathematics professors and mathematics supervisors, junior high school teachers, a sample of Grade IX students,

and a sample of parents of Grade IX students;

(3) to analyse and compare these perceptions as to priority, agreement within these groups, and agreement among these groups on the consensus rankings.

Definitions

(1) "Professors" refers to professors of secondary mathematics at the universities located in Edmonton, Calgary, and Lethbridge; and mathematics supervisors in Edmonton and Calgary schools.

(2) "Teachers" refers to those people teaching junior high school mathematics in the county schools of Red Deer, Lacombe and Ponoka counties.

(3) "Students" refers to a random sample of Grade IX students selected from the county schools of Ponoka, Red Deer and Lacombe counties.

(4) "Parents" refers to a random sample of parents of Grade IX students in the above counties.

Assumption

It was assumed that from an analysis of the literature, a list of objectives for teaching mathematics in the junior high school could be compiled.

Delimitations

(1) The study was restricted to the county schools of Red Deer, Lacombe, and Ponoka counties.

(2) No socio-economic data on the students' parents was collected.

(3) No data on the parents' education was collected.

(4) Teachers were not grouped according to sex or years of experience.

(5) There was no distinction made among aims, objectives and outcomes.

(6) No information was collected on the students' achievement in mathematics.

Limitations

(1) Responses from parents may have been biased by consultation with students.

(2) The generalizations regarding the student and parent perceptions are applicable to rural Central Alberta.

(3) The generalizations regarding teacher perceptions are applicable to rural Central Alberta.

The Need for the Study

Over the years, the sources of educational objectives have changed greatly in Canada and the United States. After 1900, objectives were formulated by subject matter specialists using the prevailing theories of the psychology of learning. Knowledge and skills were emphasized, and "little attention was given to the needs of society or the needs of the students (Tyler, 1968, p. 252)." However, in 1918, due to the success of psychological testing in job analysis in building vocational curriculums, curriculum makers sought the advice of psychologists on what behaviors should be taught, and subject matter became secondary in importance.

During the period from 1930 to 1957 the philosophy of Progressive Education was an important factor in educational policy. It emphasized "training students for a democratic life, and subject matter played a minor role (Broudy, 1968, p. 57)." At this time, the main purpose of teaching mathematics in Alberta was "to make meaningful much of the child's out-of-school experience (Outline of the Course of Studies, 1937-38, p. 88)."

At that time, according to Broudy (1968), a quiet technological revolution was gradually taking place. However, with the ascent of Sputnik in 1957, the public suddenly realized that Canada and the United States were lagging in the technological race. The Progressivists were condemned for lack of rigor and scope in mathematics and science courses. As a result of public criticism, committees of scholars and experts in mathematics set the mathematics curricula and texts. Little attention was given to studies of learners; specialists outlined what they thought were the important contributions of their fields which would be of value to laymen as well as persons specializing in their field (Tyler, 1968). Some attention was given to social demands, but little was given to the psychology of learning. Kline (1966) described the mathematics curricula as built up of "an isolated, self-sufficient, pure body of knowledge which is rigorously presented (p. 322)." In this way, the public's demands were appeased.

There were many criticisms of the mathematics course as it was outlined in these texts. Structure was stressed, and certain books were so technical and theoretical that some educators thought the "structure was overdone and poorly done (Klamkin, 1968, p. 133)." Then, also, so much attention was given to structure that the whole subject received a rather superficial study (Kleibard, 1965). However important structure is to the mathematician, it might not be appropriate for the majority of students to learn, as not all students are fascinated by the internal consistencies of mathematics (Mueller, 1967). Then, as a result of the stress on structure, the mathematics course did not meet the needs of students entering general education courses, for it was geared to top students who planned to specialize in mathematics (Alberty, 1966). For everyone who has made a career in mathematics, there are dozens for whom it is an "elegant tool (Bowen, 1966, p. 542)." Kline (1966) criticized the new mathematics course for its stress on terminology, the rigorous presentation of concepts, and the lack of applications. Kolb (1970) claimed that mathematics instruction "must be broadened to include goals in the affective domain (p. 261)." Students questioned the purpose of teaching concepts which they thought had no relevance to them now or in their future.

Another challenge to the mathematics course was the competition for time on the timetable from other worthwhile and much needed studies such as the exploratory courses and other major subjects (Kolb, 1970).

A job analysis carried out by Norman Laws (1966) on the requirements for skilled technicians in Michigan industries showed that a core of basic skills required by nearly all technicians included skills which were not included in "new mathematics" texts. However, although both employers and technicians agreed that more skills will be required in the future, no indication was given as to what these skills should be.

The Junior High School Mathematics Program in Alberta

After roughly five years of pilot studies, a "new mathematics" program was introduced into junior high schools in Alberta in September, 1967. Two series of texts were recommended: Seeing Through Mathematics and Exploring Modern Mathematics. There were three books in each series--one for each grade in the junior high school. Although first editions were the same as those used in the United States, later editions were "Canadianized" by changing American cities to Canadian cities.

In 1969 a new series, Contemporary Mathematics, was introduced into Alberta Junior High schools. In this series, the presentation of material was suited to "average and below average students (Department of Education Bulletin, 1969, p. 1)." If this series was especially suited to below average students, how much would an average student profit from it? Thus, none of the recommended texts was suitable for the average student.

The present objectives for mathematics in Alberta are:

(1) To develop an understanding of mathematical concepts;
(2) To develop skill in the use of the fundamental processes;
(3) To develop systematic methods of analyzing problems and of presenting their solutions;
(4) To develop habits of precise thought and expression;
(5) To develop an understanding of the significance and application of mathematics in the modern world (Curriculum Guide, Grade IX Mathematics, 1967, p. 1).

The above are some of the reasons for studying the objectives of teaching mathematics in the junior high school.

Summary of Chapter I

(1) The problem of this study was to investigate the perception of the objectives of teaching mathematics in the junior high school by groups of professors, junior high school teachers, Grade IX students and Grade IX students' parents.

(2) The groups were defined as professors, teachers, students, and parents.

(3) The assumption was that a list of objectives could be prepared from the literature.

(4) The delimitations indicated the restrictions placed on the study.

(5) The limitations indicated the generalizations that could be made from the study.

(6) The need for the study reviewed the criticisms of the new mathematics course.

(7) The junior high school mathematics program was outlined.

CHAPTER II

REVIEW OF THE LITERATURE

The literature related to this study is reviewed as follows:

(1) the criteria for educational objectives,

(2) the ranking system, and

(3) the objectives of teaching mathematics in the junior high school.

Criteria for Educational Objectives

The term "objectives" as used in education refers to the explicit formulation of ways in which students are expected to change during the education process. These include "changes in their thinking, their feelings and their actions (Bloom, 1956), p. 26)." Many changes can result from the learning experiences, but the school has limited resources and limited time in which to produce these changes. Consequently, the objectives must be clearly defined and incorporated into the learning experiences, so that time and energy are not wasted.

According to Tyler (1968) the process of determining objectives should consider "contemporary life, the student, the subject matter, the school's philosophy of education and the psychology of learning (p. 270)." The study of contemporary life should investigate the conditions and problems young people and adults encounter, as well as the opportunities for service and self-realization. Then, too, there ought to be projections into the future to determine to some extent how best to prepare for it. The study of the student should involve his needs, his interests and his present level of development. Subject matter specialists can make contributions regarding the potential of their field in education, the learning that results, and the contribution of their subjects to other subjects (Tyler, 1968).

The problem of selecting objectives and determining the emphasis that is to be placed on them depends upon the school's philosophy of education. What type of individual is the school trying to develop? What values are important? What attitudes are important? Finally, the objectives must be consistent with a psychology of learning. They must be feasible under existing or probable conditions in a given time with a particular group of students. A learning theory also enables the objectives to be appropriately placed in the learning sequence. It determines the relationship among objectives, and helps in discovering learning conditions under which the attainment of the objectives is possible (Tyler, 1968).

Downey (1960) adds another criterion to be used in selecting objectives. He (1960) states "the most important contemporary determiner of the task of education is the opinion of the public that the educational enterprise serves. The most confusion exists at this level (p. 4)." He also states that in recent years, adults have abandoned many of their responsibilities as parents, and entrusted these responsibilities to the school. Thus, the modern school has responsibility for the social, physical, moral, aesthetic, and vocational as well as the academic development of the nation's youth.

Some educators who consider public opinion an important factor in setting objectives believe that some consensus of opinion should be reached between educators and the public. Eshpeter (1970) states that there should be a comparison between the public's perception and the educator's perception. Cowan (1969) supports this by stating:

> The fact that schools are responsible to society does not imply they must yield to the demands of every vocal sub-public. Parental prescription of the task of educating youth might not be one which educators would adopt. However, the school and society must eventually arrive at consensus concerning the role of education. A logical place to start is with a survey of public opinion. Such an indication contributes to improved understanding and ultimately to necessary reforms (p.3).

A curriculum expert, Harold McNally, (1968) goes farther than involving parents, when he declares that "lay persons, students and parents, should take part in curriculum development wherever they can contribute (p. 186)."

Society is a dynamic, changing entity. If education is to be useful to society, it must change with society. Thus, the perceived tasks of education are constantly changing.

The Ranking System

In the ranking system, different degrees of importance are assigned to the objectives of the questionnaire. This is important when the data, to be of use, must be presented as "an aggregate of widely divergent opinions (Andrews, 1959, p.6)." The aggregates for the different objectives show the order of importance as expressed by a group, but do not show at what point the importance is so low that an objective should be omitted. On the bottom of a questionnaire returned by a parent the following comment was written, "The objectives I have numbered one, two, three are most important. The others don't really matter." This person believed that the objectives he had chosen as one, two and three were the only important ones, and his rankings of the rest were simply negative votes of varying weights. However, another person may believe that all of the objectives are important in the order which he has indicated.

The Objectives of Teaching Mathematics

A list of objectives was compiled from an analysis of the literature which dealt with the aims, purposes and objectives of teaching mathematics. The major reports on this topic were carefully reviewed and analysed. These included the objectives of teaching mathematics in all of the provinces in Canada as well as discussions of this subject in education journals. The National Council of Teachers of Mathematics and other study groups have set up a basic framework for modern mathematics programs (Monsour, 1965), and this has influenced the literature on the objectives of teaching mathematics. According to these groups, every modern mathematics program should:

(1) Give a good presentation on deductive reasoning and logical proofs of the basic rules or laws of algebra and geometry;
(2) Introduce adequate structure to mathematics, showing it as an organized body of knowledge generated from a finite number of basic assumptions;
(3) Balance the "why" and "how" of both theoretical and manipulative skills of the mathematics process;
(4) Define clearly and accurately the use of language and vocabulary of mathematical statements and expressions;
(5) Give unity to the ideas of functions, set and number systems, thus presenting a unified concept of the knowledge gained in the elementary grades;
(6) Make use of the discovery method in its presentation of material to enable the student to use his creative skills (Monsour, 1965, p. 43-44).

These, then, are guidelines for setting objectives for a modern mathematics course. In the discussion of literature which follows, the objectives are underlined.

To develop an understanding of mathematical concepts. While it is true that concepts are not sensory data; they are the results of numerous sensory experiences which are combined, generalized, and carefully developed (Gagne, 1965). How are concepts learned? Children learn meanings through direct experience involving the manipulation of materials, e.g., three cats, three books, etc. Finally they learn to use the word "three"; and later, after generalizing they are able to apply the concept "three" in any situation (Gagne, 1965). Thus the steps in concept forming are: sense perception, abstraction and generalization.

As children become more mature, and learning experiences become more complex, direct experiences involving manipulation and sense perception become less feasible. Since the learner no longer must have specific stimuli, "he can learn by means of instruction, because the words that he uses arouse concepts in his hearers or readers that operate just as his do (Gagne, 1970, p. 175)." Concepts have concrete referents, but they free thought and expression from the physical world. Thus, it is the learning of concepts that makes education possible.

How does a child discover how to add abstract quantities such as 2x + 3x? Instead of referring to the physical world, he uses his concept of multiplication such that 2x is the sum of two x's, and 3x is the sum of three x's, and his concept of coefficients to discover that 2x + 3x = 5x. Finally, he generalizes and evolves a rule for the addition of algebraic quantities (3 + 2)x = 5x. In this manner, he combines various concepts into principles or rules.

<u>To develop skill in the fundamental processes of arithmetic and algebra</u>. The fundamental processes in arithmetic and algebra are addition, subtraction, multiplication and division. Donovan Johnson (1967) states, "we need skills and a storehouse of facts, but the emphasis is on computation with understanding (p. 185)."

The literature regarding the development of skills in fundamental processes is contradictory. Rote memorization of rules and mechanical manipulation in computation are no longer considered satisfactory achievement because they do not produce "learning with understanding (Johnson, 1967, p. 185)." Some authorities believe that once the theory behind a skill is understood, little practice is needed to master the computation, and that "drill should be the exception rather than the rule (Cambridge Report, 1963, p. 16)." Speed in computation is discounted, but accuracy is demanded. A recent study by Miller (1970) on drill, indicates that students weak in arithmetic skills can improve with practice. Willoughby (1970) states that the available evidence suggests that a child can understand a skill without becoming adept at it; but if the skill is one in which he ought to become proficient, practice or drill is needed. Ausubel (1963) is in agreement with Willoughby that drill is necessary. He goes further by saying drill need not be rote. For practice to result in mastery of material, the task must be meaningful to the learner, who must want to learn and have sufficient background to master the skill. Finally, drill exercises must be prepared according to learning principles. The importance of processes to students is expressed in the <u>The Fifteenth Yearbook of the National Council of Mathematics Teachers</u> (1940), as follows: "Unless a pupil is able to use the processes with facility, mathematics will be a source of discouragement (p. 41)."

To develop methods of analysing problems and presenting their solutions. What is a problem? The Thorndike-Barnhart Dictionary (1955) definition of a problem is "a question; a difficult question; something to be worked out; a problem in arithmetic (p. 619)." Florence Jacobson (1968) states that a problem in mathematics:

> may mean an application to the physical sciences, or a question arising from some other discipline outside of mathematics that can be answered by mathematical methods. All would agree that active participation is sought . . . A problem must involve a student; he must search for an answer (p. 101).

Moreover, according to O'Brien (1956) the main features of a problem are:

> (1) something you want to get, and (2) some difficulty or obstacle to overcome which stimulates mental activity (p. 79).

Some educators believe that teaching a strategy for problem solving is of value. M. E. Lazerte (1963) states that there is positive value in teaching children the structure of problems, and critically analysing their method of attack. Bruner (1966), also, declares that "strategies are important in problem solving regardless of content. The suggestion from some writing is that they are of over-riding importance as a goal of education (p. 72)."

How does a child attack a problem? Butler and Wren (1965) note that in order to solve a problem, the student should be able to do the things required, and that he must decide what things need to be done and in what order. Each of the recommended texts in Alberta provides a pattern for procedures as well as demonstrating how this is applied to problems. Contemporary Mathematics (1967) advocates the following method for solving "word problems":

(1) Read the problem carefully, and draw a diagram if necessary.
(2) Represent the variable in the problem by a place holding symbol, and state the limitation on the variable.
(3) Express the condition stated in the problem as an equation (or inequality).
(4) Solve the equation or inequality.
(5) Check the solution by replacement in the original problem.
(6) Write a conclusion. Use proper units, if units are involved (p. 123).

The strategy outlined in Exploring Modern Mathematics, Book III (1963), is as follows:

(1) Study and understand the situation.
(2) Describe the situation in mathematical language.
(3) Re-describe the situation in more useful mathematical language.
(4) From the redescription get an answer to the problem (p. 2).

Step 2 refers to given information and formulas to use, while Step 3 involves setting up an equation and solving it.

The strategy used to solve problems in Seeing Through Arithmetic, Book 6 (1968) is as follows:

(1) Obtaining from the verbal problem a mathematical sentence that describes the situation.
(2) Processing to get the unknown number in accordance with certain mathematical properties and definitions.
(3) Interpreting the end result of processing in terms of the original solution (p. 624).

To develop the mathematical skills used in daily living. According to many educators, one of the tasks of education is to prepare individuals for "effective daily living." Findley (1956) states that the school "should insure the mastery of skills necessary to effective living (p. 5)." Downey (1960) described this task as "practical consumer mathematics (p. 23)." Moreover, Johnson (1967) states that "mathematics programs must develop basic skills and techniques, vocabulary, facts and principles because this knowledge is basic to becoming an independent and understanding consumer (p. 185)." The citizen of today is dependent upon mathematics. "He must balance his budget, adjust his expenses to his income and compute his taxes (Breslick, 1966, p. 464)." To many people, effective living consists of making a living, keeping up payments on a home and a car, paying all kinds of taxes, maintaining proper and adequate insurance on a home and car, making good investments, keeping informed of his country's economy, ability in reading and interpreting graphs in the financial section of the newspaper, and making thoughtful analyses of his problems. To this individual the efficient use of skills and the concepts of mathematics is basic (Fehr, 1968). In the new series of texts (1968) issued by School Mathematics Study Group, the first sections contained those "ideas which any well-educated citizen should know, and the more technical topics appear later (Begle, 1968, p. 242)." Thus, some educators believe that the mathematical skills used in daily living should be an objective of mathematics teaching.

To develop the ability to think critically. The importance of critical thinking is evident. At present "40,000 jobs are being taken up by machines every week . . . the student must be trained to do the things that machines cannot do and that is to reason and to think (Monsour, 1965, p. 43)." Mathematics is a way of thinking, and no subject is equal to it for developing correct thinking (Breslich, 1966). It stresses thinking in terms of relationships which exist between facts. If a given statement follows logically from definitions and assumptions, then it is true within the framework of this set of definitions and assumptions. It is quite possible and proper that someone may not accept the framework necessary to establish the truth of a given statement, so that there would be no way to convince him of that truth. Students in Grades VIII and IX are familiar with the idea of informal proofs. They know that equations can be proven true by justifying each step with an axiom which is usually a number property. They also know the procedures of proving statements true in geometry.

Mathematical reasoning can be applied to life situations (Breslich, 1966). The student must differentiate between facts and assumptions, analyse data carefully, and logically arrive at a conclusion which is based on evidence, using the principles and processes of reasoning. Breslick (1966) claims there is little transfer of reasoning power, unless teaching is done for that purpose. Pupils may be given problems in living to be analysed and solved. Training in attacking and solving problems will be helpful to pupils in school and in later life. For many pupils "the power of reasoning will be of greater value than the meagre knowledge of remembered mathematical facts (Breslick, 1966, p. 468)." Critical thinking is necessary for members of a democratic society, since each member has a share in the responsibility of government.

To develop an understanding of the role of precise language and to appreciate the power of symbolism in mathematics. Language in mathematics has "extraordinary precision (Cambridge Report, 1963, p. 10)." In ordinary speech, usage determines the meaning of a word. It may sound contradictory to the above statement to say that language in mathematics is based on undefined terms; nevertheless, this is true. However, the undefined terms become defined by their properties and can be applied to diverse situations, e.g., number, count, point, equal, etc. Undefined terms are the keywords of mathematics.

The following provide examples of definitions which are dependent upon undefined terms and are agreed upon by mathematicians, e.g., circle, locus, area, etc. (Dodes, 1966). Many definitions are expressed in reversible form as a pair of "halves" where one half represents the "if" part and the other the "only if" part. An example is: If a polygon has three sides, then it is a triangle. A closed figure is a triangle if and only if it is a polygon with three sides.

Postulates are statements which are accepted as true. However, if a system can be deduced by denying a statement, then that statement is a postulate. If it cannot be denied, then that statement is a theorem within the system. However, this does not mean that all theorems can be proven.

Proofs are formed by using definitions, postulates and theorems in a logical, sequential set of statements.

To show the preciseness of meaning in mathematics, let us examine the word "run." "Run" has various meanings: (1) to go faster than a walk; as, the boy runs. (2) to operate; as, this machine runs. The meaning depends upon the context. When "run" is used mathematically, it refers to the horizontal component of a slope. Other words with precise meanings in mathematics are base, index, prime, principal, and so on.

The signs of operations in mathematics +, -, x, ÷, $\cup$, $\cap$, have precise meanings also. There are definite rules for the order in which these operations are performed.

Students develop some appreciation of the power of mathematical symbols, not only for facility of operation and as a means of storing information compactly as in formulas, but in their application to problems. Dienes (1964) asserts that the symbol system is a "powerful weapon" in solving problems because:

> First, there is an exact one-to-one correspondence between elements of the imagined situation and the mathematical structure called into play. Second, we are able to run back and forth at will between the corresponding elements of the imagined situation and the structure. . . . At the end, we have to translate the language of the structure into the language of the situation. (p. 144).

<u>To develop "inventiveness" (creativity)</u>. Many educators consider creativity to be one of the tasks of education. Downey (1960), after examining the objectives of education, as stated by the American Federation of Teachers and those of such educators as Findley, and Mayer, concluded that creativity is one of the goals of education and that the school must prepare individuals to create. The Cambridge Report (1963) also emphasized the need for "personal exploration" in mathematics to foster creativity.

What is creativity? E. Paul Torrence (1962) defines creativity as:

> We have defined creativity quite simply as "the process of forming ideas or hypotheses, testing hypotheses and communicating results." Implied in this definition is the creation of something one has never seen before or something which has never before existed (p. 65).

Taylor Pearce (1971) in his dissertion at the University of Alberta says "it is obvious that invention or discovery in mathematics or in any other discipline takes place by means of combining ideas (p. 17)."

Creativity or inventiveness may be handled in various ways in the schools. A pupil may work on a project of his own choosing. Thus, working and discovering on his own, he is challenged to use his ability to create structures, ideas and generalizations. Polya (1966) asserts that non-routine problems demand some degree of creativity and originality from the student while routine or application problems do not. Wood (1968) points out that students should be given non-routine problems in which they are required to invent a solution by co-ordinating their skill and knowledge. Sometimes the problems may be open-ended, and in this case any consistent solution can be accepted.

The importance of creativity is stressed by eminent educators. Taylor-Pearce states that "most mathematical inventions have resulted from problem-solving activities, and the difficult and unsolved problems of mathematics have enabled effective mathematics to be created (1971, p. 25)." Taba (1962) emphasizes the importance of creativity or inventiveness by stating:

> If education is to serve an unpredictable future. it is important to cultivate the type of mental processes which will transfer knowledge to new situations, the creative approaches to problem solving and the methods of learning by discovery (p. 275).

<u>To develop a student's confidence in his analytical powers and problem solving ability</u>. This objective is adapted from the Cambridge Report (1963). Other educators-- W. W. Sawyer (1959), C. H. Butler and F. L. Wren (1951) state, that developing a student's self-confidence should be one of the objectives of teaching mathematics. According to Ausubel successful experiences increase a student's self-confidence and motivate him to persevere, and at the same time increase the attractiveness of the learning experience. He states:

> It also maintains in a state of general readiness the kinds of perceptions and responses involved in meaningful learning. This type of experience motivates the individual to make further use of what he has learned and encourages him to continue developing it as an end in itself and as a means of enhancing self-esteem (1963, p. 162).

In this manner the student develops a feeling of confidence in his abilities.

Bruner (1961) maintains that the discovery method develops self-confidence and motivates problem solving. The student is freed of both parent and teacher authority and is free to discover on his own, setting up hypotheses and testing them. In this way he develops his analytical abilities and self-reliance.

<u>To understand that mathematics is a human activity, and its history is marked by inventions, discoveries, guesses and mistakes</u>. The progress of civilization parallels the advance of mathematics. Arithmetic and geometry developed because man applied mathematics to his environment, resulting in geometry for surveying, and arithmetic for business and

commercial enterprises as in Egypt (Klamkin, 1965). After the Greeks rose to power, they adopted the mathematics which the Egyptians had developed. Mathematics became a source of stimulation and relaxation for wealthy men who started reorganizing the knowledge of mathematics to make it simpler, i.e., structuring it. As a result, a system of geometry based on postulates was developed by Euclid.

It is commonly believed that mathematics is the only science which is absolutely true and unchangeable. The "facts" of any branch of mathematics must be recognized as being assumptions, definitions, and theorems; these are used to develop new relationships by logical methods. The most that can be claimed is that if the postulates and the definitions are accepted and the reasoning is sound, then, the theorems are true. In other words, a concept of relative truth, instead of absolute truth, results. An example might be considered. According to Euclidean geometry, the sum of the angles of a triangle is greater than 180°; using a different parallel postulate as in spherical geometry, the sum of the angles of a triangle is greater than 180°; in hyperbolic geometry the sum of the angles of a triangle is less than 180°. Each is true within its system of postulates.

Mathematics solves its problems and those of other sciences by making a model (structure) which is a rather long and complicated process involving intuition, a long series of experiments, guesswork, and logical inferences (Klamkin, 1968). Thus, mathematics in the making is not a deductive process; it is an inductive experimental science, and guesswork is the experimental tool of mathematicians. Theories are formulated from hunches, analogies, and simple experiments. From these, hypotheses are formulated and tested. When mathematicians are sure their work is correct, they work out rigorous proofs.

Since mathematics is a human activity, it is subject to error. D'Alembert proved mathematically that flight was impossible. Fortunately, this proof was ignored and the airplane was invented. His fallacy was that in making his model, he assumed that air behaved as a perfect liquid.

Knowledge of the history of mathematics is a valuable aid in teaching. The difficulties which mathematicians have experienced are just the same as those that students will experience. Mathematicians knew of negative numbers for over a thousand years before they knew how to use them, hence, students can expect to have difficulty with signed numbers (Kline, 1966).

In mathematics there are many unsolved problems such as Fermat's last theorem, $x^n + y^n = z^n$, the four color map problem, prime number problems, set theory problems, and many others. These problems do not detract from mathematics, but rather stimulate much research.

Mathematics is not the product of one or of a few geniuses. It is the outcome of the work of many men and women, and comes from all parts of the world. Its contributions have always aided the progress of humanity.

To understand the significance of mathematics in science and technology. According to Broudy (1968), a technological society had been slowly developing since the industrial revolution. During the twentieth century, the rate accelerated due to the increased knowledge in mathematics and its application to many fields of study.

The applications of mathematics originate when someone is trying to design or build something new: a machine or a structure; or someone wants to understand, predict or explain some phenomenon in the world of nature, business or men. The research and the solving of the problem are done by a professional mathematician who uses the technique of logic and perhaps model construction, as well as computation, observation of relationships and the formulation and testing of hypotheses. The solution may involve different branches of mathematics.

Not only is mathematics a valuable tool in solving the problems of science and technology, it is one of the basic factors in scientific and technological research training. It is also necessary in the education of engineers, physicists, chemists, biologists, and navigators all of whose services are necessary to society.

Mathematics of a different type must be included in the education of skilled workmen and technicians. Without the services of these people, the discoveries could neither be used effectively in industry and other enterprises, nor could they be kept in operation (Fehr, 1968).

The use of mathematics both as a language for expressing the problems of science and technology, and as a tool for dealing with these problems, has stimulated the development of machines which can produce computational answers to the computation quickly and accurately. However, the invention of the electronic computer does not mean that it is no longer important for students to study mathematics. The computer cannot think for itself; it can perform only those processes which a human being can think of and program into it. Only the mathematical understanding of a human being can recognize and formulate problems and devise methods for solving them. The computer performs the processes from programs. Once a solution is complete, a human being must interpret and apply the solution.

In these ways our culture depends upon a growing body of mathematical knowledge.

To understand the structure of mathematics. Without structure mathematics would be a collection of numerous facts and skills, but structure organizes it into an entity which is unified by fundamental concepts, e.g., sets. This term should grow in meaning as the student progresses through his mathematical program.

Bruner (1966) supports teaching structure because it is fundamental to the pupil's understanding of the relationships which exist in mathematics. When a child is learning the natural number system he learns all of its properties, and these same properties will be found in other numbers systems which he will study later. Thus, teaching structure not only presents the number systems as a unified entity, but is economical of time, so that the pupil feels he has less to learn (Buck, 1966). Regarding structure, Bruner (1966) observes

> that learning that falls short of the grasp of general principles has little reward in terms of intellectual excitement. The best way to create interest in a subject is to render it worth knowing, which means to make the knowledge gained usable in one's thinking, beyond the situation in which the learning has occurred. Third, knowledge one has acquired without structure is likely to be forgotten. Organizing facts in terms of principles and ideas from which they may be inferred is the only known way of reducing the quick rate of loss of human memory (p. 31).

Bellack (1968) says that teaching structure narrows the gap between advanced and elementary knowledge. A child who studies natural numbers in Grade VII will be able to relate these to complex numbers in Grade XII, as the properties of natural numbers are among those of complex numbers. Thus, structure provides a framework for mathematics.

<u>To acquire the process skills of mathematics</u>. Terry Barton (1970) claims that:

> the student starting first grade this year will face double the current amount of knowledge by the time he reaches tenth grade, and four times as much when he finishes graduate school. Three-quarters of that knowledge we cannot teach him now because we do not know it. According to Dr. Hendrik Gideonese, whose job in the office of Education's Bureau of Research, includes trying to predict the educational implications of the future, "Knowing a special content area will continue to be important, but we cannot predict which content that will be. What we can predict is the importance of developing a much more precise knowledge of processes for handling information." (p. 69).

What are processes? According to Parker and Rubin (1966), process is "the cluster of diverse procedures which surround the acquisition and utilization of knowledge (p. 1)." Bruner (1966) suggested that the kinds of processes learned by the students are far more important than the subject matter, because in some instances the subject matter will have to be relearned. For example, at one time the atom was thought to be indivisible. Gagne (1965), in agreement with Bruner, lists some of the processes: "skill and ability to think, methods of listening, reading, storing information, retrieving information and solving problems (p. 72)." The Fifteenth Yearbook of the National Council of Teachers of Mathematics (1940) lists the following processes: ability in collecting data, organizing it, reflective thinking about it, and arriving at a conclusion consistent with the given information. Bellack (1968) would add "the mode of thought (p. 307)" to this list of processes.

Since there are basic processes by which a student gathers information in the inquiry or discovery method, Gagne (1965) and Parker and Rubin (1966) suggest that "these methods or processes should be part of the curriculum (Parker and Rubin, p. 12)." The learner can thus develop his own particular style of effective learning, since he operates as a scholar within a particular discipline. That is to say, in mathematics he sets up hypotheses and tests them (Kline, 1966).

Howard Fehr (1968) claims that by teaching students processes, "learning becomes a perpetual endeavor and not something that terminates with formal schooling (p. 437)." In fact, Trimble (1966) states that "learning to learn is the heart of education (p. 488)."

To provide an understanding of the interaction between mathematics and reality. The two aspects of mathematics are applied and pure. Everyone understands something of the applications of mathematics to everyday living. According to Fehr (1968) mathematics is the best describer of the universe about us. How does mathematics describe the universe? It describes the quantitative aspects: how much? how many? Sometimes these relationships may be expressed as a statement, e.g., distance is proportional to time; or as a relationship expressed in symbols, e.g., $E = MC^2$.

Since mathematics grew out of experience in the physical world, the significant mathematical concepts, operations and theorems were suggested by real situations. Hence, real situations and real problems should be used to introduce mathematical concepts, operations and theorems (Kline, 1966).

Many educators look upon mathematics as a tool servicing engineers, physicists, economists, and accountants. While the importance of applications cannot be minimized, they do not in themselves contribute to the further developments of mathematics (Barnett, 1968). However, those mathematicians engaged in pure research rarely have any stimulus from areas outside their own field. They see their subject as "self-sufficient, generating its own sub-disciplines and producing its own problems of research (Buck, 1965, p. 949)." Thus, pure mathematics does not depend on reality, applications or concrete representations. All through the ages there has been an interest in pure mathematics. Appollonius of Ancient Greece did considerable research on conic sections.

What is the role of pure mathematics in reality? Many people regard pure mathematics as a storehouse of ideas which can be used to describe some facet of reality. Sometimes there are ideas which can be used. The pure mathematics of Appollonius was used by Kepler 1500 years later to describe the orbits of heavenly bodies. This is an instance in which pure mathematical research has discovered the solution of a problem. Thus, some of the pure mathematics can be applied to the physical world.

The mathematical method of solving problems is used in solving problems from other fields. Mathematics is used to set up a structure or model which represents one of the possible abstractions from a concrete problem. This model is used to test the hypotheses. However, in some cases pure mathematics may make a large contribution to the solution of a problem. Thus, if mathematics does not already have a solution to a problem, the method of solving mathematical problems is used to find one.

To develop an appreciation of mathematics in the world about us. Mathematics has a cultural value. It is possible for a person to enjoy and appreciate something which can be explained by, or is a result of, mathematical applications without actually knowing the mathematics. But Fehr (1952) claims that this is not appreciation of mathematics but "it is appreciation of color, of design, of tone, of architecture (p. 19)," since appreciation results from actual knowledge of and the search for mathematics to explain a phenomenon. Breslick (1966) also claims that mathematical training is necessary for full appreciation of the beauties of form in nature, art and architecture.

Appreciation of mathematics "involves the aesthetic and the emotions (Fehr, 1952, p. 19)." Walter (1963) is in agreement with this when she states that appreciation results from studying mathematics and having satisfying experiences. Jerbert (1944) summarizes appreciation as:

> an awareness of a unifying principle of symmetry, balance and repetition together with an emotional reaction of pleasure (p. 544).

Thus, appreciation comes from studying mathematics and developing the capacity to understand and use it. "Mystic awe, clever manipulations, magical tricks do not lead to higher values. To be appreciated, mathematics must be understood (Fehr, 1954, p. 21)."

To foster enjoyment of mathematics. Enjoyment of mathematics is necessary for motivation. According to Fehr (1954) enjoyment of mathematics does not depend on the individual's ability to perform in mathematics. Some mathematics that can be enjoyed by exploring their unusual features are Fibonacci numbers, the Mobius strip, the magic squares (Johnson, 1968). The Cambridge Report (1963) advocated using some of the mathematical "tricks" which are fun for children. Enjoyment in mathematics stimulates curiosity and interest so that children will be motivated to explore and create on their own. According to Johnson (1968) "the key to successful mathematics teaching is enjoyment (p. 328)."

The above objectives could well serve as guidelines for setting up mathematics curriculum. The order of the objectives of teaching mathematics in the review of the literature neither indicates an order of priority, nor is there any attempt to rank them.

Summary of Chapter II

(1) Since the school is limited in its time and resources, it must make choices from a wide variety of learning experiences and objectives.

(2) The following criteria for the selection of objectives were suggested by Tyler (1968): (a) the needs, interests, and present level of the development of the student; (b) a study of the problems and conditions of contemporary life which offer opportunities to individuals; (c) the nature of the subject matter; (d) the philosophy of education; and (e) the psychology of learning.

(3) Downey points out that the real determining factor in the choosing of objectives is public opinion.

(4) Cowan and Eshpeter state that objectives should be a consensus of public and educators' opinions.

(5) A rank is assigned to each objective on the basis of the aggregate rank for each objective.

(6) A summary of the objectives of teaching mathematics follows: (a) to develop an understanding of matematical concepts; (b) to develop skill in the fundamental processes of arithmetic and algebra; (c) to develop methods of analysing problems and presenting their solutions; (d) to develop the mathematical skills used in daily living; (e) to develop the ability to think critically; (f) to develop an understanding of the role of precise language and to appreciate the power of symbolism in mathematics; (g) to develop "inventiveness" (creativity) (h) to develop a student's confidence in his analytic powers and problem solving ability; (i) to understand that mathematics is a human activity and that its history is marked by inventions, discoveries, guesses, and mistakes; (j) to understand the significance of mathematics in science and technology; (k) to understand the structure of mathematics; (l) to acquire the process skills of mathematics; (m) to provide an understanding of the interaction between

mathematics and reality; (n) to develop an appreciation of mathematics in the world about us; (o) to foster enjoyment of mathematics.

CHAPTER III

RESEARCH PROCEDURES

This chapter contains an account of the research procedures used in this study. It describes the sampling procedure, the construction of the instrument, the statistical techniques used, and the null hypotheses.

Sampling Procedure

The samples consisted of:

(1) "professors" including educators in secondary mathematics at the universities in Edmonton, Calgary, and Lethbridge and secondary mathematics supervisors in Edmonton and Calgary schools;

(2) "teachers" comprising the junior high school mathematics teachers in the country schools of Ponoka, Lacombe and Red Deer;

(3) "students" comprising a random selection of ten Grade IX students from each of the Grade IX classes in the above counties; and

(4) "parents" including a random selection of parents of ten Grade IX students from each class in the above counties.

The Instrument

The instrument consisted of a list of fifteen objectives which were prepared from the literature. As questionnaires are easily misinterpreted, the technical language of educators, teachers and professors was modified, and to further clarify the meanings a sentence of explanation followed some objectives.

When the original questionnaire was completed, it was discussed in Education Curriculum and Instruction 573. Suggestions for improvement were obtained, and the questionnaire was revised accordingly. The students in this class ranked the objectives, and a tabulation of the rankings indicated that there was some agreement among the members.

A pilot study using two Grade IX classes was conducted in an Edmonton school. The school staff had designated one class as high average and the other as low average. After a tabulation of the ranking of the objectives by these students, by inspection it was evident that there was agreement among them on the ranking of these objectives.

All populations received the same questionnaire and ranked the same Objectives 1 through 15 in order of the perceived priority. Students filled out an additional questionnaire (see Appendix A). A letter of explanation accompanied the questionnaires to teachers, professors and parents. Teachers received special instructions which were to be read to students who were selected to complete the questionnaire and to students whose parents had been selected.

Collection of Data

The questionnaires for university professors of secondary mathematics and secondary mathematics supervisors were sent out through the mail and returned in self-addressed, stamped envelopes.

After permission was received to work in the above counties' schools, the principal or vice-principal of each school was interviewed by the writer, and the procedure of administering the questionnaire was discussed. In some cases, the writer randomly selected the students and parents, while in other instances the mathematics teacher selected them using the same random selection method. All completed questionnaires were returned to the school, and the writer collected them two weeks later.

The following table shows the distribution of questionnaires.

TABLE I

DISTRIBUTION OF QUESTIONNAIRES

County	Teachers	Students	Parents	Professors
Ponoka	11	120	120	
Lacombe	15	150	150	
Red Deer	13	150	150	
Totals	39	420	420	9

Statistical Techniques

Since the responses could not be assumed to have a normal distribution and were of an ordinal nature, non-parametric statistics were used.

Sampling. In the statistical analysis, it was necessary to vary the sampling procedure previously explained (p. 37). For the Mann-Whitney U tests, the random samples of returned student and parent questionnaires were too large for the available computer program, so stratified random samples of parents and students were prepared from the random samples obtained from the different counties. In the stratified student samples, the ratio of boys to girls was maintained. However, in all other statistical procedures all responses were used. Garret (1947) states:

> Except by chance, however, neither a given sample nor another similarly selected and approximately the same size will describe the population perfectly--we must necessarily work with samples instead of the whole population. Variations from sample to sample--the so-called "errors of sampling"--are not to be thought of as mistakes, failures and the like, but rather as fluctuations from the fact that no two samples are ever exactly alike (p. 225-226).

Ranking of the objectives. In this study, the objectives with the smallest sum of the ranks was considered to be most important and was ranked one; the objective with the second smallest sum of the ranks was ranked two and so on. When ties occurred among the objectives, each objective was assigned the average of the ranks that they would have been assigned had there been no ties.

Agreement within the groups. To find the amount of overall agreement within each of the groups: professors, teachers, students, parents, and student subgroups on the ranking of the objectives, the Kendall coefficient of concordance *W* was computed. Siegel (1965) observes:

> It should be emphasized that a significant value of *W* does not mean that the orderings observed are <u>correct</u>. In fact they may be incorrect with respect to some external criterion . . . It is possible that a variety of judges can agree in ordering objects because all employ the "wrong" criterion. In this case a high or significant *W* would simply show that all more or less agree in the use of a wrong criterion. (p. 237-238).

For this study a significant value of *W* indicated that the members of each group and subgroup were an entity. The required level for significance was $p \leq 0.05$.

<u>The agreement between the groups on the consensus ranking</u>. A Kendall coefficient of concordance was computed. The required level of significance was $p \leq .05$. The groups were compared pairwise as follows: (1) professors and teachers, (2) professors and parents, (3) professors and students, (4) teachers and parents, (5) teachers and students, (6) parents and students, (7) boys and girls, (8) students who liked mathematics and students who disliked mathematics, (9) students who had chosen occupations and students who had not, (10) students who had chosen senior high school mathematics courses and students who had not.

<u>Tests for independent groups</u>. The Mann-Whitney *U* Test was used for an item-by-item analysis of the distribution differences in the samples. Siegel (1965) claims that:

> When at least ordinal measure has been achieved, the Mann-Whitney *U* Test may be used to test whether two independent groups have been drawn from the same population (p. 116).

Another advantage is that this test can be used for very large samples, small samples, or samples with unequal populations. The level of significance required for any item was $p \leq 0.05$. Null hypotheses were rejected when there was a significant difference on one or more of the objectives.

Association between the groups and the consensus rankings. The contingency coefficient C was computed to measure the correlation between the groups and the rankings. Siegal (1965) claims

> C can be used since the contingency coefficient makes no assumptions about the shape of the population of scores, it does not require underlying continuity in the variable under analysis, and requires only nominal measurement (the least refined variety of measurement) of the variables (p. 201).

The level of significance required for each contingency coefficient C was $p \leq 0.05$.

The Null Hypotheses

(1) There is no agreement on ranking the objectives within the groups of: (a) professor, (b) teachers, (c) students, (d) parents, (e) boys, (f) students who had not chosen vocations, (g) students who had not chosen vocations, (h) girls, (i) students who liked mathematics, (j) students who disliked mathematics, (k) students who had not chosen senior high school mathematics courses, and (l) students who had not chosen senior high school mathematics courses.

(2) Professors and teachers rank the objectives in the same order.

(3) Parents and junior high school mathematics teachers rank the objectives in the same order.

(4) Students and parents rank the objectives in the same order.

(5) Parents and professors rank the objectives in the same order.

(6) Professors and students rank the objectives in the same order.

(7) Teachers and students rank the objectives in the same order.

(8) Boys and girls rank the objectives in the same order.

(9) Students who had chosen vocations rank the objectives in the same order as students who had not.

(10) Students who liked mathematics rank the objectives in the same order as students who did not.

(11) Students who had chosen senior high school mathematics courses rank the objectives in the same order as students who had not.

(12) There is no association between the different groups and the rankings.

(13) There is no agreement on the consensus rankings of the objectives by: (a) professors and students, (b) professors and parents, (c) professors and teachers, (d) students and teachers, (e) parents and teachers, (f) students and parents, (g) boys and girls, (h) students who liked mathematics and students who disliked mathematics, (i) students

who have chosen vocations and students who had not chosen vocations, (j) students who had chosen senior high school mathematics programs and students who had not chosen senior high school programs.

Summary of Chapter III

(1) The purpose of this study was to ascertain the priority given to the objectives of teaching mathematics by professors, junior high school teachers, a sample of Grade IX students, and a sample of parents of Grade IX students in the counties of Red Deer, Lacombe and Ponoka.

(2) The instrument consisted of a questionnaire constructed from the related literature.

(3) The following statistical analysis was applied: (a) the objectives were ranked by finding the sums of the ranks for each objective for each group and subgroup. In each group or subgroup the objective with the smallest sum of the ranks was the most important, the next smallest sum of the ranks was the next most important, and so on; (b) the Kendall coefficient of concordance W was used to ascertain agreement within the groups and subgroups; (c) the Kendall coefficient of concordance W was used to ascertain agreement among the groups and subgroups on the overall agreement among the groups on the consensus rankings; (d) the Mann-Whitney U Test was used to determine the homogeneity of the groups; (e) the contingency coefficient C was used to find the association between the groups and the ranking of each of the objectives.

CHAPTER IV

RESEARCH FINDINGS

This chapter contains a summary of the returned questionnaires and the discussion of the null hypotheses.

The number of useable questionnaires which were returned by May 31, 1971, was as follows:

TABLE II

QUESTIONNAIRES RETURNED

Group	Number Returned	Percentage
Professors	8	88.8%
Teachers	34	87.18%
Students	338	80.50%
Parents	242	57.62%

The data from the questionnaires were placed on punch cards which were processed by the Division of Education Research Services.

TABLE III

SUMMARY OF STUDENT RESPONSES

Subgroup	Girls	Boys
1. Students who liked mathematics	65.59%	52.63%
2. Students who had chosen vocations	44.62%	40.80%
3. Students who had chosen mathematics programs in the senior high school	61.40%	50.30%

N for girls = 186   N for boys = 152

Discussion of the Null Hypotheses

Null hypothesis I. There is no agreement on the ranking of the objectives within the group of: (a) professors, (b) teachers, (c) students, (d) parents, (e) boys, (f) girls, (g) students who liked mathematics, (h) students who disliked mathematics, (i) students who had chosen senior high school mathematics programs, (j) students who had not chosen senior high school programs, (k) students who had chosen vocations, and (l) students who had not chosen vocations. To determine the agreement within the groups and the subgroups, the Kendall's coefficient of concordance W was computed for each group and subgroup.

For professors, the Kendall coefficient of concordance W was 0.225 for the ranking of the objectives. A Chi Square value of 25.212, significant at 0.03 level, was computed

Therefore, the agreement among the members of this group was greater than it would have been by chance.

The Kendall coefficient of concordance W for the junior high school mathematics teachers was 0.268 on the ranking of objectives. A Chi Square value of 136.168 with a probability less than 0.001 is associated with this value of W. Therefore, the agreement among the junior high school teachers was greater than it would have been by chance.

The Kendall coefficient of concordance W for parents was 0.545 on the ranking of the objectives. A Chi Square of 1846.460 with probability less than 0.001 is associated with the Value of W. Therefore, the agreement among parents was greater than it would have been by chance.

The Kendall coefficient of concordance W for students was 0.176 on the ranking of the objectives. The Chi Square associated with this value of W is 964.832 with probability less than 0.001. Therefore, the agreement among students was greater than it would have been by chance.

The Kendall coefficient of concordance W for the boys was 0.210 on the ranking of the objectives. Associated with this value of W is a Chi Square value of 446.880, which is significant at less than 0.01 level. Therefore, the amount of agreement among the boys was more than it would have been by chance.

The Kendall coefficient of concordance W for the girls was 0.176 on the ranking of the objectives. This value of W is associated with a Chi Square of 458. 304, which is significant at less than the 0.01 level. Therefore, the agreement among the girls was more than it would have been by chance.

The Kendall coefficient of concordance W for students who liked mathematics was 0.340. This value of W is associated with a Chi Square of 961.52 which has a probability less than 0.001. Therefore, the agreement among students who liked mathematics was greater than it would have been by chance.

The Kendall coefficient of concordance W for students who disliked mathematics was 0.156. Associated with this value of W is a Chi Square of 297.024 which has a probability less than 0.001. Therefore, the agreement among the students who disliked mathematics was greater than it would have been by chance.

The Kendall coefficient of concordance W for students who had chosen senior high school mathematics programs was 0.214. This value of W is associated with a Chi Square of 560.252, which has a probability less than 0.001. Therefore, the agreement among students who had chosen a senior high school mathematics course was greater than it would have been by chance.

The Kendall coefficient of concordance W for students who had not chosen senior high school mathematics courses was 0.171. Associated with this value of W is Chi Square of 361.494 which has a probability less than 0.001. Therefore, the agreement among the students who had not chosen mathematics courses was more than it would have been by chance.

The Kendall coefficient of concordance *W* for students who had chosen vocations was 0.186. The Chi Square associated with this value of *W* is 380.184 which has a probability less than 0.001. Therefore, the agreement among the students who had chosen vocations was greater than it would have been by chance.

The Kendall coefficient of concordance *W* for students who had not chosen vocations was 0.208. Associated with this value of *W* is a Chi Square of 558.624, which has a probability less than 0.001. Therefore, the agreement among students who had not chosen vocations was greater than it would have been by chance.

The Kendall coefficient of concordance *W* for agreement among all of the groups on the consensus ranking the objectives was 0.723. The Chi Square associated with this value of *W* is 41.488, which is significant at $p < 0.001$. Therefore, the agreement among the combined groups of professors, teachers, students and parents was greater than it would have been by chance.

Since there was more agreement among the above groups than there would have been by chance, the null hypothesis was rejected.

Null hypothesis II. Professors and teachers rank the objectives in the same order. Table IV shows the Mann-Whitney *U* and *Z* scores for the ranking of objectives by professors and

TABLE IV

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN PROFESSORS AND TEACHERS

Objectives	U	Z	Level of Significance
1. Fundamental process	101.0	-1.131	0.26
2. Mathematical concepts	116.5	-0.629	0.53
3. Process skills	121.0	-0.489	0.62
4. Problem solving	118.5	-0.566	0.57
5. Confidence in ability	112.0	-0.773	0.44
6. Mathematics in daily life	61.5	-2.395	0.02
7. Mathematics in science and technology	80.5	-1.793	0.07
8. Mathematics and the physical world	115.5	-0.660	0.51
9. Structure	105.0	-0.997	0.32
10. Appreciation	69.5	-2.141	0.03

TABLE IV (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	80.0	-1.802	0.07
12. Mathematics a human activity	101.0	-1.135	0.25
13. Creativity	99.5	-1.176	0.26
14. Precise meaning and symbolism	119.5	-0.531	0.60
15. Enjoyment	94.0	-1.351	0.18

N for professors = 8   N for teachers = 34 teachers. Table V shows the consensus rankings for these groups. The item-by-item analysis indicated there were significant differences between these two groups. A difference at the 0.02 level of significance was obtained on Objective 6, mathematics in daily living. Professors ranked it 13, while teachers ranked it 5. A difference at the 0.03 level of significance was obtained on Objective 10, appreciation. Professors ranked it 8, while teachers ranked it 14.

Since there were significant differences between the professors and teachers on the ranking of the objectives, the null hypothesis was rejected.

Null hypothesis III. Parents and junior high school teachers rank the objectives in the same order. Table VI shows the Mann Whitney *U* and *Z* scores for teachers and a random sample of returned questionnaires from parents. Tables V and VII show the consensus rankings for these groups. On an item-by-item analysis of the ranking of objectives in Table VI there were significant differences between parents and teachers on three of the objectives. A significant difference at the 0.03 level was obtained on Objective 6, mathematics in daily living. Parents ranked it 1, while teachers ranked it 5. A significant difference at the 0.01 level was obtained on Objective 1, fundamental processes. Parents ranked it 2, while teachers ranked it 4. A significant difference at the 0.004 level was obtained on Objective 15, enjoyment. Teachers ranked it 8, while parents ranked it 13.

TABLE V

CONSENSUS RANKINGS OF OBJECTIVES BY PROFESSORS AND TEACHERS

Objectives	Professors		Teachers	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
1. Fundamental process	60	7	187	4
2. Mathematical concepts	46	2	170	2
3. Process skills	37	1	140	1
4. Problem solving	49	3.5	178	3
5. Confidence in ability	50	5	258	6.5
6. Mathematics in daily life	82	13	201	5
7. Mathematics in science and technology	94	15	332	10
8. Mathematics and the physical world	73	11	341	11
9. Structure	52	6	282	8
10. Appreciation	61	8	356	14

TABLE V (continued)

Objectives	Professors: Sum of Ranks	Professors: Consensus Rank	Teachers: Sum of Ranks	Teachers: Consensus Rank
11. Critical thinking	88	14	258	8
12. Mathematics a human activity	78	12	401	15
13. Creativity	69	9	349	13
14. Precise language and symbolism	72	10	343	12
15. Enjoyment	49	3.5	284	9

N for professors = 8 N for teachers = 34

TABLE VI

MANN-WHITNEY *U* TEST ANALYSIS OF DIFFERENCES BETWEEN TEACHERS AND PARENTS

	Objectives	*U*	*Z*	Level of Significance
1.	Fundamental processes	981	-2.482	0.01
2.	Mathematical concepts	1100.5	-1.705	0.09
3.	Process skills	1088.5	-1.787	0.07
4.	Problem solving	1179.5	-1.217	0.22
5.	Confidence in ability	1206.5	-1.049	0.29
6.	Mathematics in daily life	1021.0	-2.203	0.03
7.	Mathematics in science and technology	1255.5	-0.748	0.45
8.	Mathematics and the physical world	12848.5	-0.569	0.57
9.	Structure	1285.5	-0.563	0.57
10.	Appreciation	1115.0	-1.612	0.11

TABLE VI (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	1198.5	-1.097	0.27
12. Mathematics a human activity	1128.5	-1.533	0.13
13. Creativity	1280.0	-0.597	0.55
14. Precise language and symbolism	1332.5	-0.274	0.79
15. Enjoyment	915.5	-2.855	0.004

N for teachers = 34 N for parents = 81

TABLE VII

CONSENSUS RANKINGS OF OBJECTIVES BY PARENTS AND STUDENTS

Objectives	Parents: Sum of Ranks	Parents: Consensus Rank	Students: Sum of Ranks	Students: Consensus Rank
1. Fundamental process	1030	2	1592	2
2. Mathematical concepts	1337	4	2203	4
3. Process skills	1194	3	1962	3
4. Problem solving	1498	5	2417	5
5. Confidence in ability	1622	6	2813	6
6. Mathematics in daily life	1017	1	1518	1
7. Mathematics in science and technology	2277	10	2878	8
8. Mathematics and the physical world	2389	12	3074	11
9. Structure	2101	7	2748	7
10. Appreciation	2250	9	3061	10

TABLE VII (continued)

Objectives	Parents: Sum of Ranks	Parents: Concensus Rank	Students: Sum of Ranks	Students: Consensus Rank
11. Critical thinking	1996	7	3046	9
12. Mathematics a human activity	2679	15	3517	14.5
13. Creativity	2459	14	3225	12
14. Precise language and symbolism	2346	11	3260	13
15. Enjoyment	2411	13	3517	14.5

N for parents = 242 N for students = 338

Since there were significant differences between the groups of teachers and parents on the ranking of the objectives, the null hypothesis was rejected.

Null hypothesis IV. Parents and students rank the objectives in the same order. Table VIII shows that there are significant differences between the parents and students on ranking the objectives. At the 0.04 level there is a significant difference in the ranking of Objective 13, creativity in mathematics. Students ranked this objective 12, while parents ranked it 14. At the 0.03 level, there is a significant difference on Objective 3, process skills of mathematics. Both parents and students ranked it 3. This result seems to be contradictory. Each group's consensus ranking was obtained by summing all of the individual ranks for a particular objective. In this case, the different addends produced the same sum. However, this is the reason that the consensus rankings are significantly different by the Mann-Whitney Test.

Since there were significant differences in the ranking of objectives by parents and students, the null hypothesis was rejected.

Null hypothesis V. Parents and professors rank the objectives in the same order. Table IX shows the Mann-Whitney U and Z values for the ranking of objectives by parents and professors. On the item-by-item analysis there were significant differences in the ranking of four of the

TABLE VIII

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN PARENTS AND STUDENTS

Objectives	U	Z	Level of Significance
1. Fundamental processes	4159.5	-0.805	0.42
2. Mathematical concepts	4238.0	-0.577	0.56
3. Process skills	3668.0	-2.098	0.03
4. Problem solving	4.36.5	-0.847	0.39
5. Confidence in ability	3839.0	-1.638	0.10
6. Mathematics in daily life	4304.0	-0.405	0.68
7. Mathematics in science and technology	3904.5	-1.463	0.14
8. Mathematics and the physical world	4372.0	-0.221	0.83
9. Structure	3781.0	-1.791	0.07
10. Appreciation	4416.5	-0.102	0.92

TABLE VIII (continued)

Objective	U	Z	Level of Significance
11. Critical thinking	4121.5	-0.886	0.37
12. Mathematics a human activity	4371.5	-0.222	0.85
13. Creativity	3683.0	-2.053	0.04
14. Precise language and symbolism	4267.5	-0.499	0.62
15. Enjoyment	3887.0	-1.522	0.13

N for parents = 81 N for students = 110

TABLE IX

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN PROFESSORS AND PARENTS

Objectives	U	Z	Level Significance
1. Fundamental processes	165.0	-2.344	0.02
2. Mathematical concepts	312.5	-0.166	0.47
3. Process skills	282.0	-0.610	0.54
4. Problem solving	317.5	-0.094	0.93
5. Confidence in ability	307.0	-0.245	0.80
6. Mathematics in daily life	102.0	-3.220	0.001
7. Mathematics in science and technology	178.0	-2.105	0.04
8. Mathematics and the physical world	295.0	-0.418	0.67
9. Structure	222.5	-1.463	0.14
10. Appreciation	229.5	-1.360	0.17

TABLE IX (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	203.0	-1.742	0.08
12. Mathematics a human activity	286.0	-0.548	0.58
13. Creativity	218.0	-1.528	0.13
14. Precise language and symbolism	271.0	-0.764	0.45
15. Enjoyment	141.0	-2.660	0.008

N for professors = 8 N for parents = 82 objectives. Objective 6, mathematics in daily life, had a significant difference at the 0.001 level. Parents ranked this objective 1, while professors ranked it 13. There was a significant difference at the 0.02 level in the ranking of Objective 1, fundamental processes of mathematics. Professors ranked it 7, while parents ranked it 2. On the ranking of Objective 7, mathematics in science and technology, there was a significant difference at the 0.04 level. Professors ranked this objective 15, while parents ranked it 10. On the ranking of Objective 15, to foster enjoyment of mathematics, there was a significant difference at the 0.008 level. Professors ranked this objective 3.5, while parents ranked it 13.

Since there were significant differences in the ranking of the objectives by professors and parents, the null hypothesis was rejected.

Null hypothesis VI. Professors and students rank the objectives in the same order. Table X shows significant differences in the ranking of three objectives by professors and students. At the 0.0008 level there was a significant difference in the ranking of Objective 6, mathematics in daily living. Professors ranked this objective 13, while students ranked it 1. At the 0.009 level there was a significant difference in the ranking of Objective 7, the application of mathematics in science and technology. Students ranked this objective 8, while professors ranked it 11. At the 0.05 level there was a significant difference in the ranking of Objective 15, to foster enjoyment of mathematics. Professors ranked this objective 3.5, while students ranked it 14.5.

TABLE X

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN PROFESSORS AND STUDENTS

Objectives	U	Z	Level of Significance
1. Fundamental processes	214.0	-1.655	0.10
2. Mathematical concepts	327.5	-0.007	0.99
3. Process skills	265.0	-0.900	0.37
4. Problem solving	291.0	-0.527	0.60
5. Confidence in ability	269.5	-0.833	0.41
6. Mathematics in daily life	108.5	-3.143	0.0008
7. Mathematics in science and technology	145.5	-2.598	0.009
8. Mathematics and the physical world	299.0	-0.413	0.68
9. Structure	230.0	-1.394	0.16
10. Appreciation	262.0	-0.939	0.35

TABLE X (continued)

Objectives	*U*	*Z*	Level of Significance
11. Critical thinking	224.5	-1.475	0.14
12. Mathematics a human activity	300.5	-0.392	0.70
13. Creativity	292.5	-0.506	0.61
14. Precise language and symbolism	280.5	-0.676	0.50
15. Enjoyment	190.5	-1.969	0.05

N for professors = 8   N for students = 82

Since there were significant differences in the ranking of objectives by professors and students, the null hypothesis was rejected.

Null hypothesis VII. Teachers and students rank the objectives in the same order. Table XI shows that there were significant differences in the ranking of four objectives by teachers and students. There was a significant difference at the 0.04 level in the ranking of Objective 7, mathematics in science and technology. Teachers ranked it 10, while students ranked it 8. At the 0.02 level there was a significant difference in the ranking of Objective 2, mathematical concepts. Teachers ranked it 2, while students ranked it 4. There was a significant difference at the 0.01 level in the ranking of Objective 4, developing skills in problem solving. Teachers ranked this objective 3, while students ranked it 5. At the 0.00011 level there was a significant difference in the ranking of Objective 3, the process skills of mathematics. Teachers ranked this objective 1, while students ranked it 3.

Since there were significant differences in the ranking of the objectives by teachers and students, the null hypothesis was rejected.

Null hypothesis VIII. Boys and girls rank the objectives in the same order. Table XII shows the Mann-Whitney U Test analysis of differences between boys and girls for the ranking of the objectives. Table XIII shows the ranking of the objectives by boys and girls. Since there were no significant differences between the rankings, the null hypothesis was not rejected.

TABLE XI

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN TEACHERS AND STUDENTS

Objectives	U	Z	Level of Significance
1. Fundamental processes	1197.5	-1.210	0.23
2. Mathematical concepts	1014.0	-2.317	0.02
3. Process skills	791.5	-3.673	0.00011
4. Problem solving	972.5	-2.567	0.01
5. Confidence in ability	1325.0	-0.420	0.67
6. Mathematics in daily living	1142.0	-1.542	0.12
7. Mathematics in science and technology	1052.5	-2.078	0.04
8. Mathematics and the physical world	1241.0	-0.932	0.36
9. Structure	1360.5	-0.204	0.84
10. Appreciation	1130.5	-1.605	0.11

TABLE XI (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	1128.5	-1.616	0.11
12. Mathematics a human activity	1099.0	-1.802	0.07
13. Creativity	1203.5	-1.160	0.25
14. Precise language and symbolism	1169.5	-1.367	0.17
15. Enjoyment	1171.0	-1.361	0.17

N for teachers = 34 N for students = 82

TABLE XII

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN BOYS AND GIRLS

Objectives	U	Z	Level of Significance
1. Fundamental processes	4459.5	-0.636	0.26
2. Mathematical concepts	4220.0	-1.221	0.22
3. Process skills	4124.5	-1.489	0.14
4. Problem solving	4557.5	-0.376	0.70
5. Confidence in ability	4135.5	-1.459	0.14
6. Mathematics in daily life	4455.0	-0.646	0.61
7. Mathematics in science and technology	4610.0	-0.231	0.82
8. Mathematics and the physical world	4300.5	-1.036	0.30
9. Structure	4652.5	-0.132	0.90
10. Appreciation	4023.0	-1.748	0.08

TABLE XII (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	4659.5	-0.114	0.91
12. Mathematics a human activity	4679.0	-0.064	0.95
13. Creativity	4347.0	-0.917	0.36
14. Precise language and symbolism	5315.0	-0.999	0.32
15. Enjoyment	4642.5	-0.159	0.87

N for boys = 96 N for girls = 98

TABLE XIII

CONSENSUS RANKINGS OF OBJECTIVES BY BOYS AND GIRLS

Objectives	Boys: Sum of Ranks	Boys: Consensus Rank	Girls: Sum of Ranks	Girls: Consensus Rank
1. Fundamental processes	667	1	915	2
2. Mathematical concepts	949	4	1254	4
3. Process skills	886	3	1076	3
4. Problem solving	1100	5	1317	5
5. Confidence in ability	1334	6	1479	6
6. Mathematics in daily life	697	2	821	1
7. Mathematics in science and technology	1246	8	1632	10
8. Mathematics and the physical world	1398	10	1676	11
9. Structure	1195	7	1553	8
10. Appreciation	1440	11	1621	9

TABLE XIII (continued)

Objectives	Boys		Girls	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
11. Critical thinking	1552	13	1494	7
12. Mathematics a human activity	1583	14	1934	15
13. Creativity	1363	9	1862	13
14. Precise language and symbolism	1437	12	1823	12
15. Enjoyment	1638	15	1879	14

N for boys = 152 N for girls = 186

Null hypothesis IX. Students who had chosen vocations rank the objectives in the same order as those who had not. Table XIV shows the Mann-Whitney U and Z scores for the ranking of the objectives by students who had chosen vocations and students who had not. Table XV shows the consensus rankings. There was a significant difference at the 0.02 level of significance in ranking Objective 13, developing creativity in mathematics. Students who had chosen vocations ranked it 13, while students who had not, ranked it 9.

Therefore, since there was a significant difference in ranking the objectives, the null hypothesis was rejected.

Null hypothesis X. Students who liked mathematics rank the objectives in the same order as those who did not.

Table XVI shows the Mann-Whitney U Test for the analysis of differences in the ranking of the objectives by students who disliked mathematics and students who liked mathematics, while Table XVII shows the consensus rankings by these subgroups.

There was a significant difference at the 0.02 level in the ranking of Objective 4, problem solving techniques. Both groups of students ranked it 5.

Since there was a significant difference in the ranking of the objectives by students who disliked mathematics and students who disliked mathematics, the null hypothesis was rejected.

TABLE XIV

MANN-WHITNEY *U* TEST ANALYSIS OF DIFFERENCES BETWEEN STUDENTS WHO HAD CHOSEN VOCATIONS AND THOSE WHO HAD NOT

Objectives	*U*	*Z*	Level of Significance
1. Fundamental processes	4457.5	-0.971	0.33
2. Mathematical concepts	4356.0	-1.219	0.22
3. Process skills	4528.0	-0.788	0.43
4. Problem solving	4234.5	-1.523	0.13
5. Confidences in ability	4503.0	-0.849	0.39
6. Mathematics in daily life	4345.0	-1.265	0.20
7. Mathematics in science and technology	4312.0	-1.327	0.18
8. Mathematics and the physical world	4788.0	-0.133	0.90
9. Structure	4674.0	-0.419	0.67
10. Appreciation	4432.5	-1.025	0.30

TABLE XIV (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	4789.5	-0.129	0.90
12. Mathematics a human activity	4649.0	-0.483	0.63
13. Creativity	3944.5	-2.253	0.02
14. Precise language and symbolism	4581.0	-0.654	0.51
15. Enjoyment	4721.5	-0.304	0.76

N for students who had chosen vocations = 94
N for students who had not chosen vocations = 103

TABLE XV

CONSENSUS RANKINGS OF OBJECTIVES BY STUDENTS WHO HAD CHOSEN VOCATIONS AND STUDENTS WHO HAD NOT

Objectives	Had Chosen Vocations		Had Not Chosen Vocations	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
1. Fundamental processes	627	1	965	2
2. Mathematical concepts	987	6	1216	4
3. Process skills	899	3	1063	3
4. Problem solving	976	4	1441	5
5. Confidence in ability	1201	10	1612	6
6. Mathematics in daily life	642	2	876	1
7. Mathematics in science and technology	1168	9	1710	7
8. Mathematics and the physical world	1215	11	1851	10
9. Structure	978	5	1770	8
10. Appreciation	1141	8	1920	12

TABLE XV (continued)

Objectives	Had Chosen Vocations		Had Not Chosen Vocations	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
11. Critical thinking	1058	7	1988	14
12. Mathematics a human activity	1570	15	1947	13
13. Creativity	1456	13	1769	9
14. Precise language and symbolism	1368	12	1874	11
15. Enjoyment	1474	14	2043	15

N for students who had chosen a vocation = 146
N for students who had not chosen a vocation = 192

TABLE XVI

MANN-WHITNEY U TEST ANALYSIS OF DIFFERENCES BETWEEN STUDENTS WHO LIKED MATHEMATICS AND STUDENTS WHO DID NOT

Objectives	U	Z	Level of Significance
1. Fundamental processes	4207.0	-0.687	0.49
2. Mathematical concepts	4429.5	-0.087	0.93
3. Process skills	4349.0	-0.302	0.76
4. Problem solving	3601.5	-2.299	0.02
5. Confidence in ability	3996.5	-1.242	0.22
6. Mathematics in daily life	4190.0	-0.736	0.46
7. Mathematics in science and technology	3926.0	-1.431	0.15
8. Mathematics and the physical world	4414.0	-0.128	0.46
9. Structure	4412.5	-0.132	0.90
10. Appreciation	4111.5	-0.936	0.35

TABLE XVI (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	4195.0	-0.712	0.48
12. Mathematics a human activity	4155.5	-0.820	0.41
13. Creativity	4220.5	-0.645	0.51
14. Precise language and symbolism	4454.0	-0.021	0.98
15. Enjoyment	4361.0	-0.271	0.79

N for students who disliked mathematics = 92
N for students who liked mathematics = 97

TABLE XVII

CONSENSUS RANKINGS OF OBJECTIVES BY STUDENTS WHO LIKED MATHEMATICS AND STUDENTS WHO DISLIKED MATHEMATICS

Objectives	Liked Mathematics		Disliked Mathematics	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
1. Fundamental processes	735	1	592	1
2. Mathematical concepts	1250	4	953	4
3. Process skills	1151	3	811	3
4. Problem solving	1416	5	1001	5
5. Confidence in ability	1680	7	1151	9
6. Mathematics in daily life	907	2	611	2
7. Mathematics in science and technology	1787	8	1091	6
8. Mathematics and the physical world	1844	9	1230	12
9. Structure	1612	6	1336	8
10. Appreciation	1885	10	1176	10

TABLE XVII (continued)

Objectives	Liked Mathematics		Disliked Mathematics	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
11. Critical thinking	1912	12	1134	7
12. Mathematics a human activity	2160	11	1357	14
13. Creativity	1857	14	1368	15
14. Precise language and symbolism	1981	13	1279	13
15. Enjoyment	2322	15	1195	11

N for students who liked math = 202
N for students who disliked math = 136

Null hypothesis XI. Students who had chosen mathematics courses for the senior high school rank the objectives in the same order as those who had not.

Table XVIII shows the Mann-Whitney U and Z scores for the rankings of objectives by students who had not chosen senior high school mathematics programs and those who had. Table XIX shows the consensus rankings. There were significant differences in the ranking of two of the objectives. There was a significant difference at the 0.02 level in the ranking of Objective 8, mathematics and the physical world. Students who had not chosen a senior high school mathematics program ranked it 9, while students who had chosen a senior high school mathematics program ranked it 12. There was also a significant difference at the 0.02 level in the ranking of Objective 14, precise language and symbolism of mathematics. Students who had not chosen senior high school mathematics courses ranked it 13, while students who had chosen senior high school mathematics courses ranked it 11.

Since there were significant differences in the ranking of the objectives, the null hypothesis was rejected.

Null hypothesis XII. There is no association between the different groups and the consensus rankings. Table XX shows the contingency coefficients. The null hypothesis was not rejected on the following objectives: mathematical concepts, process skills, mathematics in science and technology, mathematics and the physical world, structure, appreciation,

TABLE XVIII

MANN-WHITNEY *U* TEST ANALYSIS OF DIFFERENCES BETWEEN STUDENTS WHO HAD CHOSEN HIGH SCHOOL MATHEMATICS COURSES AND THOSE WHO HAD NOT

Objectives	*U*	*Z*	Level of Significance
1. Fundamental processes	4468.0	-0.855	0.39
2. Mathematical concepts	4674.0	-0.319	0.75
3. Process skills	4288.5	-1.294	0.19
4. Problem solving	4477.5	-0.816	0.41
5. Confidence in ability	4417.5	-0.967	0.33
6. Mathematics in daily life	4258.5	-1.388	0.16
7. Mathematics in science and technology	4647.5	-0.385	0.70
8. Mathematics and the physical world	3881.0	-2.325	0.02
9. Structure	4767.5	-0.087	0.93
10. Appreciation	4243.0	-1.408	0.16

TABLE XVIII (continued)

Objectives	U	Z	Level of Significance
11. Critical thinking	4397.5	-1.017	0.31
12. Mathematics a human activity	4131.0	-1.696	0.31
13. Creativity	4573.0	-0.574	0.57
14. Precise language and symbolism	3865.5	-2.363	0.02
15. Enjoyment	4532.5	-0.681	0.50

N for not chosen programs = 96
N for chosen programs = 100

TABLE XIX

CONSENSUS RANKING OF OBJECTIVES BY STUDENTS WHO HAD CHOSEN HIGH SCHOOL MATHEMATICS COURSES AND THOSE WHO HAD NOT

Objectives	Had Courses		Had Not Courses	
	Sum of Ranks	Consensus Rank	Sum of Ranks	Consensus Rank
1. Fundamental processes	938	2	654	1
2. Mathematical concepts	1249	5	954	4
3. Process skills	1040	3	922	3
4. Problem solving	1233	4	1184	5.5
5. Confidence in ability	1629	10	1184	5.5
6. Mathematics in daily life	731	1	787	2
7. Mathematics in science and technology	1577	8	1301	7
8. Mathematics and the physical world	1620	9	1454	12
9. Structure	1426	6	1322	8
10. Appreciation	1705	11	1356	9

TABLE XIX (continued)

Objectives	Had Courses Sum of Ranks	Had Courses Consensus Rank	Had Not Courses Sum of Ranks	Had Not Courses Consensus Rank
11. Critical thinking	1492	7	1554	14
12. Mathematics a human activity	2062	15	1455	13
13. Creativity	1856	12	1369	10
14. Precise language and symbolism	1878	13	1382	11
15. Enjoyment	1936	14	1581	15

N for students who have chosen courses = 187
N for students who have not chosen courses = 151

TABLE XX

CONTINGENCY COEFFICIENTS FOR PROFESSORS, TEACHERS, STUDENTS AND PARENTS

Objectives	χ^2	C	Level of Significance
1. Fundamental processes	12.07	.14	0.01
2. Mathematical concepts	7.02	.11	0.08
3. Process skills	6.61	.10	0.07
4. Problem solving	8.00	.11	0.05
5. Confidence in ability	16.70	.16	0.001
6. Mathematics in daily life	24.41	.23	0.001
7. Mathematics in science and technology	5.29	.09	0.15
8. Mathematics in the physical world	3.56	.07	0.30
9. Structure	1.61	.05	0.60
10. Appreciation	4.90	.09	0.20

TABLE XX (continued)

Objectives	χ^2	C	Level of Significance
11. Critical thinking	3.75	.07	0.30
12. Mathematics a human activity	8.60	.11	0.03
13. Creativity	.78	.001	0.85
14. Precise language and symbolism	2.50	.004	0.45
15. Enjoyment	9.93	.13	0.02

N for teachers = 8   N for students = 338
N for teachers = 34   N for parents = 242   df = 3

critical thinking, creativity, and precise language.

The degree of association is significant between the groups of professors, teachers, students, and parents, and the rankings of the following objectives: fundamental processes of mathematics; problem solving techniques; students' confidence in his analytic ability; mathematics in daily life; mathematics, a human activity; and enjoyment. Therefore, the null hypothesis for these objectives was rejected.

Table XXI shows the contingency coefficients between boys and girls and the ranking of the objectives. According to the data there was no association between boys and girls and the ranking of the objectives. Therefore, the null hypothesis was not rejected.

Table XXII shows the contingency coefficient C for students who liked mathematics and students who disliked mathematics and the objectives. On Objective 8, to understand the interaction of mathematics and the physical world, there is a significant association at the 0.015 level. Hence, the null hypothesis that there is no association among the variables was rejected.

Null hypothesis XIII. There is no agreement between following groups on the consensus ranking of the objectives: (a) professors and students, (b) professors and teachers, (c) professors and parents, (d) students and teachers, (e) teachers and parents, (f) students and parents, (g) boys and girls, (h) students who had chosen vocations and students who

TABLE XXI

CONTINGENCY COEFFICIENTS FOR STUDENTS WHO DISLIKED MATHEMATICS AND STUDENTS WHO LIKED MATHEMATICS AND THE OBJECTIVES

Objectives	χ^2	C	df	Level of Significance
1. Fundamental processes	17.80	0.22	10	0.15
2. Mathematical concepts	20.25	0.24	13	0.075
3. Process skills	7.61	0.15	12	0.80
4. Problem solving	14.55	0.20	13	0.40
5. Confidence in ability	22.18	0.29	13	0.40
6. Mathematics in daily life	16.86	0.22	10	0.07
7. Mathematics in science and technology	16.56	0.22	14	0.29
8. Mathematics in the physical world	29.83	0.28	13	0.015
9. Structure	9.029	0.16	13	0.75
10. Appreciation	20.57	0.24	13	0.075

TABLE XXI (continued)

Objectives	χ^2	C	df	Level of Significance
11. Critical thinking	11.59	0.18	13	0.60
12. Mathematics a human activity	9.50	0.17	11	0.60
13. Creativity	11.09	0.15	12	0.48
14. Precise language and symbolism	10.66	0.18	11	0.50
15. Enjoyment	12.52	0.19	12	0.40

N for students who liked mathematics = 202
N for students who disliked mathematics = 136

TABLE XXII

CONTINGENCY COEFFICIENTS FOR BOYS AND GIRLS

Objectives	χ^2	C	df	Level Significance
1. Fundamental processes	10.72	0.18	10	0.30
2. Mathematical concepts	16.675	0.21	11	0.15
3. Process skills	16.83	0.22	9	0.07
4. Problem solving	5.20	0.12	12	0.95
5. Confidence in ability	15.56	0.22	14	0.40
6. Mathematics in daily life	7.50	0.15	11	0.75
7. Mathematics in science and technology	14.00	0.19	14	0.40
8. Mathematics and the physical world	7.74	0.11	13	0.85
9. Structure	9.20	0.16	13	0.75
10. Appreciation	13.19	0.19	13	0.40

TABLE XXII (continued)

Objectives	χ^2	C	df	Level of Significance
11. Critical thinking	11.26	0.18	13	0.60
12. Mathematics a human activity	7.44	0.15	11	0.40
13. Creativity	12.95	0.19	12	0.40
14. Precise language and symbolism	9.60	0.17	11	0.60
15. Enjoyment	6.35	0.14	10	0.80

N for boys = 152 N for girls = 186

had not, (i) students who liked mathematics and students who disliked mathematics, and (j) students who had chosen mathematics courses and student who had not.

For the consensus rankings of the objectives by the groups of professors and students, the Kendall coefficient of concordance W was 0.618. Associated with this value of W is Chi Square value of 17.304 which is significant at the 0.25 level. Therefore, the null hypothesis of no agreement between professors and students on the consensus ranking of the objectives was not rejected.

For the groups of professors and teachers, the Kendall coefficient of concordance W was 0.746 for the consensus rankings of the objectives. This value of W is associated with a Chi Square value of 20.888, which is significant at the 0.10 level. Therefore, the null hypothesis of no agreement between teachers and professors on the consensus ranking of the objectives was not rejected.

The Kendall coefficient of concordance W for professors and parents was 0.68 on the consensus ranking of the objectives. The Chi Square associated with this value of W is 19.04 which is significant at the 0.20 level. Therefore, the null hypothesis of no agreement between professors and parents on the ranking of the objectives was not rejected.

The Kendall coefficient of concordance W for students and teachers for the consensus rankings of the objectives was 0.93. The Chi Square associated with this value of W is 26.04 which is significant at the 0.05 level. Therefore the null hypothesis of no agreement between the groups of students and teachers on the consensus rankings of the objectives was rejected.

For teachers and parents the Kendall's coefficient of concordance _W_ was 0.93. Associated with this value of _W_ is a Chi Square of 26.4 which is significant at the 0.05 level. Again, the null hypothesis of no agreement between teachers and parents on the consensus rankings of the objectives was rejected.

The Kendall coefficient of concordance _W_ for students and parents was 0.93. The Chi Square which is associated with this value of _W_ is 26.04 and is significant at the 0.05 level. Therefore, the null hypothesis of no agreement between the groups of students and parents on the consensus rankings of the objectives was rejected.

For the subgroup of boys and girls, the Kendall coefficient of concordance _W_ was 0.94 on the ranking of the objectives. Associated with this value of _W_ is Chi Square of 26.448 which is significant at the 0.02 level. Therefore, the null hypothesis of no agreement among boys and girls on the consensus rankings of the objectives was rejected.

The Kendall coefficient of concordance _W_ for students who had chosen vocations and students who had not chosen vocations was 0.80 for the consensus rankings of the objectives. The Chi Square associated with this value of _W_ is 22.400 and is significant at the 0.075 level. Therefore, the null hypothesis of no agreement between students who had chosen vocations and students who had not chosen vocations on the consensus rankings of the objectives was not rejected.

The Kendall coefficient of concordance W for students who liked mathematics and students who disliked mathematics was 0.971. Associated with this value of W is Chi Square of 27.188 which is significant at .015 level. Therefore, the null hypothesis of no agreement between students who liked mathematics and students who disliked mathematics on the consensus ranking of the objectives was rejected.

The Kendall coefficient of concordance W for students who had chosen senior high school courses and students who had not was 0.81. The Chi Square associated with this value of W is 22.596 and is significant at the 0.075 level. Therefore, the null hypothesis of no agreement between students who had chosen senior high school mathematics courses and students who had not chosen senior high school mathematics courses on the consensus ranking of the objectives was not rejected.

Consensus Rankings for Each Objective by the Groups

Consensus rankings by the various groups are shown in Table XXIII.

Consensus Rankings for Each Objective by Subgroups of Students

The consensus rankings of the objectives by subgroups of students is shown in Table XXIV.

TABLE XXIII

CONSENSUS RANKINGS FOR EACH OBJECTIVE BY THE GROUPS

Objectives	Rankings by Groups			
	Professors	Teachers	Parents	Students
1. Fundamental processes	7	4	2	2
2. Mathematical concepts	2	2	4	4
3. Process skills	1	1	3	3
4. Problem solving	3.5	3	5	5
5. Confidence in ability	5	6.5	5	5
6. Mathematics in daily life	13	5	1	1
7. Mathematics in science and technology	15	10	10	8
8. Mathematics and the physical world	11	11	12	11
9. Structure	6	8	8	7
10. Appreciation	8	14	9	10

TABLE XXIII (continued)

Objectives	Rankings by Groups			
	Professors	Teachers	Parents	Students
11. Critical thinking	14	6.5	7	9
12. Mathematics a human activity	12	15	15	14.5
13. Creativity	9	13	14	12
14. Precise language and symbolism	10	12	11	13
15. Enjoyment	3.5	9	13	14.5

N for professors = 8 N for parents = 242
N for teachers = 36 N for students = 338

TABLE XXIV

CONSENSUS RANKINGS OF OBJECTIVES BY STUDENT SUBGROUPS

Objectives	Boys	Girls	Liked Math.	Disliked Math.	Chosen Vocation	Not Chosen Vocation	Chosen Courses	Not Chosen Courses
1. Fundamental process	1	2	1	1	1	2	2	1
2. Mathematical concepts	4	4	4	4	6	4	5	4
3. Process skills	3	3	3	3	3	3	3	3
4. Problem solving	5	5	5	5	4	5	4	5.5
5. Confidence in ability	6	6	7	9	10	6	10	5.5
6. Mathematics in daily life	2	1	2	2	2	1	1	2
7. Mathematics in science and technology	8	10	8	6	9	7	8	7
8. Mathematics and the physical world	10	11	9	12	10	11	9	12
9. Structure	7	8	6	8	5	8	6	8

TABLE XXIV (continued)

	Subgroups of Students							
Objectives	Boys	Girls	Liked Math.	Disliked Math.	Chosen Vocation	Not Chosen Vocation	Chosen Courses	Not Chosen Courses
10. Appreciation	11	9	10	10	8	12	11	9
11. Critical thinking	13	7	12	7	7	14	7	14
12. Mathematics a human activity	14	15	11	14	15	13	15	13
13. Creativity	9	13	14	15	13	9	12	10
14. Precise language	12	12	13	13	12	11	13	11
15. Enjoyment	15	14	15	11	14	15	14	15

N for boys = 152 N for chosen courses = 187 N for liked mathematics = 202
N for girls = 186 N for not chosen courses = 151 N for disliked mathematics = 136
N for chosen vocations = 146 N for not chosen vocations = 192.

Consensus Ranking of Objectives Related to Content

The following shows the consensus rankings of the objectives related to content:

(1) to develop systematic methods of analysing problems and presenting their solutions (professors 3.5, teachers 3, parents 5, students 5);

(2) to develop skill in fundamental processes (professors 7, teachers 4, parents 2, students 2);

(3) to develop an understanding of mathematical concepts (professors 2 teachers 2, parents 3, students 4);

(4) to acquire the process skills of mathematics (professors 1, teachers 1, parents 3, students 3);

(5) to develop the mathematical skills used in daily life (professors 13, teachers 5, parents 1, students 1);

(6) to understand the structure of mathematics (professors 6, teachers 8, parents 8, students 7).

Consensus Rankings of Cultural and Personal Objectives

The cultural and personal objectives were ranked as follows:

(1) to develop an understanding of the significance of mathematics in science and technology (professors 15, teachers 10, parents 10, students 8);

(2) to understand the interaction of mathematics and the physical world (professors 11, teachers 10, parents 12, students 11);

(3) to develop an appreciation of mathematics

(professors 8, teachers 14, parents 9, students 10);

(4) to develop the ability to think critically (professors 14, teachers 6.5, parents 7, students 9);

(5) to understand that mathematics is a human activity and to understand its history (professors 12, teachers 15, parents 15, students 14.5);

(6) to develop "inventiveness" (creativity) (professors 9, teachers 13, parents 14, students 12);

(7) to develop the precise thought and expression of mathematics (professors 10, teachers 12, parents 11, students 13).

Consensus Rankings of Enjoyment of Mathematics

The objective "to foster enjoyment of mathematics" was ranked as follows: professors 3.5, teachers 9, parents 13 and students 14.5.

Summary of Chapter IV

(1) The Kendall coefficient of concordance *W* was computed to determine the agreement within the groups and subgroups. In all cases the agreement was greater than it would have been by chance.

(2) The null hypothesis of no agreement between the following pairs of groups on the consensus rankings was not rejected: (a) professors and students, (b) professors and teachers, (c) professors and parents, (d) students who had chosen vocations and students who had not chosen vocations, and (e) students who had chosen senior high school courses and

students who had not chosen senior high school courses.

(3) The hypothesis of no agreement between the following pairs of groups was rejected: (a) students and teachers, (b) teachers and parents, (c) students and parents, (d) boys and girls, and (e) students who liked mathematics and students who disliked mathematics.

(4) The Mann-Whitney U Test was used to test for significant differences in the ranking of the individual objectives. In the following section, the objectives for which significant differences were computed between groups and subgroups are shown. The rankings for each of the groups and the level of significance are placed after each objective in brackets.

(a) Professors and teachers

Objective 6. To develop the mathematical skills used in daily living (professors 13, teachers 5, significance level 0.02).

Objective 10. To develop appreciation of mathematics in the world around us. (professors 8, teachers 14, significance level 0.03).

(L) Junior high school teachers and parents

Objective 1. To develop skills in the fundamental processes of algebra and arithmetic (teachers 4, parents 2, significance level 0.01).

Objective 6. To develop the mathematical skills used in daily living (teachers 5, parents 1, significance level 0.03).

Objective 15. To foster enjoyment of mathematics (teachers 9, parents 13, significance level 0.004).

(c) Parents and students

Objective 3. To acquire the process skills used in mathematics (parents 4, students 4, significance level 0.03).

Objective 13. To develop inventiveness (creativity) (parents 14, students 12, significance level 0.04).

(d) Parents and professors

Objective 1. To develop fundamental processes of arithmetic and algebra (parents 2, professors 7, significance level 0.02).

Objective 6. To develop the mathematical skills used in daily life (parents 1, professors 13, significance level 0.001).

Objective 7. Mathematics in science and technology (parents 10, professors 15, significance level 0.04).

Objective 15. To foster enjoyment of mathematics (parents 13, professors 3.5, significance level 0.008).

(e) Professors and students

Objective 1. To develop skills in fundamental processes (professors 7, students 2, significance difference 0.02).

Objective 6. To develop the mathematical skills used in daily living (professors 13, students 1, significance level 0.001).

Objective 7. Mathematics in science and technology (professors 15, students 8, level of significance 0.04).

Objective 15. To foster enjoyment of mathematics (professors 3.5, students 13, significance level 0.008).

(f) Teachers and students

Objective 2. To develop an understanding of mathematical concepts (teachers 2, students 4, significance level 0.02).

Objective 3. To acquire the process skills of mathematics (teachers 1, students 3, significance level 0.00011).

Objective 4. To develop systematic methods of analysing problems and presenting their solutions (teachers 3, students 5, significance level 0.01).

Objective 7. To develop an understanding of mathematics in science and technology (teachers 10, students 8, significance level 0.04.

(5) The contingency coefficient showed no significant association among the groups (professors, teachers, students and parents) and the consensus ranking of the following objectives: (a) to develop an understanding of mathematical concepts; (b) to understand the significance of mathematics in science and technology; (c) to understand the interaction of mathematics and the physical world; (d) to develop an understanding of the structure of mathematics; (e) to develop an understanding of appreciation of mathematics; (f) to develop critical thinking; (g) to develop "inventiveness" (creativity); (h) to understand the precise language and symbolism of mathematics.

(6) The hypothesis of no association between the groups of professors, teachers, students and parents on the following objectives was rejected: (a) to develop skill in the fundamental processes; (d) to develop methods of analysing problems and presenting their solution; (c) to develop a student's confidence in his analytic powers and problem solving

ability; (d) to develop the mathematical skills used in daily living; (e) to understand mathematics is a human activity; (f) to foster enjoyment of mathematics.

(7) There is no significant association between boys and girls and the ranking of the objectives.

(8) The hypothesis of no significant association between students who liked mathematics and students who disliked mathematics was rejected on the ranking of Objective 8, the interaction of mathematics and the physical world.

CHAPTER V

SUMMARY

Agreements

The agreements on the ranking of the objectives within all of the groups and subgroups was more than agreement by chance. However, when compared pairwise, the null hypothesis of no agreement between the following groups on the ranking of the objectives was not rejected:

(1) professors and teachers,

(2) professors and students, and

(3) professors and parents.

The null hypothesis of no agreement between the following pairs of groups on the ranking of the objectives was rejected:

(1) teachers and students,

(2) teachers and parents, and

(3) parents and students.

Ranking of the Objectives

The following null hypotheses were rejected for the ranking of the objectives:

(1) professors and teachers rank the objectives in the same order;

(2) parents and teachers rank the objectives in the same order;

(3) students and professors rank the objectives in the same order;

(4) parents and professors rank the objectives in the same order;

(5) parents and students rank the objectives in the same order;

(6) teachers and students rank the objectives in the same order;

(7) students who had chosen vocations rank the objectives the same as those who had not chosen vocations;

(8) students who liked mathematics rank the objectives the same as those who did not like mathematics;

(9) students who had chosen senior high school mathematics courses rank the objectives in the same order as students who had not chosen senior high school mathematics courses.

The following null hypothesis was not rejected:

(1) boys and girls rank the objectives in the same order.

IMPLICATIONS

Student, Parent and Teacher Perception of the Objectives

The perceptions of these groups were very similar. Teachers, parents and students chose the same six objectives to be most important. Parents and students ranked them in exactly the same order, but teachers ranked them differently.

Students and parents chose the same objectives for numbers 7 to 10 inclusive but ranked them differently. Teachers chose three of the four objectives that parents and students had chosen in the ranking of 7 to 10 inclusive. This agreement of perception is also shown by the Kendall coefficient of concordance W for the agreement on the consensus ranking of all of the objectives between teachers and parents, teachers and students, and students and parents. Between each of the pairs of the above groups, the Kendall coefficient of concordance W was 0.93 which is significant at the 0.05 level. This indicated a great deal of uniformity in ranking. However, the Mann-Whitney U test on the item-by-item analysis indicated that the groups were independent. As many of the teachers had had long years of service in these areas, they have been able to observe for some time the occupations in which students of these areas have been and are employed. As a result, some teachers seemed to indicate that a mathematics course which is based on structure is not necessary for most students. Parents, too, are familiar with the vocations which many students enter. They seemed to indicate that a practical mathematics was necessary. Students agreed with parents on the type of course because many students question the use of part of the present mathematics course. Perhaps these were the reasons for the high Kendall coefficient of concordance among these groups.

Professors and Teacher Perception of the Objectives

Professors and teachers chose the same objectives for first and second respectively. However, on comparing the consensus rankings of all of the objectives for these two groups, the Kendall coefficient of concordance was not significant. Therefore, it was impossible to conclude that there was agreement between professors and teachers. This, it would seem, implies a lack of communication between professors and teachers.

Perceptions of the Groups on Objectives Related to Content

Parents and students indicated that the important content of the mathematics course should consist of fundamental processes and the mathematical skills used in daily life. Downey's study (1960) shows that there was a tendency in Alberta for the public to stress practical, vocational mathematics. This is also in keeping with what one parent wrote on a questionnaire, "Mathematics is a tool which enables people to make a living."

Professors and teachers indicated that those process skills of mathematics which enable a student to work on his own were most important. Then, too, at the junior high school level, these groups seemed to think that fundamental processes should not be stressed as much as concepts, because the mastery of the fundamental processes is the work of the elementary school.

Structure, an important feature of "new math," was not considered to be as important as the practical skills by teachers, parents, and students. However, professors ranked structure just above fundamental processes. Thus, it would seem that teachers, parents, and students did not think that structure in mathematics is important at the junior high school level.

Perceptions of the Groups on the Objective of Fostering Enjoyment of Mathematics

This objective was ranked 3.5 by professors, 9 by teachers, 13 by parents, and 14.5 by students. One parent commented on this objective as follows:

> 5 (to develop a student's confidence in his analytic powers and problem solving ability) and 15 (to foster enjoyment) could be listed as 1 and 2--however, perhaps after considering all aspects--these will automatically be the end results.

This might express the views of parents and students regarding motivation. Thus, these groups who ranked this objective as unimportant would leave motivation to chance. However, professors seemed to believe that enjoyment should be used to motivate mathematics, and hence is important. Teachers ranked enjoyment as 9, and hence they did not think it was very important. However, according to Johnson (1968) enjoyment is necessary for successful mathematics teaching.

Perceptions Relating to Cultural and Personal Objectives

In general, the cultural and personal objectives were ranked secondary in importance. This seemed to imply that these groups did not consider them important.

The Present Objectives of Teaching Mathematics in the Junior High School

The present objective for teaching mathematics in the Junior High School of Alberta (Curriculum Guide, Grade IX Mathematics, 1967) were included in the questionnaire. Below is a summary of how the present objectives were ranked by the groups:

(1) to develop an understanding of mathematical concepts, (professors 2, teachers 2, parents 4, students 4);

(2) to develop skill in the use of fundamental processes, (professors 7, teachers 4, parents 2, students 2);

(3) to develop systematic methods of analysing problems and presenting their solutions, (professors 3.5, teachers 3, parents 5, students 5);

(4) to understand the precise language of thought and expression in mathematics, (professors 10, teachers 12, parents 11, students 13); and

(5) to develop an understanding of the significance of mathematics in science and technology, (professors 15, teachers 10, parents 10, students 8).

None of the present objectives was ranked as 1 by these groups. However, the first three of the present objectives were ranked as being important by all groups, but the last two of the present objectives were ranked as being of secondary importance by all groups.

Does this imply that there should be a revision of the objectives? Similar studies should be done in other areas in Alberta to determine what people in other areas deem important. However, it would seem that a revision of the present objectives is necessary.

Significant Differences Between Subgroups of Students

Do the significant differences which exist between subgroups of Grade IX students imply streaming of Grade IX students? Or does it imply there should be a two-track mathematics program? Were these significant differences due to this study being conducted late in the year (May)? Would these significant differences appear among Grades VII and VIII students? The results indicated that there are significant differences, and these should be investigated further.

Public Opinion

The significant differences between the perceptions of the objectives of teaching mathematics raises the following question: How important is public opinion? What effect can it have on education?

Parker and Rubin (1966) describe the effect of public opinion on education after the ascent of Sputnik as follows:

> For the most part the curriculum change was a defensive response to various kinds of criticism some rational and some irrational. It demonstrates that the professional educator will never come to the sheltered path where public attitude, informed or not can be ignored (p. 15).

Downey (1960) agreed that public opinion is very important because the schools should be responsible to the people they serve.

> The expert who may be more competent than most people in delineating the school's function, is, nonetheless quite ineffective unless his judgment ultimately influences public desires. For within the collective public lies the ultimate authority to prescribe the task of the public school.
>
> It follows then, that the student of education, must also be a student of public opinion. His expertise will carry educational policy making only so far as public opinion will permit. To be right is not good enough for the leader of public education; he must also be recognized as being right by the power-wielding public (p. 72).

Another view of public opinion was presented by a panel on "Society's Expectations of Education" at the Red Deer Area A.T.A. Convention, 1972. Dr. H. Kreisel claimed that it was fashionable to attack education and wondered how sincere the public was. However, whether sincere or not, the panel agreed that the pressure of public opinion does exercise an influence on education.

At present there is a confusion of aims and goals which we must learn to live with, and absolute agreement seems impossible. Thus, inflexibility must be provided in the educational system to allow for differences to be worked out. Therefore, in organizing a mathematics program in the junior high school, a two-track program would provide two curricula. Streaming of students with different expectations for each steam would provide a flexible system. Content could vary according to the needs and abilities of students. Hopefully, each student would be able to attain some measure of success.

How does a curriculum receive the public's approval? Perhaps there never will be absolute agreement between the public and the school. However, improved communication between the two groups will enable the different points of view to be discussed, and the differences will become less.

Suggestions for Further Studies

This study opens several avenues to further research.

(1) This study should be carried out in an urban area.

(2) A study should compare the perceptions of the objectives of teaching mathematics in rural and urban areas.

(3) A similar study should compare the perceptions of students who are grouped according to their achievements in mathematics.

(4) The instrument should include a section which would determine the socio-economic status of the respondents. Then, a study should compare the perceptions of students according to their socio-economic status.

(5) A study of the significant differences among student subgroups should be done to investigate the feasibility of streaming.

(6) A study of the perceptions of all junior high school mathematics teachers who are grouped according to sex, training, and years of teaching experience should be done.

(7) A study of the need for revising the present objectives of teaching mathematics should be done.

(8) Various groups, students, parents, professors, or teachers, should prepare lists of objectives.

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APPENDIX A

APPENDIX A

LETTER TO THE SUPERINTENDENTS

Dear Sir:

I am attending the University of Alberta working toward a master's degree in Secondary Education, specializing in junior high school mathematics.

My advisor, Dr. A. T. Olson, has given his approval to my study of "Objectives of Teaching Mathematics in the Junior High School." My plan is to send questionnaires to junior high school students in Grade IX, their parents and teachers in order to collect data on their perceived objectives. Consequently, I am requesting your permission to distribute questionnaires to teachers and pupils in your county.

Hoping that this will meet with your approval,

Yours sincerely,

LETTER TO PARENTS AND TEACHERS

Dear ____________:

Will you please complete the enclosed questionnaire? Its purpose is to gather data for my Master of Education thesis, which is how various groups perceive the relative importance of the objectives of teaching mathematics in the Junior High School.

This thesis is being written under the direction of Dr. A. T. Olson, Department of Secondary Education, University of Alberta.

The list of objectives in the questionnaire has been constructed from an analysis of the literature on the objectives of teaching mathematics. My plan is to collect data from secondary mathematics educators, junior high school mathematics teachers, Grade IX students and their parents as to the relative importance of the objectives of teaching mathematics. Please express your own opinions in ranking these. All returns will be treated as confidential and only combined information will be published.

To make my study reasonably sound, I must have a high percentage of returns. Please complete the questionnaire and return it to the school as soon as possible. I hope to have all of my information in by May 19, 1971.

Thank you for your co-operation.

Yours sincerely,

INSTRUCTIONS REGARDING THE QUESTIONNAIRES

1. Please read the following to your grade IX students:

   Mrs. Freeman, a student at the University of Alberta, is conducting a study on what Grade IX students, their parents and junior high school mathematics teachers perceive as the objectives of teaching mathematics.

   What are objectives? Objectives are aims, goals or purposes.

   For the study, students and parents are selected at random. In order to make the study reasonably sound, there must be a high percentage of returns.

   Please fill out the questionnaire and return it to your teacher by May 17, 1971.

2. Pass out the questionnaire to those students who have been selected.

3. Ask the students to look at question 4 on the short sheet. 'Don't know program' means that the student has not selected a mathematics program for senior high school.

4. Please pass out questionnaires to students for their parents. The students are to fill in their parents' name.

   Thank you for your co-operation.

SPECIAL STUDENT QUESTIONNAIRE

Please place a check in the proper spot so that the answer is correct for you.

1. I am a girl ________ boy _____.
2. I have chosen an occupation. Yes _____ No _____.
3. I like mathematics. Yes _____ No _____.
4. I plan to take the following mathematics program in high school.

   Math 15-25 _____ Math 13-23 _____

   Math 10-20-30 _____

   Have not chosen a program _____

Below is a list of objectives for teaching matheamtics in the Junior High School.

Please rank these objectives in order of importance. The most important is to be ranked 1, the next most important is to be ranked 2, and so on, the least important will be ranked 15. Please place the rank number in the space before the objective.

_____ 1. To be able to add, subtract, multiply, divide and to solve equations correctly in arithmetic and algebra.

_____ 2. To develop an understanding of the mathematical concepts from arithmetic, algebra and geometry, e.g. area, volume, perimeter, congruence, similarity, etc.

_____ 3. To acquire the process skills required in obtaining mathematical knowledge, e.g. methods of reading, finding information, the way of thinking, and using the knowledge.

_____ 4. To develop systematic methods of analyzing problems and presenting their solutions.

_____ 5. To develop a sutdent's confidence in his analytic powers and problem solving abilities.

_____ 6. To develop mathematical skills used in daily living, i.e. be able to use mathematics in business and personal finance, e.g. insurance, taxes, discount, etc.

_____ 7. To develop an understanding of the significance of math in science and technology.

_____ 8. To understand the interaction between mathematics and the physical world, e.g. how man controls his environment.

_____ 9. To develop an understanding of the structure of mathematics. This is understanding how mathematical knowledge is related, e.g. all number systems have certain common structural properties, e.g. the commutative property. $4 \times 3 = 3 \times 4$.

_____ 10. To develop an appreciation of mathematics in the world around us, beauty in art, nature, architecture, etc. in form, balance, regularity of patterns, symmetry, etc.

_____ 11. To be able to apply mathematical reasoning to social and personal problems and to reach conclusions based on facts.

_____ 12. To understand that mathematics is a human activity (invented by man) and its history is marked by inventions, discoveries, guesses and mistakes.

_____ 13. To develop inventiveness (creativity). Students should be given problems for which they must "invent" a method of solving, e.g. find the diameter of the earth.

_____ 14. To understand that mathematical words have exact meanings and to realize how mathematical symbolism makes problem solving easier.

_____ 15. To foster enjoyment of mathematics.