UNIVERSITY OF CALGARY

A STUDY OF THE RELATIONSHIP BETWEEN SELECTED TEACHER CHARACTERISTICS AND STUDENT ACHIEVEMENT IN TRADITIONAL AND MODERN MATHEMATICS

by

STUART WESLEY COOKE

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ABSTRACT

The purpose of the study was to survey a selected group of mathematics teachers to determine their state of professional preparedness for teaching a modern algebra course at the grade ten level and to analyze the effect of various degrees of preparedness on student achievement on (a) a traditional part and (b) a modern part of a criterion examination.

Data were obtained by means of a questionnaire on the professional training, teaching experience and related professional activities of a group of grade ten algebra teachers in Southern Alberta. The criterion measure of student achievement was an externally administered objective test constructed by the writer. The reading ability of the student, as measured by the stanine score of the student on the grade nine reading examination, was used as the covariate to control for initial differences in ability among the students.

The method used to analyze the data was multiple linear regression analysis using an analysis of covariance design. The analysis was performed on the IBM 1620.

The findings suggest that teachers are well trained to teach traditional mathematics but, in terms of recent modern mathematics courses taken in university, are very poorly trained to teach modern mathematics. This is of particular concern, for the study showed that the teacher with less recent training, a weaker mathematical background and more experience got significantly better results on the traditional part of the criterion examination; however, the teacher with more recent training, a stronger

mathematical background but less experience got very significantly better results on the modern part of the criterion examination.

In view of the projected trend towards still greater revision of the high school mathematics program in Alberta, the urgent need for an immediate, deliberate and concentrated retraining of many of the present grade ten algebra teachers in Southern Alberta is apparent.

ACKNOWLEDGEMENTS

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THE NATURE OF THE PROBLEM

I. INTRODUCTION

A cursory examination of the literature immediately reveals that the consensus of opinion among leading mathematicians and educators is that tremendous changes are urgently needed in the mathematics curriculum. The Quebec Royal Commission (1965) comments that " . . . the changes needed in the teaching of mathematics are probably as profound, if not more so, than those required in any other subject in the programme."[1] The immediate prospect of revolutionary changes in the high school mathematics program raises many important questions which must be answered and poses many crucial problems which must be solved. Questions relevant to the present study are: How well are new teachers being prepared to teach the new mathematics? How well are the present teachers prepared to teach the new content? Is a massive re-education of teachers necessary and desirable or will brief but concentrated refresher sessions be adequate? All of these questions demand conscientious research so that the leaders of innovation and change in the field of mathematics education can give responsible--if not final--answers to an enquiring public.

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[1] _Report of the Royal Commission of Inquiry on Education in the Province of Quebec_, Vol. III, Part 2 (Montreal: Pierre DesMarais, Lithographer, 1965), p. 103.

II. ORIENTATION OF THE PROBLEM

In Alberta the Department of Education has committed itself to an upgrading of the entire school mathematics program. A significant beginning has been made at both the elementary and junior high school levels. Much attention was given to textbook and course selection problems. The Faculty of Education at the University of Calgary, Calgary, and the Faculty of Education at the University of Alberta, Edmonton, have taken the initiative to implement strong programs of teacher re-education with particular emphasis on six week summer courses, special mathematics courses offered during the winter sessions, assistance to school boards for in-service training programs and television instruction. As well, the Mathematics Council of the Alberta Teachers' Association has actively encouraged teachers to upgrade their qualifications to keep pace with the most recent developments in school mathematics. Now, however, with the prospect of revolutionary changes in the high school mathematics program, this same problem of teacher re-education has reached the high school level. The magnitude of the problem is forcefully stated by Francis Keppel, former U.S. Commissioner of Education, in the forward to the Cambridge Report when he says:

> It is not only that most teachers will be completely incapable of teaching much of the mathematics set forth in the curricula proposed here; most teachers would be hard pressed to comprehend it.[2]

Irving Adler adds:

> Although the goal proposed by the Cambridge Report is realizable, it will not be easy to realize. There are some serious obstacles

[2]Francis J. Keppel, Forward to the Report of the Cambridge Conference on School Mathematics, Goals For School Mathematics, (Boston: Houghton Mifflin Co., 1963).

> that will have to be overcome before significant progress toward the goal can be made. The first of these is the low level of mathematical preparation of teachers.[3]

George Polya adds:

> No change in the curriculum, however desirable it may be in itself, can cure all the ills; the real bottleneck is, in my opinion, the insufficient training of the teachers.[4]

While improved content may be a necessary condition for an improved mathematics program, as Glennon says, " . . . improved content is not a sufficient condition for an improved mathematics program."[5]

III. THE PROBLEM

The purpose of this study was to survey a selected group of mathematics teachers to determine their present state of professional preparedness for teaching a new high school mathematics program and to analyze the effect of teacher preparedness on student achievement in a grade ten mathematics course. Specifically, the present situation with respect to teacher qualification, teaching experience and related professional activities of the selected group of teachers was determined and various aspects of these were analyzed to determine the independent effect of each aspect on student achievement on both modern and traditional parts of the present grade ten mathematics course.

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[3]Irving Adler, "Blueprint or Fantasy," The Mathematics Teacher, Vol. LIX, No. 3 (March 1966), p. 215.

[4]George Polya, To the Panel Discussion of the Canadian Mathematical Congress, September 1961 in Symposium on the Training in Mathematics Given at the University to Future High School Teachers, at the University of Montreal, (Toronto: University of Toronto Press, 1963).

[5]V.J. Glennon, "An Now Synthesis," The Arithmetic Teacher, Vol. 12, No. 2 (February 1965), p. 139.

IV. MAJOR HYPOTHESIS

Student achievement on (a) the modern part and (b) the traditional part of the algebra section of the grade ten mathematics course is not significantly related to:

1. the professional qualifications of the teacher,
2. the number of years of actual teaching experience of the teacher,
3. the related professional activities of the teacher in the area of mathematics education.

V. DELIMITATION OF THE PROBLEM

Teacher Qualifications

Although there are many intangible factors which contribute to the success of a teacher in a classroom, this study evaluated only the concrete and readily measurable qualities related to actual academic preparation for teaching. Teacher qualification was restricted to the total number of years of university training as well as the teacher's formal training in the specific field of mathematics as measured by the number of university mathematics courses taken by the teacher. Both the total number of courses and the number of modern mathematics courses were considered.

Professional Activities

Related professional activities referred to selected activities of the teacher related to mathematics education other than actual classroom instruction. Some of these activities are carried on inside the school--such as the sponsorship of a mathematics club. Other activities are carried on outside the school--such as participation in a specialist council. All such activities, however, are indicative of a teacher's interest in, and dedication to, both the subject matter and the pupils and are therefore relevant to this study.

The Criterion Measure

The evaluation of the influence of a teacher on a student in the school situation is a persistent and complicated problem. Adequate measuring instruments are difficult to construct and the results can often be interpreted in different ways. Because of this inherent difficulty, no attempt was made to measure any of the intangible effects of teacher on student such as change of attitude. However, it is necessary to have a criterion measure by which the influence of teacher preparedness on the learning situation can be measured. Student achievement measured by an external examination is generally accepted as one of the basic criteria of teacher effectiveness; thus the criterion measure used in this study was an externally administered objective test constructed by the writer on the algebra section (chapters 1-5) of the authorized text. The evaluation of the criterion measure is described in Chapter III.

Traditional vs. Modern Mathematics

The total mathematical content of the algebra section was considered to consist partly of modern mathematics and partly of traditional mathematics. Modern mathematics was defined to be any mathematics in the text that was new to the grade ten program and included such ideas as inequalities, absolute value and sets. Traditional mathematics was considered to be any mathematics included in the text that normally had been taught in the Alberta high school and included such topics as factoring, solving equations and using equations to solve problems. The criterion measure was constructed in two equal parts to evaluate student achievement on the traditional and modern parts separately.

The Covariate

The grade nine reading test score of each student was included in the study as a covariate to control for initial differences of ability among the students. The reading test scores were used rather than the grade nine mathematics marks on the assumption that the reading test scores give an indication of general intelligence whereas the mathematics scores give only an indication of achievement in a particular course.

VI. IMPORTANCE OF THE STUDY

The central importance of the present study lies in the fact that high school mathematics programs are in a state of flux. Teachers must be prepared to meet the challenge of the changing programs, for competent teaching of the new material at the high school level is basic to the success of the proposed programs. The Cambridge Report presents a clear statement of the problem when it says:

> There is a special reason why the training of teachers should be rapid and highly coordinated. Probably the easiest part of our program to put into the classroom is its first part, in the first three grades. If this is done, then children will develop a set of expectations which will be disappointed by teachers in later grades unless the training of teachers has kept pace with the progress of the children themselves. Much of our work will be wasted unless curricular development and teacher training keep pace with each other.[6]

[6] Goals For School Mathematics, The Report of the Cambridge Conference on School Mathematics, (Boston: Houghton Mifflin Company, 1963), p. 27.

In the light of this fact, the possibility of successfully implementing a new mathematics program at the high school level in Alberta must be carefully re-evaluated.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

I. INTRODUCTION

In recent years most of the advanced countries of the world have developed broad programs of research with the aim of reforming the mathematics curriculum at all levels. At the present time a virtual revolution is in progress. The philosophy of mathematics education, the nature of the mathematical content to be taught, and the methods of teaching it are all being seriously examined and in most cases being vigorously revised. Melton and Osbourn say that:

> The major impetus for change stems from a widespread dissatisfaction among mathematicians and educators with a mathematics curriculum that has remained largely unchanged for years despite a mushrooming of new developments.[1]

II. DEVELOPMENTS IN EUROPE

In 1959 the Organization for European Economic Cooperation, which has now become the Organization for Cooperation and Economic Development, began a study of mathematics teaching and of the reforms needed in it. The work was completed with the publication of a book which recommended

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[1]H.G. Osbourn and R.J. Melton, "Prediction of Proficiency in a Modern and Traditional Course in Beginning Algebra," Educational and Psychological Measurement, Vol. 23, No. 2 (Durham N.C.: College Station, 1963), p. 277.

a program that emphasizes the fundamental unity of the branches of mathematics: algebra, geometry and analysis.[2]

This initial impetus for revision of the school mathematics curriculum has had an impact on most European countries which are now in the process of making extensive revisions to the traditional curricula. France is vigorously modernizing its curriculum. Felix says:

> Actually the work of research in teaching modern aspects of mathematics is being actively carried on, and results are being achieved at various levels. This research deals, on the one hand, with methods of teaching and, on the other, with the construction of curricula . . . the present situation is far from satisfactory because too many teachers have been inadequately trained.[3]

Curriculum revision in Britain has begun with the work of The School Mathematics Project (1959). A director of this project criticizes the traditional program in that it (a) fails to present mathematics as the unity it should be at the school level, (b) is unexciting and irrelevant and (c) fails to reflect the extraordinary advances of the last sixty years in mathematical knowledge and technique. To overcome these shortcomings, The School Mathematics Project is currently writing revised pupils' texts for the whole grammar school program with special emphasis on the mathematical content of the course.[4]

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[2]New Thinking in School Mathematics, Organization For European Economic Cooperation, Office for Scientific and Technical Personnel, (Paris: OEEC Publications, 1961).

[3]Lucienne Felix, "The Development of the Teaching of Mathematics in France at the First and Second Degree Levels," The Mathematics Teacher, Vol. LVIII, No. 7 (November 1965), p. 638.

[4]Byran Thwaites, "Mathematical Reforms in English Secondary Schools," The Mathematics Teacher, Vol. LIX, No. 1 (January 1966), pp. 42-52.

Probably the most radical of all the international reform movements, however, has been that undertaken in the Danish gymnasium.[5] The new Danish curriculum is largely algebra oriented and is far more radical than most of the revised programs on this continent. At the level equivalent to the Canadian grades 10-12, the Danish student is already studying such topics as complex functions, equivalence relations, groups, rings and fields, probability, vector spaces and topology, integral and differential calculus. The subject matter is taught at a high level of abstraction with strong emphasis on the unity of the different branches of mathematics. A Danish mathematics educator concludes that:

> the pupils are given a substantial piece of mathematics containing nice, nontrivial, and useful theorems and theories, both classical and modern, and given it in a language and a spirit in accordance with the language and spirit of contemporary mathematics.[6]

It would appear that if the reform of the mathematics curriculum in Canada is to parallel that of Europe, especially Denmark, still greater and more far-reaching changes will yet be made in the program now in operation.

IV. DEVELOPMENTS IN THE UNITED STATES

One of the first influential groups to promote revision of the mathematics curriculum in the United States was the College Entrance Examination Board with The Report of the Commission of Mathematics[7]

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[5] Ole Rindung, "The New Mathematics Program in the Danish Gymnasium," The Mathematics Teacher, Vol. LVIII, No. 2 (February 1965), pp. 150-155.

[6] Ibid., p. 155.

[7] Program For College Preparatory Mathematics, The Report of the Commission on Mathematics, (New York: College Entrance Examination Board, 1959).

(1959). This concise and scholarly analysis of the school mathematics program puts all its weight behind immediate revision of the mathematics curriculum. However, the recommended changes were conservative in that there was reasonable expectation that most of the recommendations could be implemented in the immediate future. In fact, since 1959 many of the proposed ideas have been tried and are forming the foundation for the fundamental revisions that are now taking place.

A more revolutionary but no doubt equally significant document is The Cambridge Report[8] (1963). It also recommends drastic revision of the mathematics curriculum towards the realization of a proposed set of objectives by 1990. As Adler says,

> The report is not, and is not intended to be a blueprint for the curriculum of the future. It is a general statement of a goal to be reached, with a description of two different paths that may be followed to reach that goal and an invitation to the teaching community to propose other possible paths.[9]

Many programs are in the process of being developed which incorporate to different degrees and with different degrees of success many of the suggested revisions. One of the most extensive programs financed by the United States Government through the National Science Foundation is the School Mathematics Study Group (SMSG) originally of Yale University and now of Stanford University, California. Its goal was to reform the teaching of elementary mathematics, but it started with the problem of deciding what mathematics a student should know at the end of the twelfth year. It then developed a program for the ninth to twelfth years

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[8] Goals For School Mathematics, op. cit.

[9] Adler. op. cit., p. 213.

for students who had not been taught the ideas of the new mathematics, and it then continued with a study of the seventh and eighth year programs. Afterwards, appropriate elementary school programs were developed. In 1959-1960 these programs were tested and after some revision, interim textbooks were published by the Yale University Press. These texts have since had a strong influence in the United States and Canada.

Numerous other groups and committees such as the University of Illinois Committee on School Mathematics (UICSM), the University of Maryland Mathematics Project (UMMP) and the Ball State Program are also working towards active revision of the mathematics curriculum. As well, many textbooks have been and are being written which reflect the proposed changes and some of these are gaining wide acceptance.

The full utilization of the above reform projects obviously requires that teachers be well instructed in modern mathematics. This was one of the reasons why the Mathematical Association of America, supported by the National Science Foundation, formed a committee called the Committee on the Undergraduate Programme in Mathematics (CUPM) with the object of studying mathematics teaching at the undergraduate university level. In 1961 the committee published a report which classified the various teaching levels and specified the mathematical education that teachers at each level should have. It was recommended that at least 20 per cent of mathematics teachers in elementary schools have at least two years of university instruction in mathematics, that teachers of the elements of algebra and geometry have three years of university instruction in analysis, algebra, geometry, and probability based on set theory and that teachers at the high school level have a bachelor's degree with a major in mathematics and a minor in mathematics as applied to physics.[10]

V. DEVELOPMENTS IN ALBERTA

The influence of these rather rapid and revolutionary developments has been felt in Canada. All ten provinces are to some degree experimenting with a revised mathematics curriculum for some or all of the grades. Alberta in particular made a dual authorization of the series of texts Seeing Through Arithmetic[11] and Arithmetic We Need[12] on an experimental basis in 1956. In 1959 the two series were introduced on a province-wide basis with each local district, division or county taking its choice of the two series of texts. This year (1965-66) the new mathematics is at the grade seven level throughout the province with schools choosing either the Seeing Through Mathematics[13] series or the Exploring Modern Mathematics[14] program on an experimental basis at the grade eight and nine levels. Also, a new text, Secondary School Mathematics, Grade Ten

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[10] Recommendations of the Mathematical Association of America for the Training of Teachers of Mathematics," The Mathematics Teacher, Vol. LIII, No. 8 (December 1960), pp. 632-638.

[11] M.L. Hartung, H. Van Engen, L. Knowles and C. Mahoney, Seeing Through Arithmetic, Books 3-6, (Chicago: Scott, Foresman and Co., 1955-58).

[12] G.T. Buswell, W.A. Brownell, I. Sauble and C.W. Maedel, Arithmetic We Need, Books 3-8, (Toronto: Ginn and Company, 1955-59).

[13] H. Van Engen, M.L. Hartung, H.C. Trimble, E.J. Berger and R.W. Cleveland, Seeing Through Mathematics, Books 1-3, (Chicago: Scott Foresman and Company, 1962-64).

[14] M.L. Keedy, R.E. Jamison, and P.L. Johnson, Exploring Modern Mathematics, Books 1-3, (New York: Holt, Rinehart and Winston, Inc., 1962-64).

by Maclean et al.,[15] was authorized in 1965 for the grade ten program. Although it is not a radical departure from traditional texts, it does introduce new symbolism and terminology and presents the mathematics with a new emphasis and from a different viewpoint. It also includes much of the algebra that was taught previously at the grade eleven level.

For many years, much was written about the need for immediate revision of the mathematics curriculum. Presently the actual revision is in progress, and the new programs are rapidly being implemented in the school systems. However, the inclusion of a comprehensive, detailed teacher's guidebook for most of the new programs is a tacit admission that the majority of teachers are not adequately prepared to handle the new materials in a competent manner.

VI. RESEARCH FINDINGS

A few researchers have investigated this situation with respect to student achievement. Valsame[16] (1961) did a study to determine among other things the qualifications of white secondary public school teachers in North Carolina to teach mathematics courses which include modern mathematics. He reviewed a variety of recommendations to establish a national pattern of qualifications. A questionnaire survey was done to determine the qualifications of teachers in the school system.

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[15] W.B. MacLean, D.L. Mumford, R.W. Bock, D.N. Hazell and G.A. Kaye, Secondary School Mathematics, Grade Ten, (Toronto: The Copp Clark Publishing Co. Ltd., 1964).

[16] J. Valsame, "A Study of Selected Aspects of Mathematics Teacher Training in North Carolina as Related to Recent Trends in Mathematics Teaching" (unpublished Master's thesis, The University of North Carolina, Chapel Hill, 1961).

Some of the significant conclusions were that the teachers surveyed were not well qualified when compared with either the recommended national or state patterns but were reasonably well qualified from the standpoint of traditional mathematics. He recommended that the mathematical requirements for mathematics teachers be increased and that more modern mathematics be included in pre-service and in-service training.

Pruitt[17] (1963) did a study in Ohio which was designed to determine (a) the mathematical preparation in college mathematics of all teachers of mathematics in Ohio public secondary schools who had been teaching less than eight years, (b) the teaching assignments of these teachers and (c) the attitudes and professional plans of the unqualified teacher of mathematics. His conclusions were that there was a shortage of qualified teachers, that less than one third of the mathematics teachers in grades seven and eight had the equivalent of a major in mathematics and that over five per cent of the secondary school mathematics teachers had not earned a single credit hour in college mathematics.

Ford[18] (1961) did a study in Missouri to determine the extent to which persons preparing to teach secondary school mathematics are provided with experiences necessary to understand and teach the content of the major modern programs in secondary school mathematics. A questionnaire was used to determine the nature of the courses which made up the undergraduate mathematics program. The content of the textbooks for these courses

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[17]R. Pruitt, "The Mathematics Preparation of Select Secondary School Teachers of Mathematics in Ohio Public Schools, 1961-1962," (unpublished Master's thesis, Ohio State University, 1963).

[18]Patrick L. Ford, "The Mathematics Included in Programs for the Education of Secondary School Teachers in the Southern Association" (unpublished Ph.D. thesis, University of Missouri, Columbia, 1961).

was analyzed. He concluded that experiences were being provided that were pertinent to both the traditional and experimental programs but that there were indications that those currently being prepared to teach mathematics will be unfamiliar with the types of secondary school mathematics programs in which they may begin their teaching careers.

Garner[19] (1963) did a study in Texas to determine if the educational backgrounds and attitudes of teachers towards algebra are related to the attitudes and achievements of their Anglo-American and Latin-American pupils in first year algebra classes. Each pupil and teacher selected was administered an attitude inventory, especially designed for the study, at the beginning and at the end of the school year. The Cooperative Algebra Test was also administered at the beginning and the end of the school year. The hours in college mathematics and in professional education were obtained for each teacher. He found that the Anglo-American pupils' end-of-course attitudes toward algebra and judgments on the practical value of algebra are significantly related to their achievements in algebra. He also found that significant relationships existed between teachers' backgrounds in mathematics and pupil achievements in algebra, and between teachers' attitudes toward algebra and the end-of-course attitudes of pupils toward algebra. No significant relationship existed between teachers' attitudes toward algebra and pupils' achievements in algebra.

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[19]Meridon V. Garner, "A Study of the Educational Backgrounds and Attitudes of Teachers Toward Albegra as Related to the Attitudes and Achievements of Their Anglo-American and Latin-American Pupils in First-Year Algebra Classes of Texas" (unpublished Ed.D. thesis, North Texas State University, Denton, Texas, 1963).

Lindstedt[20] (1960) did a study in Alberta to determine the relationship between selected teacher characteristics and teacher competence as measured by student achievement on a grade nine mathematics examination. The characteristics selected were (a) years of teaching experience (b) years of training (c) the number of university mathematics courses taken and (d) the subject preference of the teacher. A representative sample of the total population of grade nine mathematics teachers in the province was used. He found that teachers with ten or more years of experience are more competent than teachers with less experience and that teachers with four or more years of training are more competent than teachers with less training. As well, he found that the combined effect of teacher training and teaching experience had a very significant effect on student achievement in a traditional grade nine mathematics course.

The proponents of a revised curriculum are cognizant of a relationship that appears to exist between teacher preparation and student performance. The Report of the Commission on Mathematics notes that:

> The role of the teacher is vital: curricular change must be accompanied by effective meaningful teaching, directed toward the development of mathematical power and understanding . . . no curricular recommendations, however worthwhile, can be translated into classroom action except by the efforts of teachers. To this end, schools must have teachers trained to teach the subject matter in the spirit of twentieth century mathematics. Only a small percentage of teachers have had the up-to-date training required for the task.[21]

The Cambridge Report presents a forceful restatement of the same concern

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[20]Sidney A. Lindstedt, "Teacher Qualifications and Grade Nine Mathematics Achievement," The Alberta Journal of Educational Research, Vol VI, No. 1 (March 1960), pp. 76-85.

[21]Program For College Preparatory Mathematics, loc. cit.

when it says:

> It appears that many teachers do a better job than the state of their own knowledge would give anybody a right to expect; the craft of the schoolmaster, plus a reasonably good textbook that the schoolmaster can manage to keep up with, goes a long way in place of the basic knowledge which we would like to regard as normal. With due allowance for this principle, the gulf between the demands that we propose to make on teachers and the qualifications of the present generation of teachers is very wide.[22]

The purpose of the present study was to investigate the seriousness of this situation in Southern Alberta in view of the current revision of the high school mathematics program.

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[22] Goals For School Mathematics, op. cit., p. 26.

CHAPTER III

DESIGN OF THE STUDY

I. INTRODUCTION

This study seeks to survey the professional preparedness of teachers to teach grade ten algebra and to examine the relationship between teacher preparedness for teaching that specific subject and student achievement in that subject.

The present chapter specifies the location of the school systems involved in the study, the teacher and student samples, the materials used to collect the data, an evaluation of the criterion measure and the procedures followed.

II. AREA

The investigation was confined to the general area of Southern Alberta encompassed by the Lethbridge Inspectorate of the Department of Education. Specifically, the divisions, districts and counties in this study are shown in Table I.

III. SAMPLES

The students who took part in the study were all the students residing in the area outlined above who wrote the grade ten mathematics final examination in June as prepared and distributed by the Southern Alberta Cooperative Testing Program.

TABLE I

ALBERTA SCHOOL SYSTEMS IN THE SOUTHERN ALBERTA TESTING PROGRAM 1965-1966

School System	
Bow Island RCSD #82	Bow Island
Coleman School Dist. #1216	Coleman
Crowsnest Cons. S.D. #78	Blairmore
Forty Mile County #8	Foremost
Lethbridge RCSD #9	Lethbridge
Lethbridge County #26	Lethbridge
Taber School Division #6	Taber
Taber RCSD #54	Taber
Vulcan County #2	Vulcan
Warner County #5	Warner
Willow Creek School Div. #28	Claresholm

Only those students for whom grade nine reading scores were available were included in the study. This eliminated any 'transfer-in' students who might have had a different background in mathematics.

The study included all teachers in the participating area who taught at least one class of grade ten mathematics throughout the 1965-1966 school term.

The project involved a total of 975 students and 32 teachers in the schools shown in Table II; however, one teacher did not return a questionnaire and reading test scores were not available for 130 students. Thus the analysis was based on a total of 845 students and 31 teachers.

IV. MATERIALS

The materials used were a criterion test, a questionnaire and a control test.

The test[1] used as the criterion measure was a 50 minute, thirty item multiple choice test on the algebra section of the grade ten mathematics course. The authorized text for this course was Secondary School Mathematics, Grade Ten by Maclean et al.[2] The algebra section includes chapters 1-7; however, chapters 6 and 7 were considered optional and therefore omitted by most teachers. Thus, for the purpose of this study, the algebra section of the course was considered to be chapters 1-5 which includes the major topics shown in Table III. Each chapter was carefully

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[1]See Appendix A.

[2]Maclean, loc. cit.

TABLE II

NUMBER OF MATHEMATICS TEN TEACHERS AND STUDENTS IN EACH SCHOOL SYSTEM

School	City or Town	Number of Teachers	Number of Students
St. Michael's Separate	Bow Island	1	12
Catholic Central High	Lethbridge	1	99
Chamberlain	Grassy Lake	1	14
Claresholm High	Claresholm	1	37
Coalhurst High	Coalhurst	1	13
Enchant	Enchant	1	5
Foremost	Foremost	1	22
Horace Allen High	Coleman	1	44
Isabelle Sellow High	Blairmore	1	43
J. T. Foster High	Nanton	1	31
Kate Andrews High	Coaldale	2	65
Livingstone	Lundbreck	1	14
Lomond	Lomond	1	25
Macleod High	Fort Macleod	1	46
Manyberries	Manyberries	1	9
Milk River High	Milk River	1	33
Milo	Milo	1	11
Nobleford	Nobleford	1	10
Picture Butte High	Picture Butte	1	57
Raymond Senior High	Raymond	1	47
Senator Gershaw High	Bow Island	1	40
Stavely High	Stavely	1	22
Stirling	Stirling	1	9
St. Mary's Separate	Taber	1	22
St. Michael's Separate	Pincher Creek	1	18
Vauxhall High	Vauxhall	1	46
Vulcan High	Vulcan	2	80
Warner	Warner	1	12
W. R. Myers High	Taber	2	89

TABLE III

CHAPTER TOPICS OF ALGEBRA SECTION OF MATHEMATICS TEN TEXT

Chapter	Topics
I	Rational, irrational and real numbers
II	Equations and inequations
III	Problem solving
IV	Factoring polynomials
V	Simplification of rational expressions
VI	Relations
VII*	Systems of Linear Equations

*Omitted from study because these chapters were optional for the year 1965-1966.

analyzed to determine the major mathematical ideas and skills emphasized. Then test questions were constructed to test each of these. The total material was categorized into (a) modern mathematics or (b) traditional mathematics. Any skill or idea that previously had been a part of the Alberta high school course was called traditional mathematics, while all material that had not been taught previously in the Alberta high school was called modern mathematics.

The questionnaire[3] consisted to six questions to provide data on teacher qualifications and teaching experience and a check list of ten items, answered Yes or No, to determine the related professional activities of the teacher in the area of mathematics education.

The test used to control for initial differences in ability of the participating students was the Cooperative Reading Test administered to all grade nine pupils throughout the province in June of each year by the provincial Department of Education. Each teacher was asked to provide this score for each student tested.

V. CRITERION EVALUATION

The criterion test was originally constructed as a thirty-eight item multiple choice test and was pretested on the students shown in Table IV. The test was scored on the IBM 1230 and descriptive statistics and item analysis were performed on the IBM 1620. The pretest had a KR20 reliability of .7611 and after an item analysis the eight least acceptable

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[3]See Appendix B.

TABLE IV

NUMBER OF PUPILS AND LOCATIONS IN WHICH PRETEST WAS ADMINISTERED

Town	School	Number of Pupils
Acme	Acme	22
Banff	Banff Consolidated	54
Three Hills	Prairie High	59
Three Hills	Three Hills High	25

items were discarded. As well, nine other items were revised for content and seven were revised to improve wording, typing and general impression. Items were considered acceptable only if the biserial correlation of that item with the test as a whole was greater than or equal to .30 and the range of acceptable difficulty was .30 to .80. The items were again rearranged so that the fifteen odd-numbered items were questions testing student achievement on modern material and the fifteeen even-numbered items were questions testing student achievement on traditional material. All items had five possible responses of which only one was correct. The average difficulty of all thirty-eight items was found to be .45.

An item analysis[4] was also performed on the final administration of the test to the Southern Alberta sample and the KR20 reliability was .73 and the average difficulty was evaluated at .5086.

VI. PROCEDURE

The revised test used as the criterion measure was forwarded to those responsible for the construction of the complete Mathematics 10 examination. A geometry section was added to the algebra section and these two sections were printed and distributed to the participating school systems as the June final examination of the Southern Alberta Cooperative Testing Program. An IBM 501 answer sheet was included with each examination paper along with appropriate instructions for both teachers and students.[5]

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[4]See Appendix D.

[5]See Appendix B.

The criterion test was administered in the schools on the morning of June 20th from 9:00 a.m. to 12:00 a.m. The teachers immediately forwarded the IBM answer sheets, the reading test score sheets and the completed questionnaires as instructed. The answer sheets were scored on the IBM 1230, descriptive statistics was done of the IBM 1620, and the results were returned to the teachers for their use. The actual answer sheets were retained for further analysis.

CHAPTER IV

ANALYSIS OF DATA

I. INTRODUCTION

The present study was designed to determine the effect of selected teacher characteristics on (a) student achievement in traditional mathematics and (b) student achievement in modern mathematics. This chapter explains the general method and procedure used to test each hypothesis, identifies the variables involved in the study and presents a detailed analysis of the data for each hypothesis.

II. THE GENERAL METHOD

The general method of analysis of data was multiple linear regression analysis using an analysis of covariance design which was performed on the IBM 1620.[1] The main teacher predictor variable (factors) were divided into three categories (levels) and the question was whether the students in the various categories differed significantly on the criterion measures. A covariate was employed to control statistically for initial differences of student ability.

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[1]R.A. Bottenberg and J.H. Ward Jr., Applied Multiple Linear Regression Analysis, Technical Documentary Report PRL-TDR-63-6, Clearinghouse for Federal Scientific and Technical Information of the U.S. Department of Commerce, March, 1963.

III. THE PROCEDURE

The procedure followed was to create a set of variables one for each category and to assign a score of one if a subject was in that category and a zero if the subject was not. These variables were then included along with the covariate in a full regression model to predict the criterion measure, solving for the best weighted linear combination of these predictors (least error sum of squares). The squared-multiple-correlation RSQ1 of the full model was used as a measure of the efficiency of the prediction. A similar model, the restricted model, was then written, which included only the covariate and excluded the teacher predictor variables. The resulting squared-multiple-correlation RSQ2 is necessarily less than RSQ1, and the difference was considered a measure of the effect on the criterion of belonging to that category (or set of categories). Under certain assumptions, the ratio $\frac{(RSQ1 - RSQ2)/df1}{(1 - RSQ1)/df2}$ is distributed as F. When a significant difference between the correlations was found, a modification of this procedure was employed to isolate the source of significance and to determine its precise effect on student achievement. Throughout the analysis of the data, differences at the .05 level were accepted as significant.

IV. IDENTIFICATION OF THE VARIABLES

The Criterion Variables

The criterion variables were (a) the student's score on the traditional part of the criterion test (V1), and (b) the student's score on the modern part of the criterion test (V2).

The Covariate

The variable chosen to act as the covariate to control for initial differences in ability among the students writing the test was the reading ability of the student as measured by the stanine score of the student on the grade nine reading test (V3).

The Predictor Variables

Certain aspects of a teacher's academic preparation for the teaching of mathematics were chosen as the predictor variables as follows:

V4 - V6 Total number of university mathematics courses

- level 4 zero to two courses
- level 5 three to five courses
- level 6 six or more courses

V7 - V9 Total number of modern mathematics courses

- level 7 no courses
- level 8 one or two courses
- level 9 three or more courses

V10-V12 Recency of training

- level 10 no courses in last six years
- level 11 one to three courses in last six years
- level 12 four or more courses in last six years

V13-V15 Total number of years of teacher training

- level 13 less than four years
- level 14 four years
- level 15 more than four years

V16-V18 Total number of years of teaching experience

- level 16 one to four years

level 17 five to fourteen years

level 18 fifteen or more years

V19-V21 Related professional activities

level 19 score of zero to two

level 20 score of three to five

level 21 score of six to ten

V. THR MAJOR HYPOTHESIS

Student achievement on (a) the modern part and (b) the traditional part of the algebra section of the grade ten mathematics course as measured by the criterion test is not significantly related to:

1. the professional qualifications of the teacher,
2. the number of years of actual teaching experience of the teacher,
3. the related professional activities of the teacher in the area of mathematics education.

VI. TESTING OF MINOR HYPOTHESES

Hypothesis 1A

Student achievement on the traditional part of the algebra section of the grade ten mathematics test is not significantly related to the total number of university mathematics courses taken by the teacher.

This hypothesis was tested by constructing a full model (model 01) using the covariate and the variable V4-V6 as predictors and variable V1 as the criterion. Then a restricted model (model 02) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0603 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0597. The F ratio associated with the difference between RSQ1 and RSQ2 was 0.20 which was not significant ($p = 0.75$). In effect, a knowledge of the predictor variable did not increase significantly the efficiency of the prediction; therefore, a knowledge of the number of mathematics courses taken in university by the student's teacher did not significantly increase ability to predict the student's score on the traditional part of the criterion examination.

Hypothesis 1B

Student achievement on the modern part of the algebra section of the grade ten mathematics test is not significantly related to the total number of university mathematics courses taken by the teacher.

This hypothesis was tested by constructing a full model (model 03) using the covariate and variable V4-V6 as the predictors and variable V2 as the criterion. Then a restricted model (model 04) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.1014 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0895. The F ratio associated with the difference between RSQ1 and RSQ2 was 5.54 which was significant ($p = 0.004$). A knowledge of the number of mathematics courses taken in university by the student's teacher increased significantly the ability to predict the student's score on the modern part of the criterion examination.

The analysis of the full model was continued to locate the specific combination of levels of the predictor variable that accounted for

TABLE V

MODELS TO TEST EFFECT OF NUMBER OF UNIVERSITY MATHEMATICS COURSES OF TEACHER ON STUDENT ACHIEVEMENT IN TRADITIONAL MATHEMATICS

Model 01 (Full)		Model 02 (Restricted)	
Criterion 1		Criterion 1	
Predictors 3, 4, 5, 6,		Predictors 3	
RSQ = 0.00603		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight
4	-.1496	3	0.4396
5	0.0000		
6	0.0000		
3	0.4418		
Constant = 4.8064		Constant = 4.7681	
F ratio = 13.4989		F ratio = 0.2898	
		p = 0.75474 (not sig.)	

the significant increase in prediction and to examine the effect of these on student achievement. The first restricted model (model 05) used the covariate and level 4 of the variable as the predictors. The F ratio associated with it was 1.25 which was not significant (p=0.29). The second restricted model (model 06) used the covariate and level 5 of the variable as the predictors and the F ratio associated with it was 0.34 which was not significant (p = 0.80). The third restricted model (model 07) used the covariate and level 6 of the variable as the predictors and the F ratio associated with it was 3.56 which was significant (p = 0.01). The proportion of the variance predicted by the full model (RSQ1) was 0.1014 but the proportion of the variance predicted by the third restricted model was only 0.0899; therefore, the levels of the variable combined as predictors in the third restricted model (levels 4 and 5) were different enough to have contributed significantly to the overall prediction. Thus the knowledge of whether the student's teacher had few university mathematics courses (level 4) or an average number of courses (level 5) significantly increased ability to predict student achievement in modern mathematics. The independent weighted contribution of level 4 to the overall prediction (-.55) indicated a negative effect on student achievement, whereas the independent weighted contribution of level 5 to the overall prediction (0.62) indicated a positive effect on student achievement. It follows, then, that students who had teachers with very few mathematics courses scored significantly lower on the modern part of the criterion examination than did students with teachers who had a greater number of mathematics courses. However, the beta weight of level 6 (-.14) indicated that a point can be reached beyond which additional courses do not add to,

TABLE VI

MODELS TO TEST EFFECT OF NUMBER OF UNIVERSITY MATHEMATICS COURSES OF TEACHER ON STUDENT ACHIEVEMENT IN MODERN MATHEMATICS

Model 03 (Full)		Model 04 (Restricted)	
Criterion 2		Criterion 2	
Predictors 3, 4, 5, 6		Predictors 3	
RSQ = 0.01014		RSQ = 0.0895	
Var. No.	Weight	Var. No.	Weight
4	0.0000	3	0.5621
5	0.7234		
6	0.2360		
3.	0.5614		
Constant = 4.3862		Constant = 4.7349	
F ratio = 23.7148		F ratio = 5.5374	
		p = 0.00418 (sig.)	

TABLE VI (continued)

Model 05 (Restricted)		Model 06 (Restricted)		Model 07 (Restricted)	
Criterion 2		Criterion 2		Criterion 2	
Predictors 3, 4		Predictors 3, 5		Predictors 3, 6	
RSQ = 0.0973		RSQ = 0.1003		RSQ = 0.0899	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
4	-.5469	5	0.6190	6	-.1397
3	0.5701	3	0.5568	3	0.5588
Constant = 4.8750		Constant = 4.5150		Constant = 4.7892	
F ratio = 1.2534		F ratio = 0.3420		F ratio = 3.5584	
p = 0.28740 (not sig.)		p = 0.80459 (not sig.)		p = 0.01410 (sig.)	

but rather subtract from, this relationship.

Hypothesis 2A

Student achievement on the traditional part of the algebra section of the grade ten mathematics test is not significantly related to the number of modern mathematics courses taken by the teachers.

This hypothesis was tested by constructing a full model (model 08) using the covariate and the variable V7-V9 as predictors and variable V1 as the criterion. Then a restricted model (model 09) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0648 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0597. The F ratio associated with the difference between RSQ1 and RSQ2 was 2.30 which was not significant ($p = .10$). A knowledge of the predictor variable did not increase significantly the efficiency of the prediction; therefore, a knowledge of the number of modern mathematics courses taken in university by the student's teacher did not increase significantly the ability to predict the student's score on the traditional part of the criterion examination.

Hypothesis 2B

Student achievement on the modern part of the algebra section of the grade ten mathematics test is not significantly related to the number of modern mathematics courses taken by the teacher.

This hypothesis was tested by constructing a full model (model 10) using the covariate and the variable V7-V9 as predictors and variable V2 as the criterion. Then a restricted model (model 11) was constructed using

TABLE VII

MODELS TO TEST EFFECT OF NUMBER OF MODERN MATHEMATICS COURSES OF TEACHER ON STUDENT ACHIEVEMENT IN TRADITIONAL MATHEMATICS

Model 08 (Full)		Model 09 (Restricted)	
Criterion 1		Criterion 1	
Predictors 3, 7, 8, 9		Predictors 3	
RSQ = 0.0648		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight
7	0.4650	3	0.4396
8	0.0000		
9	0.1163		
3	0.4381		
Constant = 4.6084		Constant = 4.7681	
F ratio = 14.5707		F ratio = 2.3055	
		p = 0.09936 (not sig.)	

only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.09936 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0895. The F ratio associated with the difference between RSQ1 and RSQ2 was 4.59 which was significant ($p = 0.01$). A knowledge of the predictor variable significantly increased the ability to predict the student's score on the modern part of the criterion examination.

The analysis of the full model was continued to locate the specific combination of levels of the predictor variable that accounted for the significant increase in prediction and to examine the effect of these on student achievement. The first restricted model (model 12) used the covariate and level 7 of the variable as the predictors. The F ratio associated with it was 0.049 which was not significant ($p = 0.98$). The second restricted model (model 13) used the covariate and level 8 of the variable as the predictors and F ratio associated with it was 2.36 which was not significant ($p = 0.070$). The proportion of the variance predicted by the full model was not significantly greater than the proportion of the variance predicted by any of the three restricted models. However, the beta weight of level 7 of the variable (-.63) indicated a negative effect on student achievement in modern mathematics, whereas the beta weights of level 8 of the variable (0.30) and level 9 of the variable (0.33) indicated a progressively positive relationship with student achievement in modern mathematics. It follows, then, that students who had teachers with no modern mathematics courses scored significantly lower on the modern part of the criterion examination than did students with teachers who had a greater number of modern mathematics courses.

TABLE VIII

MODELS TO TEST EFFECT OF NUMBER OF MODERN COURSES OF TEACHER ON STUDENT ACHIEVEMENT IN MODERN MATHEMATICS

Model 10 (Full)		Model 11 (Restricted)	
Criterion 2		Criterion 2	
Predictors 3, 7, 8, 9		Predictors 3	
RSQ = 0.09936		RSQ = 0.0895	
Var. No.	Weight	Var. No.	Weight
7	-.5997	3	0.5620
8	0.0000		
9	0.0827		
3	0.5632		
Constant = 4.8906		Constant = 4.735	
F ratio = 23.1960		F ratio = 4.5926	
		p = 0.01049 (sig.)	

TABLE VIII (continued)

Model 12 (Restricted)		Model 13 (Restricted)		Model 14 (Restricted)	
Criterion 2		Criterion 2		Criterion 2	
Predictors 3, 7		Predictors 3, 8		Predictors 3, 9	
RSQ = 0.0992		RSQ = 0.0920		RSQ = 0.0918	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
7	-.6275	8	0.2954	9	0.3295
3	0.5634	3	0.5638	3	0.5609
Constant = 4.917		Constant = 4.588		Constant = 4.6646	
F ratio = 0.0491		F ratio = 2.2762		F ratio = 2.3563	
p = 0.98193 (not sig.)		p = 0.07756 (not sig.)		p = 0.06982 (not sig.)	

Hypothesis 3A

Student achievement on the traditional part of the algebra section of the grade ten mathematics test is not significantly related to the recency of the teacher's professional training.

This hypothesis was tested by constructing a full model (model 15) using the covariate and the variable V10-V12 as predictors and variable V1 as the criterion. Then a restricted model (model 16) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0688 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0597. The F ratio associated with the difference between RSQ1 and RSQ2 was 4.10 which was significant ($p = 0.017$). A knowledge of the predictor variable increased significantly the efficiency of the prediction; therefore, a knowledge of the recency of the teacher's professional training increased significantly the ability to predict the student's score on the traditional part of the criterion examination.

The analysis of the full model was continued to locate the specific combination of levels of the predictor variable that accounted for the significant increase in prediction and to examine the effect on student achievement. The first restricted model (model 17) used the covariate and level 10 of the variable as the predictors. The F ratio associated with it was 2.61 which was significant ($p = 0.050$). The second restricted model (model 18) used the covariate and level 11 of the variable as predictors and the F ratio associated with it was 1.31 which was not significant ($p = 0.27$). The third restricted model (model 19) used the covariate and level 12 of the variable as predictors and the F ratio associated with it was 0.26 which was not significant (p = 0.87). The proportion of the variance predicted by the full model (RSQ1) was 0.0688 but the proportion of the variance predicted by the first restricted model was only 0.0601; therefore, the levels of the variable combined as predictors in the first restricted model (levels 11 and 12) were different enough to have contributed significantly to the overall prediction. Thus the knowledge of whether the student's teacher had only a moderate number of recent methematics courses (level 11) or many recent mathematics courses (level 12) significantly increased ability to predict student achievement in traditional mathematics. The independent weighted contribution of level 11 to the overall prediction (0.41) indicated a positive effect on student achievement, whereas the independent weighted contribution of level 12 to the overall prediction (-.55) indicated a negative effect on student achievement. It follows, then, that students who had teachers with many recent mathematics courses scored significantly lower on the traditional part of the criterion test than did students with teachers who had fewer recent mathematics courses.

Hypothesis 3B

Student achievement on the modern part of the algebra section of the grade ten mathematics test is not significantly related to the recency of the teacher's professional training.

This hypothesis was tested by constructing a full model (model 20) using the covariate and the variable V10-V12 as predictors and variable V2 as the criterion. Then a restricted model (model 21) was constructed using only the covariate, as a predictor.

TABLE IX

MODELS TO TEST EFFECT OF RECENCY OF TRAINING OF TEACHER ON STUDENT ACHIEVEMENT IN TRADITIONAL MATHEMATICS

Model 15 (Full)		Model 16 (Restricted)	
Criterion 1		Criterion 1	
Predictors 3, 10, 11, 12		Predictors 3	
RSQ = 0.0688		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight
10	0.0000	3	0.4396
11	0.1896		
12	-.4723		
3	0.4472		
Constant = 4.8078		Constant = 4.7681	
F ratio = 15.5268		F ratio = 4.1035	
		p = 0.01691 (sig.)	

TABLE IX (continued)

Model 17 (Restricted)		Model 18 (Restricted)		Model 19 (Restricted)	
Criterion 1		Criterion 1		Criterion 1	
Predictors 3, 10		Predictors 3, 11		Predictors 3, 12	
RSQ = 0.0601		RSQ = 0.0644		RSQ = 0.0679	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
10	0.1184	11	0.4104	12	-.5503
3	0.4394	3	0.4456	3	0.4468
Constant = 4.7272		Constant = 4.5966		Constant = 4.8980	
F ratio = 2.6132		F ratio = 1.3113		F ratio = 0.2563	
p = 0.04977 (sig.)		p = 0.26746 (not sig.)		p = 0.86708 (not sig.)	

The proportion of the variance predicted by the full model (RSQ1) was 0.1263 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0895. The F ratio associated with the difference between RSQ1 and RSQ2 was 17.71 which was very significant (p = 0.00). A knowledge of the predictor variable increased significantly the efficiency of the prediction; therefore, a knowledge of the recency of the teacher's professional training increased significantly the ability to predict the student's score on the modern part of the criterion examination.

The analysis of the full model was continued to locate the specific combination of levels of the predictor variable that accounted for the significant increase in prediction and to examine the effect on student achievement. The first restricted model (model 22) used the covariate and level 10 of the variable as predictors. The F ratio associated with it was 0.9888 which was not significant (p = 0.40). The second restricted model (model 23) used the covariate and level 11 of the variable as predictors and the F ratio associated with it was 5.2 which was significant (p = 0.002). The third restricted model (model 24) used the covariate and level 12 of the variable as predictors and the F ratio associated with it was 11.19 which was very significant (p = 0.00). The proportion of the variance predicted by the full model (RSQ1) was 0.1263 but the proportion of the variance predicted by the second restricted model was 0.1101 whereas the proportion of the variance predicted by the third restricted model was only 0.0914; therefore, the levels of the variable combined as predictors in the second restricted model (levels 10 and 12) and the levels of the variable combined as predictors in the third restricted model (levels 10 and 11) were different enough to have contributed significantly to the overall prediction. Thus the knowledge of whether the student's teacher had no recent mathematics courses (level 10) or many recent mathematics courses (level 12) significantly increased ability to predict student achievement in modern mathematics. As well, the knowlege of whether the student's teacher had no recent mathematics courses (level 10) or an average number of courses (level 11) very significantly increased ability to predict student achievement in modern mathematics. The independent weighted contribution of level 10 to the overall prediction (-1.125) indicated a strong negative effect on student achievement, whereas the relatively large positive beta weights of level 11 (0.89) and level 12 (0.28) indicated a strong positive relationship with student achievement. It follows, then, that students who had teachers with no recent training in mathematics scored significantly lower on the modern part of the criterion examination than did students with teachers who had some recent training in mathematics.

Hypothesis 4A

Student achievement on the traditional part of the algebra section of the grade ten mathematics test is not significantly related to the total number of years of professional training of the teacher.

This hypothesis was tested by constructing a full model (model 25) using the covariate and the variable V13-V15 as predictors and variable V1 as the criterion. Then a restricted model (model 26) was constructed using only the covariate as a predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0599 and the proportion of the variance predicted by the restricted

TABLE X

MODELS TO TEST EFFECT OF RECENCY OF TRAINING OF TEACHER ON STUDENT ACHIEVEMENT IN MODERN MATHEMATICS

Model 20 (Full)		Model 21 (Restricted)	
Criterion 2		Criterion 2	
Predictors 3, 10, 11, 12		Predictors 3	
RSQ = 0.1263		RSQ = 0.0895	
Var. No.	Weight	Var. No.	Weight
10	-1.316	3	0.5621
11	0.0000		
12	-.4033		
3	0.5703		
Constant = 5.2802		Constant = 4.7349	
F ratio = 30.4006		F ratio = 17.7119	
		p = 0.00000 (very sig.)	

TABLE X (continued)

Model 22 (Restricted)		Model 23 (Restricted)		Model 24 (Restricted)	
Criterion 2		Criterion 2		Criterion 2	
Predictors 3, 10		Predictors 3, 11		Predictors 3, 12	
RSQ = 0.1232		RSQ = 0.1101		RSQ = 0.0914	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
10	-1.125	11	0.8939	12	0.2780
3	0.5638	3	0.5751	3	0.5584
Constant = 5.1241		Constant = 4.3614		Constant = 4.6692	
F ratio = 1.9888		F ratio = 5.1994		F ratio = 11.1891	
p = 0.39670 (not sig.)		p = 0.00153 (very sig.)		p = 0.00000 (very sig.)	

model (RSQ2) was 0.0597. The F ratio associated with the difference between RSQ1 and RSQ2 was 0.12 which was not significant (p = 0.89). A knowledge of the predictor variable did not increase significantly the efficiency of the prediction; therefore, a knowledge of the total number of years of professional training of the student's teacher did not increase significantly the ability to predict the student's score on the traditional part of the criterion examination.

Hypothesis 4B

Student achievement on the modern part of the algebra section of the grade ten mathematics test is not significantly related to the total number of years of professional training of the teacher.

This hypothesis was tested by constructing a full model (model 27) using the covariate and the variable V13-V15 as predictors and variable V2 as the criterion. Then a restricted model (model 28) was constructed using only the covariate as a predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.1186 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0895. The F ratio associated with the difference between RSQ1 and RSQ2 was 13.86 which was very significant (p = 0.00). Hence a knowledge of the predictor variable increased significantly the ability to predict the student's score on the modern part of the criterion examination.

The analysis of the full model was continued to locate the specific combination of levels of the predictor variable that accounted for the significant increase in prediction and to examine the effect of these on

TABLE XI

MODELS TO TEST EFFECT OF TRAINING OF TEACHER ON STUDENT ACHIEVEMENT IN TRADITIONAL MATHEMATICS

Model 25 (Full)		Model 26 (Restricted)	
Criterion 1		Criterion 1	
Predictors 3, 13, 14, 15		Predictors 3	
RSQ = 0.0599		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight
13	-.1114	3	0.4396
14	0.0000		
15	0.0000		
3	0.4411		
Constant = 4.7823		Constant = 4.7681	
F ratio = 13.4087		F ratio = 0.1202	
		p = 0.89514 (not sig.)	

student achievement. The first restricted model (model 29) used the covariate and level 13 of the variable as the predictors. The F ratio associated with it was 0.32 which was not significant (p = 0.82). The second restricted model (model 30) used the covariate and level 14 of the variable as predictors and the F ratio associated with it was 5.00 which was very significant (p = 0.002). The third restricted model (model 32) used the covariate and level 15 of the variable as predictors. The F ratio associated with it was 9.07 which was very significant (p = 0.00). The proportion of the variance predicted by the full model (RSQ1) was 0.1186 but the proportion of the variance predicted by the second restricted model was 0.1028 whereas the proportion of the variance predicted by the third restricted model was only 0.0900; therefore, the levels of the variable combined as predictors in the second restricted model (levels 13 and 14) were different enough to have contributed significantly to the overall prediction. Thus the knowledge of whether the student's teacher had less than four years of teacher training (level 13) or four years of teacher training (level 14) significantly increased ability to predict student achievement. The independent weighted contribution of level 13 to the overall prediction (1.21) indicated a strong positive effect on student achievement, whereas the independent weighted contribution of level 14 (-.68) and level 15 (-.15) indicated a negative effect on student achievement. It follows, then, that students who had teachers with less than four years of professional training scored significantly higher on the modern part of the criterion examination than did students with teachers who had four or more years of professional training.

TABLE XII

MODELS TO TEST EFFECT OF TRAINING OF TEACHER ON STUDENT ACHIEVEMENT IN MODERN MATHEMATICS

Model 27 (Full)		Model 28 (Restricted)	
Criterion 2		Criterion 2	
Predictors 3, 13, 14, 15		Predictors 3	
RSQ = 0.1186		RSQ = 0.0895	
Var. No.	Weight	Var. No.	Weight
13	1.2860	3	0.5621
14	0.0000		
15	0.2116		
3	0.5450		
Constant = 4.5078		Constant = 4.7349	
F ratio = 28.2877		F ratio = 13.8644	
		p = 0.00000 (very sig.)	

TABLE XII (continued)

Model 29 (Restricted)		Model 30 (Restricted)		Model 32 (Restricted)	
Criterion 2		Criterion 2		Criterion 2	
Predictors 3, 13		Predictors 3, 14		Predictors 3, 15	
RSQ = 0.1176		RSQ = 0.1028		RSQ = 0.0900	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
13	1.2109	14	-.6773	15	-.1508
3	0.5452	3	0.5554	3	0.5614
Constant = 4.5808		Constant = 5.1230		Constant = 4.7801	
F ratio = 0.3175		F ratio = 5.0057		F ratio = 9.0748	
p = 0.82270 (not sig.)		p = 0.00199 (very sig.)		p = 0.00000 (very sig.)	

Hypothesis 5A

Student achievement on the traditional part of the algebra section of the grade ten mathematics test is not significantly related to the total number of years of teaching experience of the teacher.

This hypothesis was tested by constructing a full model (model 33) using the covariate and the variable V16-V18 as predictors and variable V1 as the criterion. Then a restricted model (model 34) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0678 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0597. The F ratio associated with the difference between RSQ1 and RSQ2 was 3.68 which was significant ($p = 0.025$). A knowledge of the predictor variable increased significantly the ability to predict the student's score on the traditional part of the criterion examination

The analysis of the full model was continued to locate the specific combination of levels of the predictor variable that accounted for the significant increase in prediction and to examine the effect on student achievement. The first restricted model (model 35) used the covariate and level 16 of the predictor variable as the predictors. The F ratio associated with it was 0.64 which was not significant ($p = 0.59$). The second restricted model (model 36) used the covariate and level 17 of the variable as the predictors and the F ratio associated with it was 0.80 which was not significant ($p = 0.80$). The third restricted model (model 37) used the covariate and level 18 of the variable as the predictor and the F ratio associated with it was 2.44 which was not significant ($p = 0.06$). The proportion of the variance predicted by the full model was not significantly greater than the proportion of the variance predicted by any of the three restricted models. The dependent weighted contribution of level 16 of the variable (-.08) suggested that few number of years of teaching experience had a negative effect on student achievement in traditional mathematics, whereas the independent weighted contribution of level 17 of the variable (0.47) suggested that a moderate number of years of teaching experience had a positive effect on student achievement in traditional mathematics.

Hypothesis 5B

Student achievement on the modern part of the algebra section of the grade ten mathematics test is not significantly related to the total number of years of teaching experience of the teacher.

This hypothesis was tested by constructing a full model (model 38) using the covariate and the variable V16-V18 as predictors and variable V2 as the criterion. Then a restricted model (model 39) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0990 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0895. The F ratio associated with the difference between RSQ1 and RSQ2 was 4.43 which was significant ($p = 0.012$). A knowledge of the predictor variable increase significantly the ability to predict the student's score on the modern part of the criterion examination.

TABLE XIII

MODELS TO TEST EFFECT OF EXPERIENCE OF TEACHER ON STUDENT ACHIEVEMENT IN TRADITIONAL MATHEMATICS

Model 33 (Full)		Model 34 (Restricted)	
Criterion 1		Criterion 1	
Predictors 3, 16, 17, 18		Predictors 3	
RSQ = 0.0678		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight
16	-.3598	3	0.4396
17	0.3146		
18	0.0000		
3	0.4468		
Constant = 4.7568		Constant = 4.7681	
F ratio = 15.3043		F ratio = 3.6852	
		p = 0.02547 (sig.)	

TABLE XIII (continued)

Model 35 (Restricted)		Model 36 (Restricted)		Model 37 (Restricted)	
Criterion 1		Criterion 1		Criterion 1	
Predictors 3, 16		Predictors 3, 17		Predictors 3, 18	
RSQ = 0.06573		RSQ = 0.06518		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
16	-.0778	17	0.4725	18	0.0419
3	0.4407	3	0.4508	3	0.4387
Constant = 4.9111		Constant = 4.5770		Constant = 4.7559	
F ratio = 0.6385		F ratio = 0.8045		F ratio = 2.4406	
p = 0.59420 (not sig.)		p = 0.49274 (not sig.)		p = 0.06250 (not sig.)	

The analysis of the full model was continued to try to locate the specific combination of levels of the predictor variable that accounted for the significant increase in prediction and to examine the effect of student achievement. The first restricted model (model 40) used the covariate and level 16 of the variable as the predictors. The F ratio associated with it was 1.68 which was not significant ($p = 0.17$). The second restricted model (model 41) used the covariate and level 17 of the variable as the predictors and the F ratio associated with it was 2.44 which was not significant ($p - 0.06$). The third restricted model (model 42) used the covariate and level 18 of the variable as the predictors and the F ratio associated with it was 0.0277 which was not significant ($p = 0.98$). The proportion of the variance predicted by the full model was not significantly greater than the proportion of the variance predicted by any of the three restricted models. However, the independent weighted contributions of level 16 of the variable (0.40) and level 17 of the variable (0.27) suggested that a few or a moderate number of years of teaching experience had a positive effect on student achievement in modern mathematics, whereas the independent weighted contribution of level 18 of the variable (-.58) suggested that many years of teaching experience had a distinct negative effect on student achievement in modern mathematics. It follows, then, that students who had teachers with a few or a moderate number of years of teaching experience scored higher on the modern part of the criterion examination than did students with teachers who had fifteeen or more years of teaching experience.

TABLE XIV

MODELS TO TEST EFFECT OF EXPERIENCE OF TEACHER ON STUDENT ACHIEVEMENT IN MODERN MATHEMATICS

Model 38 (Full)		Model 39 (Restricted)	
Criterion 2		Criterion 2	
Predictors 3, 16, 17, 18		Predictors 3	
RSQ = 0.0990		RSQ = 0.0895	
Var. No.	Weight	Var. No.	Weight
16	0.0277	3	0.5620
17	-.0543		
18	-.5776		
3	0.5739		
Constant = 4.9106		Constant = 4.7349	
F ratio = 23.1045		F ratio = 4.4260	
		p = 0.01234 (sig.)	

TABLE XIV (continued)

Model 40 (Restricted)		Model 41 (Restricted)		Model 42 (Restricted)	
Criterion 2		Criterion 2		Criterion 2	
Predictors 3, 16		Predictors 3, 17		Predictors 3, 18	
RSQ = 0.0936		RSQ = 0.0912		RSQ = 0.0989	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
16	0.4009	17	0.2704	18	-.5781
3	0.5611	3	0.5685	3	0.5744
Constant = 4.6124		Constant = 4.6254		Constant = 4.9025	
F ratio = 1.6852		F ratio = 2.4368		F ratio = 0.0277	
p = 0.16681 (not sig.)		p = 0.06280 (not sig.)		p = 0.98458 (not sig.)	

Hypothesis 6A

Student achievement on the traditional part of the algebra section of the grade ten mathematics test is not significantly related to the professional activities of the teacher as measured by the check list of professional activities.

This hypothesis was tested by constructing a full model (model 43) using the covariate and the variable V19-V21 as predictors and variable V1 as the criterion. Then a restricted model (model 44) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.0652 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0597. The F ratio associated with the difference between RSQ1 and RSQ2 was 2.47 which was not significant ($p = 0.084$). A knowledge of the predictor variable did not increase significantly the efficiency of the prediction; therefore, a knowledge of the teacher's score on the check list of professional activities did not increase significantly the ability to predict the student's score on the traditional part of the criterion examination.

Hypothesis 6B

Student achievement on the modern part of the algebra section of the grade ten mathematics test is not significantly related to the professional activities of the teacher as measured by the check list of professional activities.

This hypothesis was tested by constructing a full model (model 45) using the covariate and the variable V19-V21 as predictors and variable

TABLE XV

MODELS TO TEST EFFECT OF PROFESSIONAL ACTIVITIES OF TEACHER ON STUDENT ACHIEVEMENT IN TRADITIONAL MATHEMATICS

Model 43 (Full)		Model 44 (Restricted)	
Criterion 1		Criterion 1	
Predictors 3, 19, 20, 21		Predictors 3	
RSQ = 0.0652		RSQ = 0.0597	
Var. No.	Weight	Var. No.	Weight
19	-.1497	3	0.4396
20	0.0000		
21	0.4632		
3	0.4450		
Constant = 4.6931		Constant = 4.7681	
F ratio = 14.6571		F ratio = 2.4679	
		p = 0.08457 (not sig.)	

V2 as the criterion. Then a restricted model (model 46) was constructed using only the covariate as the predictor.

The proportion of the variance predicted by the full model (RSQ1) was 0.1503 and the proportion of the variance predicted by the restricted model (RSQ2) was 0.0895. The F ratio associated with the difference between RSQ1 and RSQ2 was 30.08 which was very significant (p = 0.00). Hence a knowledge of the predictor variable increased very significantly the ability to predict the student's score on the modern part of the criterion examination.

The analysis of the full model was continued to locate the specific combination of levels of the variable that accounted for the significant increase in prediction and to examine the effect on student achievement. The first restricted model (model 47) used the covariate and level 19 of the variable as the predictors. The F ratio associated with it was 2.11 which was not significant (p = 0.096). The second restricted model (model 48) used the covariate and level 20 of the variable as predictors and the F ratio associated with it was 4.68 which was significant (p = 0.003). The third restricted model (model 49) used the covariate and level 21 of the variable as predictors and the F ratio associated with it was 20.01 which was very significant (p = 0.00). The proportion of the variance predicted by the full model (RSQ1) was 0.1503 but the proportion of the variance predicted by the second restricted model was 0.1361, whereas the proportion of the variance predicted by the third restricted model was only 0.0896; therefore, the levels of the predictor variable combined as predictors in the second restricted model (levels 19 and 21) and the levels of the variable combined as predictors in the third restricted

TABLE XVI

MODELS TO TEST EFFECT OF PROFESSIONAL ACTIVITIES OF TEACHER ON STUDENT ACHIEVEMENT IN MODERN MATHEMATICS

Model 45 (Full)		Model 46 (Restricted)	
Criterion 2		Criterion 2	
Predictors 3, 19, 20, 21		Predictors 3	
RSQ = 0.1503		RSQ = 0.0895	
Var. No.	Weight	Var. No.	Weight
19	-1.702	3	0.5620
20	0.0000		
21	-.6390		
3	0.5700		
Constant = 5.2571		Constant = 4.7349	
F ratio = 37.1921		F ratio = 30.0788	
		p = 0.00000 (very sig.)	

TABLE XVI (continued)

Model 47 (Restricted)		Model 48 (Restricted)		Model 49 (Restricted)	
Criterion 2		Criterion 2		Criterion 2	
Predictors 3, 19		Predictors 3, 20		Predictors 3, 21	
RSQ = 0.1439		RSQ = 0.1361		RSQ = 0.0896	
Var. No.	Weight	Var. No.	Weight	Var. No.	Weight
19	-1.547	20	1.2729	21	-.0849
3	0.5742	3	0.5612	3	0.5613
Constant = 5.0761		Constant = 4.0350		Constant = 4.7544	
F ratio = 2.1107		F ratio = 4.6789		F ratio = 20.0117	
p = 0.04259 (sig.)		p = 0.00310 (sig.)		p = 0.00000 (very sig.)	

model (levels 19 and 20) were each different enough to have contributed significantly to the overall prediction. Thus the knowledge of whether the student's teacher had a score of zero to two on the check list of professional activities (level 19) or a score of six to ten (level 21) significantly increased ability to predict student achievement in modern mathematics. As well, the knowledge of whether the student's teacher had a score of zero to two on the check list (level 19) or a score of three to five on the check list (level 20) significantly increased ability to predict student achievement in modern mathematics. The independent weighted contribution of level 19 to the overall prediction (-1.5) indicated a strong negative effect on student achievement, whereas the independent weighted contribution of level 20 (1.27) indicated a strong positive effect on student achievement. However, the small negative beta weight of level 21 (-.08) indicated a slight negative effect on student achievement. It follows, then, that students who had teachers with a very low score on the check list of professional activities scored very significantly lower on the modern part of the criterion examination than did students with teachers who had a higher score on the check list with the exception of those teachers with the highest scores where there appeared to be a point reached beyond which the effect was negative rather than positive.

VII. SYNOPSIS OF RESULTS

A synopsis of the results of the analysis of the data is shown in Table XVII.

TABLE XVII

SUMMARY OF RESULTS OF ANALYSIS

Predictor Variables	Traditional Mathematics	Modern Mathematics
Number of university mathematics courses	*not sig.	sig.
Number of modern mathematics courses	not sig.	sig.
Number of recent mathematics courses	sig.	sig.
Number of years of teacher training	not sig.	sig.
Number of years of teaching experience	sig.	sig.
Score on check list of professional activities	not sig.	sig.

*Differences at the .05 level were accepted as significant.

VIII. SUMMARY OF QUESTIONNAIRE DATA

The average number of university mathematics courses taken by the participating teachers in this study was 4.2 courses per teacher. One third of the teachers had no courses in modern mathematics and another third of the teachers had one course. Over one third of the teachers had completed no university mathematics courses in the past six years. Of the teachers sampled, 78 per cent were being paid for four or more years of teacher training. The average number of years of teaching experience was 12.9 years per teacher. Only six of the thirty-one teachers belonged to the Mathematics Council of the Alberta Teachers' Association and only four teachers indicated that they read the Mathematics Teacher regularly. Moreover, ten of the teachers indicated that mathematics was not their major field of academic interest and only three teachers had ever participated in any experiment or research project in mathematics. Thirteen teachers indicated they did not believe they were qualified to teach modern mathematics and thirteen teachers indicated that they did not plan to take further study in the field of mathematics in the near future.[2]

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[2]See Appendix E.

CHAPTER V

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

I. INTRODUCTION

The purpose of the present study was to examine the present state of professional preparedness of Southern Alberta high school teachers of grade ten mathematics for the teaching of a new high school algebra program and by means of an analysis of covariance design to determine the effect of varying degrees of preparedness on student achievement on both modern and traditional parts of the grade ten algebra program. The present chapter summarises the findings from the analysis of the data and draws conclusions relative to the original hypothesis. Finally, implications of the present study are included with recommendations for further research.

II. STATEMENT OF FINDINGS

1. Student achievement on the traditional part of the criterion examination was not significantly related to the number of mathematics courses taken in university by the student's teacher.

2. Student achievement on the modern part of the criterion examination was significantly related to the number of mathematics courses taken in university by the student's teacher. The beta weights in Table VI indicated that students who had teachers with very few mathematics courses scored significantly lower on the modern part of the criterion examination

than did students with teachers who had a greater number of mathematics courses.

3. Student achievement on the traditional part of the criterion examination was not significantly related to the number of modern mathematics courses taken by the teachers.

4. Student achievement on the modern part of the criterion examination was significantlyy related to the number of modern mathematics courses taken by the student's teacher. The beta weights in Table VIII indicated that students who had teachers with a greater number of modern mathematics courses scored significantly higher on the modern part of the criterion examination.

5. Student achievement on the traditional part of the criterion examination was significantly related to the recency of the teacher's professional training. The beta weights in Table IX indicated that the relationship was a negative one. Students who had teachers with fewer recent mathematics courses scored significantly higher on the traditional part of the criterion examination; whereas students with teachers who had a greater number of recent mathematics courese scored significantly lower on the traditional part of the criterion examination.

6. Student achievement on the modern part of the criterion examination was significantly related to the recency of the teacher's professional training. The beta weights in Table X showed that students who had teachers with a greater number of recent mathematics courses scored very significantly higher on the modern part of the criterion examination.

7. Student achievement on the traditional part of the criterion examination was not significantly related to the total number of years of

professional training of the teachers.

8. Student achievement on the modern part of the criterion examination was significantly related to the total number of years of professional training of the teacher. The beta weights of Table XII showed that the relationship was a negative one. The student whose teacher had the greater number of years of training scored significantly lower on the modern part of the criterion examination.

9. Student achievement on the traditional part of the criterion examination was significantly related to the total number of years of teaching experience of the teacher. The beta weights of Table XIII indicated that few years of teaching experience had a negative effect on student achievement and that many years of teaching experience had a positive effect; therefore the student whose teacher had more experience scored significantly higher on the traditional part of the criterion examination than did the student whose teacher had less experience.

10. Student achievement on the modern part of the criterion examination was significantly related to the total number of years of teaching experience of the teacher. The beta weights of Table XIV showed that the relationship was a negative one. The more experienced teacher got poorer results on the modern part of the examination, while the less experienced teacher got better results.

11. Student achievement on the traditional part of the criterion examination was not significantly related to the score of the teacher on the check list of professional activities.

12. Student achievement on the modern part of the criterion examination was very significantly related to the score of the teacher on the

check list of professional activities. The beta weights of Table XVI showed that a low score on the check list had a very significant negative effect on student achievement, whereas a higher score showed a very positive effect on student achievement in modern mathematics.

III. CONCLUSIONS

A synthesis of the findings suggest the following conclusions:

1. The majority of teachers were well trained as measured by years of professional training but very poorly trained to teach modern mathematics as measured by the number and the recency of the mathematics courses taken in university.

2. Many of the present sample of grade ten mathematics teachers are neither actively involved nor vitally interested in mathematics as a specialized subject field, as measured by the check list of professional activities.

3. Students who had teachers with less recent training and more experience scored significantly higher on the traditional part of the criterion examination than did students who had teachers with more recent training and less experience; however, students who had teachers with more recent training and less experience scored significantly higher on the modern part of the criterion examination than did students who had teachers with less recent training and more experience.

4. The teacher with the stronger mathematical background as measured by the total number of university mathematics courses and the number of modern mathematics courses did not get significantly better results on the

traditional part of the criterion examination but did get significantly better results on the modern part of the criterion examination.

5. Many years of experience and few modern mathematics courses had a significantly positive effect on student achievement in traditional mathematics.

6. The teacher who exhibited greater interest in, and dedication to, the field of mathematics education as measured by the check list of professional activities had a significantly positive effect on student achievement in modern mathematics but not in traditional mathematics.

IV IMPLICATIONS

Some rather pointed implications arise from the conclusions of the study:

1. Student achievement in modern mathematics was more sensitive to differences in teacher characteristics than was student achievement in traditional mathematics; hence, care should be taken when making teaching assignments to modern mathematics courses.

2. Assuming that the future changes in the mathematics curriculum will be more radical and more extensive than those present in the text used in this study, it becomes imperative that the more experienced teacher, whether well-trained by years of professional training or not, be retrained in terms of recent, modern mathematics courses at the earliest possible date, for students who had teachers with less experience and training but more recent modern mathematics courses scored significantly higher on the modern part of the criterion examination than did students who had teachers with more experience and training but fewer recent modern mathematics courses.

V. RECOMMENDATIONS FOR FURTHER STUDY

An active program of continuous research must be maintained to ensure a high standard of mathematics education in Alberta. Some problems associated with the topic investigated in this study are:

1. A similar study with modifications could be done at the grade eleven and twelve levels as new and more revolutionary material is introduced in the future.

2. A similar study could be done with respect to the changes being made in the geometry sections of the new mathematics courses.

3. A study could be done to investigate interaction effects of various teacher variables affecting student achievement.

4. In view of the inadequate background of teachers in modern mathematics, a study might be done to investigate the feasibility of accelerated programs of team teaching, programmed instruction or television instruction to enhance the learning situation. In any event, further research must be done to determine the extent of the retraining that is without doubt necessary.

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APPENDICES

APPENDIX A.

CRITERION TEST

MATHEMATICS 10 - ALGEBRA

Directions - Time limit 50 minutes

Fill in the information at top of answer sheet.

Under each question or statement there are FIVE possible responses. Read each question carefully, decide which response is best, then blacken in the correct number on the answer sheet.

In marking your responses, always be sure that the question number on the answer sheet is the same as the question number in the test booklet.

Use an ordinary HB pencil to mark your responses and erase completely if you wish to change a response.

DO NOT put any other marks on answer sheet!

1. Given the sets A = {2, 4, 6, 8}; B = {1, 3, 5, 7, 9} and C = {2, 3, 5, 7} then the set $(A \cap B) \cup C$ is the set:

   (1) {1, 2, 3, 4, 5, 6, 7, 8, 9}

   (2) {2, 3, 5, 7}

   (3) { }

   (4) {2, 4, 6, 8}

   (5) {1, 3, 5, 7, 9}

2. The non-terminating recurring decimal $0.\dot{1}\dot{8}$ expressed as a rational number is:

   (1) $\frac{19}{100}$

   (2) $\frac{9}{50}$

   (3) $\frac{1}{5}$

   (4) $\frac{18}{90}$

   (5) $\frac{2}{11}$

3. What is the total possible number of subsets of A if A = {1, 2, 3}?

(1) 8
(2) 10
(3) 12
(4) 9
(5) 5

4. When completely simplified the product of $(x^2y^3) \cdot (x^5y^4z^0)$ is:

(1) $x^{10}y^{12}z$
(2) x^7y^7
(3) $x^{10}y^{12}$
(4) x^7y^7z
(5) $x^7y^7z^0$

5. The set $X = \{\pm a \mid a \epsilon N\} \cup \{0\}$ is one way of writing the set of:

(1) natural numbers
(2) rational numbers
(3) integer numbers
(4) whole numbers
(5) real numbers

6. The expression $(\frac{2}{-3} \times \frac{-5}{-7}) + \frac{6}{7}$ when simplified becomes:

(1) $\frac{4}{7}$
(2) $\frac{2}{3}$
(3) $\frac{-4}{7}$
(4) $\frac{8}{21}$
(5) $\frac{4}{3}$

7. Find: $\{x | \frac{x+6}{2} - \frac{x+3}{2} < \frac{x}{2} - \frac{2}{3}, x \epsilon R\}$

(1) $\{x | x > 4\frac{1}{3}, x \epsilon R\}$

(2) $\{x | x < 4\frac{1}{3}, x \epsilon R\}$

(3) $\{x | 3x < 13, x \epsilon R\}$

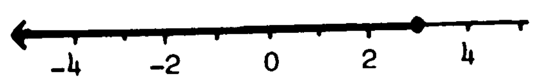
(4) $\{x | x > 13, x \epsilon R\}$

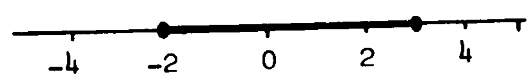
(5) $\{x | x < 13, x \epsilon R\}$

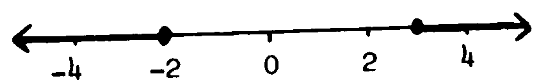
8. Find the solution set defined by $(x + 1)^2 + 2(x + 3)^2 = 3x(x + 2) \times 35$

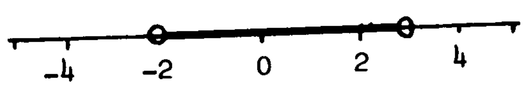
(1) {1}
(2) {-2}
(3) {2}
(4) {-1}
(5) {3}

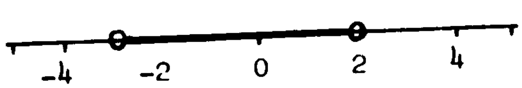
9. The graph of $\{x | 4x - 5 < 7 \text{ and } 2x + 1 > -3\}$ is:

(1)


(2)


(3)


(4)


(5)


10. One rectangular school garden has its length 10 feet longer than its width. A second garden, of equal area, is 5 feet longer and 2 feet narrower than the first. What are the dimensions of the narrower garden?

(1) 4 feet by 50 feet
(2) 10 feet by 20 feet
(3) 8 feet by 25 feet
(4) 5 feet by 40 feet
(5) 2 feet by 100 feet

11. Find the set of all real numbers such that five more than four times the number is greater than three less than twice the number:

(1) $x>-4,\ x\epsilon R$

(2) $x<4,\ x\epsilon R$

(3) $x>4,\ x\epsilon R$

(4) $x<-4,\ x\epsilon R$

(5) $x = 4,\ x\epsilon R$

12. The factors of $10a^3 + 3a^2b - 6ab^2 + b^3$ are $(5a - b)$ and:

(1) $(2a - b)$ and $(a - b)$

(2) $(a + b)$ and $(2a - 2b)$

(3) $(a + 2b)$ and $(2a - b)$

(4) $(a + b)$ and $(2a - b)$

(5) $(a + b)$ and $(a - b)$

13. Evaluate $|x + y| - |y - z|$ if $x = 2$, $y = -3$, $z = 1$

(1) 9

(2) 0

(3) -3

(4) 3

(5) 2

14. If a man paid off a debt of $10,500 in four years by paying in each successive year after the first, twice as much as the year before, then his payment for the last year would be:

(1) $6,500

(2) $3,000

(3) $4,000

(4) $7,000

(5) $5,600

15. **The subset of the natural numbers whose elements are all the even prime numbers is the set:**

(1) {1, 2}

(2) {1, 2, 3}

(3) {2}

(4) {2, 4}

(5) {2, 4, 6}

16. **The expression $4m^2 - p^2 - 16pq - 64q^2$ can be factored into:**

(1) $(2m - p + 8q)(2m + p + 8q)$

(2) $(2m - p - 8q)(2m + p + 8q)$

(3) $(2m + p - 8q)(2m - p - 8q)$

(4) $(2m + p - 8q)(2m + p - 8q)$

(5) $(2m + p + 8q)(2m + p + 8q)$

17. **If $A = \{0, 1, 2, 3, 4\}$ and $B = \{1, 2, 3\}$ then**

(1) $A \cap B = A$

(2) $B \cup A = B$

(3) $A \subset B$

(4) $B \subset A$

(5) $A \subseteq B$

18. **The expression $\frac{12}{a - b} + \frac{5}{a + b} - \frac{a + 2b}{a^2 - b^2}$ can be simplified to:**

(1) $\frac{8a + 5b}{a^2 - b^2}$

(2) $\frac{16a + 5b}{a^2 - b^2}$

(3) $\frac{16a + 5b}{a^2 + b^2}$

(4) $\frac{16a - 5B}{a^2 - b^2}$

(5) $\frac{8a + 5b}{a - b}$

19. $a/b = 0$ if, and only if:

(1) $b = 0$
(2) $a = 0$; $b \neq 0$
(3) $a.0 = b$
(4) $a = b$
(5) $a = 0$

20. Reduce the fraction $\frac{6x\ (x - 3)^2}{3x^3 - 27x}$ to lowest terms

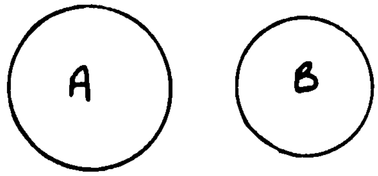
(1) $\frac{2(x - 3)}{x + 3}$; $x \neq 0$
(2) $\frac{2(x - 3)}{x + 3}$; $x \neq 3$
(3) $\frac{2(x - 3)}{x + 3}$; $x \neq 0$, $x \neq 3$
(4) $\frac{2(x - 3)}{x + 3}$
(5) $\frac{2(x + 3)}{x - 3}$; $x \neq 0$, $x \neq 3$

21. If $a, b \varepsilon I$ and $a<b$ and $b<c$ then $a<c$. This property of order is:

(1) transitive property
(2) associative property
(3) distributive property
(4) reflexive property
(5) commutative property

22. One of the factors of $x^3y - xy^3$ is:

(1) x^2y^2
(2) xy^2
(3) $x^3 - y^3$
(4) $x + y$
(5) $x^2 + y^2$

23. The Venn diagram  is an example of two sets called:

(1) universal sets

(2) null sets

(3) disjoint sets

(4) equivalent sets

(5) subsets

24. The factor missing in the equation $(18a^5b^{-3}c^2) = (-3a^3b^2c^{\ 1})$ (?) is:

(1) $(6a^2b^{-5}c^3)$

(2) $(6a^{-2}b^{-1}c^1)$

(3) $(-6a^8b^5c^3)$

(4) $(-6a^2b^{-5}c^3)$

(5) $(6a^2b^5c^{-3})$

25. The set of irrational numbers is included in the set of:

(1) integer numbers
(2) real numbers
(3) rational numbers
(4) whole numbers
(5) natural numbers

26. The value of $\frac{a}{a^{-1}} - \frac{b}{b^{-1}}$ when $a = -1$ and $b = -2$ is:

(1) -3
(2) 0
(3) 3
(4) 5
(5) -5

27. Find the solution set of the following: $\{x \mid \frac{x + 11}{6} = \frac{4 - x}{3} - 1,\ x \in I\}$

(1) { ---,-6,-5,-4,-3,-2,0,1,2,3,--- }

(2) { ---,-5,-4,-2,-1,0,2,4,--- }

(3) { ---,-4,-3,-1,0,1,2,3,--- }

(4) { ---,-6,-5,-4,-2,-1,0,1,2,3,--- }

(5) { ---,-4,-3,-2,-1,1,2,3,--- }

28. Write the number $7,110.0 \times 10^3$ in standard form:

(1) 7.1100×10^0
(2) $7,110.0 \times 10^3$
(3) 7.1100×10^5
(4) 7.1100
(5) 7.1100×10^6

29. The set represented by the graph  is:

(1) {1, 2, 4, 5, 6}
(2) {1, 2, 3, 4, 5, 6, ---}
(3) {--- 1, 2, 4, 5, 6, ---}
(4) {---1, 2, 4, 5, 6}
(5) {1, 2, 4, 5, 6, ---}

30. One of the factors of $x^5 + 6x^4 + 10x^3 - 11x - 6$ is:

(1) $x - 6$
(2) $x + 1$
(3) $x + 6$
(4) $x - 2$
(5) $x - 3$

APPENDIX B.

DATA COLLECTION MATERIALS

Dear Principal:

As you may already know, part of this year's final Mathematics 10 examination has been constructed at The University of Calgary in cooperation with the Southern Alberta Testing Program. The results of the test will be used for research purposes.

Enclosed is a set of instructions, supplementary to those on the test itself, which each Mathematics 10 teacher and the teachers supervising the writing of the Mathematics 10 examination should be asked to read in connection with the administration of the test.

Each teacher of Mathematics 10 is also asked to fill in one of the questionnaire sheets enclosed. As well, I trust you will provide the Mathematics 10 teachers with a listing of all Mathematics 10 students and their STANINE scores on the grade nine reading test. A form is provided.

It would be greatly appreciated if you would see that the student answer sheets, the questionnaires, and the reading score forms are all properly completed and returned in the enclosed envelope at the earliest possible date.

Thank you for drawing the above information to the attention of the teachers of Mathematics 10 in your school and for your cooperation in this project.

Sincerely,

S. Cooke

Dear Teacher:

As you may already know, part of this year's final Mathematics 10 examination has been constructed at The University of Calgary in cooperation with the Southern Alberta Testing Program. The results of the test will be used for research purposes.

To bring the project to a successful completion, we are asking you to do the following:

a. Follow the instructions on the front page of the examination as well as those on the first page of the key to the examination.

b. Be sure that all students have the following materials available for the algebra section of the test:

1. an IBM answer sheet
2. pencil (HB) and eraser
3. scratch paper

c. At the beginning of the examination please inform the students of the TIME LIMIT (50 minutes) for the algebra section and collect the answer sheets after the time has elapsed.

d. Fill out the enclosed questionnaire. NOTE: Instruct the teachers supervising the Mathematics 10 examination to have your students place the NUMBER of your questionnaire in the space labelled NAME OF TEACHER at the top of the answer sheets.

e. Take the enclosed mimeographed forms and write or type in each mathematics student's name and his/her STANINE score on the grade nine reading test. If a student is a 'transfer in' and no reading score is available, indicate N/A.

f. Send the student answer sheets (do not fold or staple), the questionnaires and the reading score lists by first class mail in the enclosed envelope IMMEDIATELY after the test has been written to:

Mr. S. Cooke
4935 Norquay Drive N.W.
Calgary, Alberta

g. This section of the test will be scored, analyzed and the results returned to you in a day or two. NOTE: The geometry section will be graded by you and the results handled as usual. This year, however, you will have TWO final scores--one on the algebra section and the other on the geometry section of the course to do with as you please.

Thank you for your careful attention to these matters and for your cooperation in this project.

Sincerely,

S. Cooke

TEACHER QUESTIONNAIRE

NUMBER ________

Qualification

1. What is the total number of mathematics courses you have taken in university? ________

   NOTE: Consider each full year course to be one course.
   Consider two semester courses equivalent to one full year course.
   Include undergraduate and graduate courses.
   Include summer and winter courses.

---

2. How many of each of the following type of courses have you taken in university? (Circle the appropriate number.)

   NOTE: Do not subdivide a course but place it in the category of major emphasis.

calculus (including analytic geometry)	0 ½ 1 1½ 2 3 4
geometry (excluding analytic geometry)	0 ½ 1 1½ 2 3 4
probability and statistics	0 ½ 1 1½ 2 3 4
number theory	0 ½ 1 1½ 2 3 4
applied mathematics (mechanics, etc.)	0 ½ 1 1½ 2 3 4
numerical analysis	0 ½ 1 1½ 2 3 4
topology	0 ½ 1 1½ 2 3 4
matrix algebra	0 ½ 1 1½ 2 3 4
set theory	0 ½ 1 1½ 2 3 4
general modern mathematics	0 ½ 1 1½ 2 3 4
education mathematics (methods courses,	
curriculum and instruction courses, etc.)	0 ½ 1 1½ 2 3 4
other (specify)	0 ½ 1 1½ 2 3 4
other (specify)	0 ½ 1 1½ 2 3 4

   NOTE: The sum of (2) should add to (1) above.

---

3. How many of the total number of university mathematics courses specified above would you consider to be primarily 'modern' mathematics courses? ________

---

4. How many of the mathematics courses specified above have been completed since 1960? (Including 1960.) ________

---

5. For how many years of teacher training are you now being paid? ________

Experience

1. How many years of actual teaching experience have you had? ______

Professional Activities and Attitude

1. Have you participated in any in-service training program related to the new high school mathematics courses? ______

2. Do you belong to the Mathematics Council of the Alberta Teachers' Association? ______

3. Did you take the Mathematics 341 course by television? ______

4. Do you read The Mathematics Teacher regularly? ______

5. Have you sponsored a Mathematics Club in your school in the last five years? ______

6. Is mathematics your major field of academic interest at the present time? ______

7. Have you ever participated in any experiment or research project in mathematics? ______

8. Do you believe you are qualified to teach modern mathematics? ______

9. Are you in favor of the changes presently being made in the high school mathematics program? ______

10. Do you plan to take further study in the field of mathematics in the near future? ______

STANINE SCORES ON GRADE NINE READING EXAMINATION

STUDENT	SCORE
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
16.	
17.	
18.	
19.	
20.	
21.	
22.	
23.	
24.	
25.	

APPENDIX C.

CRITERION TEST RESULTS

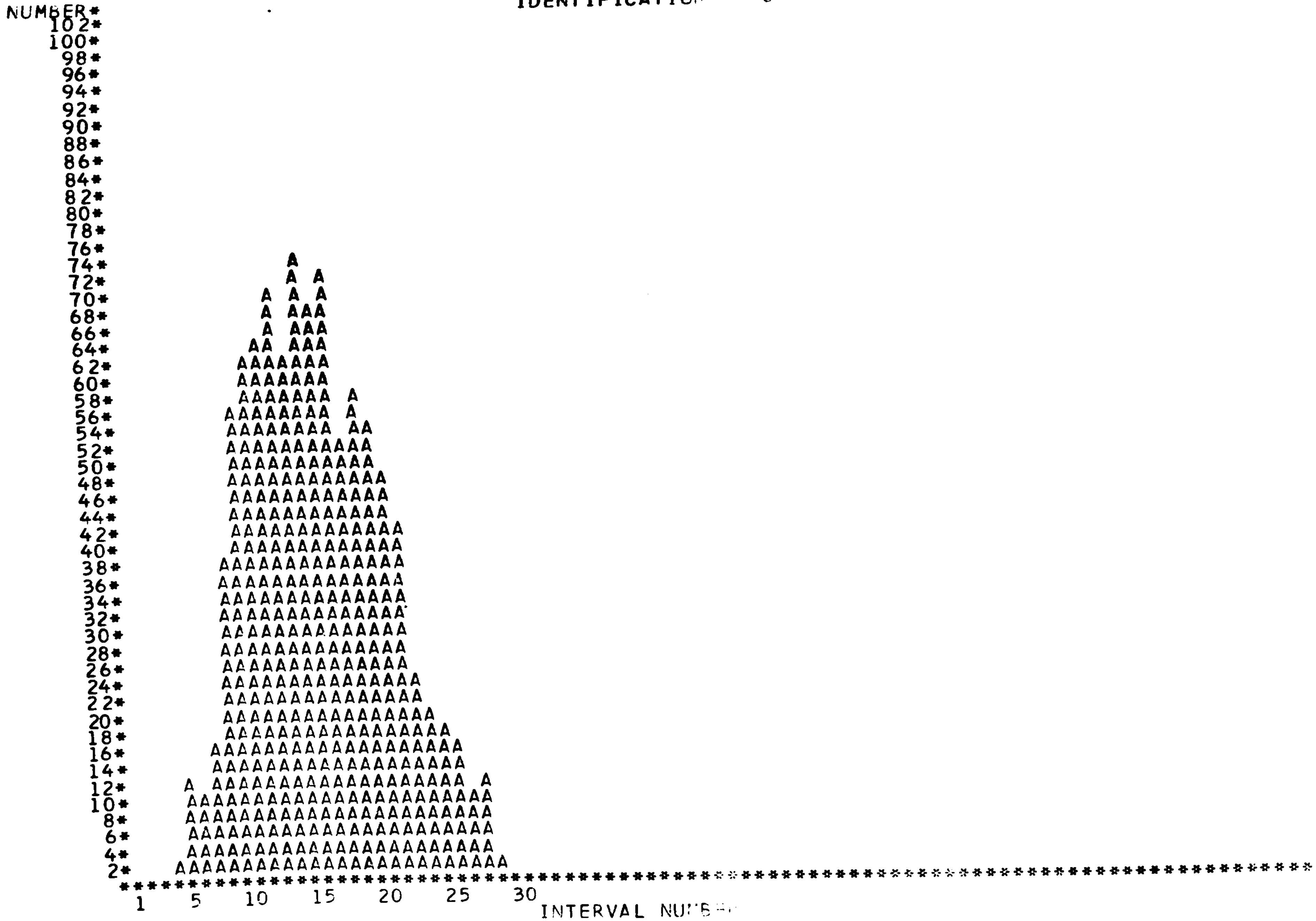
S COOKE

NUMBER OF SUBJECTS...	975
MINIMUM SCORE........	3.0000
MAXIMUM SCORE........	29.0000
RANGE................	26.0000
SUM OF SCORES........	14693.00
SUM OF SQUARES.......	246271.00
MEAN.................	15.0697
STANDARD DEVIATION...	5.0486
VARIANCE.............	25.4884
THIRD MOMENT.........	36.50
FOURTH MOMENT........	1634.94
SKEWNESS.............	.28365695
KURTOSIS.............	-.48340340
MEDIAN...............	14.7279

NORMALIZED SCORES WITH MEAN = 50.0000 , STANDARD DEVIATION = 10.0000
FOR RAW SCORES AT MIDPOINT OF EACH INTERVAL

INTERVAL NUMBER	FREQUENCY	CUMULATIVE FREQUENCY	PERCENTILE	RAW SCORE AT MIDPOINT	NORMALIZED SCORE
1	0.	0.0	0.00	1.0000	50.0000
2	0.	0.0	0.00	2.0000	50.0000
3	1.	.5	.05	3.0000	17.1636
4	2.	2.0	.20	4.0000	21.2948
5	13.	9.5	.97	5.0000	26.6348
6	10.	21.0	2.15	6.0000	29.7659
7	17.	34.5	3.53	7.0000	31.9264
8	38.	62.0	6.35	8.0000	34.7437
9	57.	109.5	11.23	9.0000	37.8552
10	63.	169.5	17.38	10.0000	40.6100
11	64.	233.0	23.89	11.0000	42.9066
12	70.	300.0	30.76	12.0000	44.9800
13	63.	366.5	37.58	13.0000	46.8416
14	74.	435.0	44.61	14.0000	48.6491
15	68.	506.0	51.89	15.0000	50.4745
16	73.	576.5	59.12	16.0000	52.3044
17	52.	639.0	65.53	17.0000	53.9945
18	59.	694.5	71.23	18.0000	55.5975
19	54.	751.0	77.02	19.0000	57.3944
20	48.	802.0	82.25	20.0000	59.2508
21	42.	847.0	86.87	21.0000	61.2041
22	24.	880.0	90.25	22.0000	62.9648
23	21.	902.5	92.56	23.0000	64.4434
24	18.	922.0	94.56	24.0000	66.0432
25	17.	939.5	96.35	25.0000	67.9435
26	11.	953.5	97.79	26.0000	70.1355
27	13.	965.5	99.02	27.0000	73.3651
28	2.	973.0	99.79	28.0000	78.7050
29	1.	974.5	99.94	29.0000	82.8358
30	0.	975.0	100.00	30.0000	50.0000

IDENTIFICATION 0



AT MIDPOINT OF FIRST IN VAL IS 1.0000
CLASS INTERVAL WIDTH IS 1.0000
NUMBER OF INTERVALS I

APPENDIX D.

CRITERION TEST ANALYSIS

ITEM	N	KEY	MR
1	975	2	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	4	0	49	227	26	2	2
MIDDLE	400	5	0	161	185	42	4	3
LOWER	265	7	0	170	56	27	2	3
TOTAL	975	16	0	380	468	95	8	8

DIFFICULTY .4800
BISERIAL R .5233

ITEM	N	KEY	MR
2	975	5	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	0	0	14	64	3	28	201
MIDDLE	400	7	0	32	128	15	56	162
LOWER	265	5	0	34	101	12	58	55
TOTAL	975	12	0	80	293	30	142	418

DIFFICULTY .4287
BISERIAL R .4760

ITEM	N	KEY	MR
3	975	1	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	3	0	195	8	9	61	34
MIDDLE	400	4	0	159	13	20	119	85
LOWER	265	4	0	46	11	31	88	85
TOTAL	975	11	0	400	32	60	268	204

DIFFICULTY .4102
BISERIAL R .5037

ITEM	N	KEY	MR
4	975	2	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	1	0	8	164	25	16	96
MIDDLE	400	5	0	22	117	36	35	185
LOWER	265	3	0	37	27	18	54	126
TOTAL	975	9	0	67	308	79	105	407

DIFFICULTY .3158
BISERIAL R .5108

ITEM	N	KEY	MR
5	975	3	4

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	309	3	0	24	16	188	61	17
MIDDLE	400	2	0	100	35	145	69	49
LOWER	262	3	0	103	38	55	31	32
TOTAL	971	8	0	227	89	388	161	98

DIFFICULTY .3979
BISERIAL R .4311

ITEM	N	KEY	MR
6	975	4	4

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	309	2	0	3	5	10	263	26
MIDDLE	400	8	0	16	9	51	269	47
LOWER	262	7	0	17	12	51	146	29
TOTAL	971	17	0	36	26	112	678	102

DIFFICULTY .6953
BISERIAL R .3694

ITEM	N	KEY	MR
7	975	1	3

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	309	4	0	200	61	21	13	10
MIDDLE	399	11	0	132	99	86	41	30
LOWER	264	13	0	43	80	58	40	30
TOTAL	972	28	0	375	240	165	94	70

DIFFICULTY .3846
BISERIAL R .5410

ITEM	N	KEY	MR
8	975	3	3

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	309	7	0	4	22	245	10	21
MIDDLE	399	14	0	21	54	246	24	40
LOWER	264	11	0	22	59	106	26	40
TOTAL	972	32	0	47	135	597	60	101

DIFFICULTY .6123
BISERIAL R .4080

ITEM	N	KEY	MR
9	975	4	1

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	2	0	6	59	14	220	9
MIDDLE	400	7	0	36	89	76	160	32
LOWER	264	6	0	33	70	59	68	28
TOTAL	974	15	0	75	218	149	448	69

DIFFICULTY .4594
BISERIAL R .4789

ITEM	N	KEY	MR
10	975	3	1

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	12	0	8	29	244	10	7
MIDDLE	400	34	0	25	72	222	31	16
LOWER	264	34	0	22	58	104	39	7
TOTAL	974	80	0	55	159	570	80	30

DIFFICULTY .5846
BISERIAL R .4403

ITEM	N	KEY	MR
11	975	1	1

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	2	0	263	3	15	24	3
MIDDLE	399	1	0	247	22	44	74	11
LOWER	265	4	0	99	26	45	65	26
TOTAL	974	7	0	609	51	104	163	40

DIFFICULTY .6246
BISERIAL R .5025

ITEM	N	KEY	MR
12	975	4	1

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	25	0	43	13	27	191	11
MIDDLE	399	37	0	101	47	51	134	29
LOWER	265	28	0	69	34	51	58	25
TOTAL	974	90	0	213	94	129	383	65

DIFFICULTY .3928
BISERIAL R .4656

ITEM	N	KEY	MR
13	975	3	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	4	0	8	6	180	108	4
MIDDLE	400	8	0	13	18	168	178	15
LOWER	265	5	0	21	23	88	117	11
TOTAL	975	17	0	42	47	436	403	30

DIFFICULTY .4471
BISERIAL R .2972

ITEM	N	KEY	MR
14	975	5	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	4	0	10	11	11	26	248
MIDDLE	400	12	0	28	37	30	58	235
LOWER	265	10	0	29	46	22	45	113
TOTAL	975	26	0	67	94	63	129	596

DIFFICULTY .6112
BISERIAL R .4225

ITEM	N	KEY	MR
15	975	3	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	2	0	13	22	228	7	38
MIDDLE	400	5	0	36	35	183	35	106
LOWER	265	1	1	21	34	62	25	121
TOTAL	975	8	1	70	91	473	67	265

DIFFICULTY .4856
BISERIAL R .5085

ITEM	N	KEY	MR
16	975	2	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	12	0	27	230	30	7	4
MIDDLE	400	29	0	46	242	47	25	11
LOWER	265	16	1	47	125	45	21	10
TOTAL	975	57	1	120	597	122	53	25

DIFFICULTY .6129
BISERIAL R .2897

ITEM	N	KEY	MR
17	975	4	2

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	2	0	15	14	6	248	25
MIDDLE	400	10	0	55	34	18	238	45
LOWER	263	4	2	64	38	29	77	49
TOTAL	973	16	2	134	86	53	563	119

DIFFICULTY .5786
BISERIAL R .5344

ITEM	N	KEY	MR
18	975	2	2

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	10	0	13	207	24	47	9
MIDDLE	400	24	0	34	177	40	93	32
LOWER	263	21	2	26	77	40	52	45
TOTAL	973	55	2	73	461	104	192	86

DIFFICULTY .4737
BISERIAL R .4199

ITEM	N	KEY	MR
19	975	2	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	0	0	67	145	31	7	60
MIDDLE	400	3	0	126	120	40	25	86
LOWER	265	2	4	66	67	34	33	59
TOTAL	975	5	4	259	332	105	65	205

DIFFICULTY .3419
BISERIAL R .2846

ITEM	N	KEY	MR
20	975	3	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	21	0	28	45	121	55	40
MIDDLE	400	41	0	46	50	113	59	91
LOWER	265	23	4	30	46	55	53	54
TOTAL	975	85	4	104	141	289	167	185

DIFFICULTY .2976
BISERIAL R .2313

ITEM	N	KEY	MR
21	975	1	3

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	3	0	264	17	5	11	10
MIDDLE	399	8	0	237	61	22	35	36
LOWER	263	5	6	101	60	34	31	26
TOTAL	972	16	6	602	138	61	77	72

DIFFICULTY .6212
BISERIAL R .5073

ITEM	N	KEY	MR
22	975	4	3

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	9	0	9	7	27	224	34
MIDDLE	399	28	0	41	9	76	178	67
LOWER	263	24	6	34	16	58	69	56
TOTAL	972	61	6	84	32	161	471	157

DIFFICULTY .4860
BISERIAL R .4863

ITEM	N	KEY	MR
23	975	3	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	0	0	2	3	300	1	4
MIDDLE	400	3	2	10	9	371	2	3
LOWER	265	1	12	17	13	196	13	13
TOTAL	975	4	14	29	25	867	16	20

DIFFICULTY .9021
BISERIAL R .4930

ITEM	N	KEY	MR
24	975	4	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	4	0	38	8	15	241	4
MIDDLE	400	21	2	59	31	21	251	15
LOWER	265	20	12	28	49	39	100	17
TOTAL	975	45	14	125	88	75	592	36

DIFFICULTY .6160
BISERIAL R .4114

ITEM	N	KEY	MR
25	975	2	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	2	0	18	257	17	4	12
MIDDLE	400	9	5	76	207	48	23	32
LOWER	265	7	16	55	84	35	21	47
TOTAL	975	18	21	149	548	100	48	91

DIFFICULTY .5744
BISERIAL R .5524

ITEM	N	KEY	MR
26	975	1	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	5	0	146	100	34	13	12
MIDDLE	400	25	5	106	195	42	10	17
LOWER	265	18	16	52	124	33	10	12
TOTAL	975	48	21	304	419	109	33	41

DIFFICULTY .3186
BISERIAL R .3599

ITEM	N	KEY	MR
27	975	4	1

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	15	2	45	48	13	177	10
MIDDLE	399	32	12	65	78	49	128	35
LOWER	265	22	28	47	57	45	39	27
TOTAL	974	69	42	157	183	107	344	72

DIFFICULTY .3687
BISERIAL R .4932

ITEM	N	KEY	MR
28	975	5	1

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	1	2	9	36	13	28	221
MIDDLE	399	13	12	22	82	31	81	158
LOWER	265	13	28	21	74	25	66	38
TOTAL	974	27	42	52	192	69	175	417

DIFFICULTY .4469
BISERIAL R .5782

ITEM	N	KEY	MR
29	975	5	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	3	6	10	4	10	3	274
MIDDLE	400	2	23	15	14	15	2	329
LOWER	265	1	33	27	22	26	7	149
TOTAL	975	6	62	52	40	51	12	752

DIFFICULTY .8236
BISERIAL R .4251

ITEM	N	KEY	MR
30	975	2	0

	TOTAL	OMIT	NF	1	2	3	4	5
UPPER	310	23	6	20	193	31	21	16
MIDDLE	400	37	23	61	140	66	52	21
LOWER	265	18	33	44	44	50	47	29
TOTAL	975	78	62	125	377	147	120	66

DIFFICULTY .4129
BISERIAL R .5125

TEST MEAN 15.0697
TEST STANDARD DEVIATION 5.0486
TEST RELIABILITY KR-20 .7296

APPENDIX E.

SUMMARY OF QUESTIONNAIRE DATA

TABLE XVIII

NUMBER OF MATHEMATICS COURSES
TAKEN BY TEACHERS

Number of Courses	Number of Teachers
0	2
1	3
2	4
3	3
4	5
5	6
6	3
7	3
8	0
9	1
10 or more	1

TABLE XIX

NUMBER OF MODERN MATHEMATICS COURSES TAKEN BY TEACHERS

Number of Courses	Number of Teachers
0	10
1	9
2	5
3	4
4	2
5	1

TABLE XX

DISTRIBUTION OF TEACHERS BY NUMBER AND TYPE OF COURSE

Type of course	Number of courses						
	0	½	1	1½	2	3	4
Calculus	8	0	6	2	15	0	0
Geometry	20	1	7	0	2	0	0
Probability and statistics	14	1	14	0	2	0	0
Number theory	24	1	6	0	0	0	0
Applied mathematics	22	1	6	0	2	0	0
Numerical analysis	31	0	0	0	0	0	0
Topology	31	0	0	0	0	0	0
Matrix algebra	28	2	1	0	0	0	0
Set theory	28	0	2	0	1	0	0
General modern mathematics	17	0	11	0	3	0	0
Education mathematics	10	2	13	2	2	2	0
Other*	26	1	3	0	1	0	0

*Included courses in advanced algebra, boolean algebra, finite mathematics and history of mathematics.

TABLE XXI

DISTRIBUTION OF TEACHERS BY RECENCY OF MATHEMATICS COURSES

Number of Courses Since 1960	Number of Teachers
0	11
1	6
2	3
3-4	2
5	6
6-8	3

TABLE XXII

DISTRIBUTION OF TEACHERS BY YEARS OF TEACHER TRAINING

Number of Years of Teacher Training	Number of Teachers
1	2
2	2
3	3
4	15
5	8
6	1

TABLE XXIII

DISTRIBUTION OF TEACHERS BY YEARS OF TEACHING EXPERIENCE

Number of Years of Teaching Experience	Number of Teachers
1 - 3	7
4 - 6	5
7 - 9	4
10 - 14	4
15 and over	11

TABLE XXIV

DISTRIBUTION OF TEACHER RESPONSE TO CHECK LIST

Question	Number of Teachers	
	Yes	No
1. Have you ever participated in any inservice training program related to the new high school mathematics course?	14	17
2. Do you belong to the Mathematics Council of the Alberta Teachers' Association?	6	25
3. Did you take the Mathematics 341 course by television?	6	25
4. Do you read the <u>Mathematics Teacher</u> regularly?	4	27
5. Have you sponsored a mathematics club in your school in the last five years?	0	31
6. Is mathematics your major field of interest at the present time?	21	10
7. Have you ever participated in any experiment or research project in mathematics?	3	28
8. Do you believe that you are qualified to teach modern mathematics?	18	13
9. Are you in favor of the changes presently being made in the high school mathematics program?	24	7
10. Do you plan to take further study in the field of mathematics in the near future?	18	13