THE UNIVERSITY OF MANITOBA

THE RELATIONSHIP BETWEEN GRADE NINE MATHEMATICS SCORES AND PERFORMANCE IN HIGH SCHOOL SCIENCE, SELECTION OF HIGH SCHOOL PROGRAM, AND PERSISTENCE IN SCHOOL

by

Dinanath Gajadhar

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF EDUCATION

DEPARTMENT OF MATHEMATICS AND NATURAL SCIENCES

FACULTY OF EDUCATION

WINNIPEG, MANITOBA

May, 1973

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to all those who made this study possible. The friendly encouragement and patient assistance of Dr. L. J. Eide, his chairman, is gratefully acknowledged.

Dr. H. Grunau and Dr. H. Williams of the advisory committee provided helpful suggestions during the study. Their help is duly recognized and much appreciated.

The writer is grateful to Dr. R. McWilliams for the invaluable assistance received in statistics and the setting up of computer programs. The interest and co-operation of Mr. W. J. Madder merit particular appreciation.

Special thanks are extended to the typist for her patience and enthusiasm throughout the study.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS iii

LIST OF TABLES vi

ABSTRACT vii

Chapter

I. INTRODUCTION 1

Background of the Study
Statement of the Problem
Hypotheses
Delimitations of the Study
Limitations of the Study
Significance of the Study
Definition of Terms
Organization of the Study

II. REVIEW OF RELATED LITERATURE 11

The Junior High School Student: Ability to Make Academic Decisions
Tests Used in Prediction
Local Research
Design of Study
Achievement and Persistence
The Effect of Non-Intellective Factors in Prediction
Summary

III. METHOD OF THE STUDY 27

Description of the Sample
Instrumentation
Statistical Procedure

IV. RESULTS AND DISCUSSION 35

Results
Discussion

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS . 50

Summary
Conclusions
Recommendations

APPENDIX A 58

APPENDIX B 60

APPENDIX C 63

APPENDIX D 66

APPENDIX E 77

BIBLIOGRAPHY 80

LIST OF TABLES

Table		Page
1.	Size of Student Samples Used in Testing Hypotheses 1 - 6	30
2.	Correlation Between Grade IX Mathematics Grades and Grades in Biology	36
3.	Correlation Between Grade IX Mathematics Grades and Grades in General Science . . .	37
4.	Correlation Between Grade IX Mathematics Grades and Grades in Chemistry	38
5.	Correlation Between Grade IX Mathematics Grades and Grades in Physics	38
6.	Analysis of Variance by Linear Regression to Show Relationship Between Grade IX Mathematics Grades and Choice of High School Program	39
7.	Multiple Comparison Between Means Using Scheffé's Test for Unequal Sample Sizes . .	40
8.	The Importance Guidance Counselors Attach to Grade IX Mathematics Scores--Reported as Percentages	41
9.	The Importance High School Science Teachers Attach to Grade IX Mathematics Scores--Reported as Percentages	42

ABSTRACT

The study reported here investigated the relationship between the grade nine final mathematics scores and performance in high school sciences, selection of high school program, and persistence in school.

The sample was composed of two hundred and fifty students who completed grade nine in a large Winnipeg high school. The period covered by the study was June 1965 to June 1968.

A review of related literature showed that correlational studies do provide useful information for predicting academic success. However, there was still a need for general information for predicting success in high school from academic achievement at the junior high level. The value of local research was emphasized, with support coming from reputable test makers.

The Pearson product-moment correlation statistic was computed between the predictor variable, grade nine mathematics scores, and each high school science subject. A zero-order correlation was determined for persistence in school. The analysis of variance utilizing multiple linear regression was used to determine the relationship between the predictor variable and selection of high school program. A questionnaire sampled the opinion of guidance

counselors and high school science teachers in the Winnipeg School Division No. 1 as to the importance they placed on grade nine mathematics grades. The analysis was reported as percentages.

The results of the study showed that there was a generally significant relationship between the grade nine final mathematics grades and performance in the physical sciences area of the high school science program. Higher correlations were reported for the university entrance courses. A significant relationship was shown to exist between the grade nine mathematics scores and the selection of high school program. Persistence was also seen to be significantly related. Both high school science teachers and guidance counselors considered performance in grade nine mathematics as an important determinant for performance in the high school sciences, especially the physical sciences.

CHAPTER I

INTRODUCTION

Background of the Study

The Core Committee on the Reorganization of Secondary Schools of Manitoba (1969) was given the responsibility of making recommendations concerning the revision of the entire process of secondary education in the province. Attention was to be focused on the functions of the secondary school as part of the total educational system.

The Interim Report of the Committee (1970) agreed in essence with the idea that to attempt to impose a curriculum or course of study on all is an approach that is in complete antithesis to a learning program which seeks to develop the potential of every child. This agreement is consistent with basic educational philosophy and corresponds with the findings of the Provincial Committee on Aims and Objectives of Education in the Schools of Ontario (1968).

The Core Committee recommended that the curriculum of the future should be more child-oriented, and a wider variety of programs with much built-in flexibility should be made available. Greater responsibility, therefore, will be given to the student for determining his high school program of study. This seems to indicate that there would be a greater demand for counseling by competent personnel.

The current practice of selecting high school courses in Manitoba is such that the student in grade nine has a program of study planned for him after consultation with student, parents, counselor, and administration. The employment of statistically valid predictive data in selecting courses is of considerable advantage. The results of the Differential Aptitude Tests (DAT) are available at this time of the student's school year, but some caution is necessary in the amount of emphasis placed on these results. Super (1957) carried out a survey of the opinions and other data provided by test authors with regard to the predictive power of several multifactor test batteries. In Super's conclusions about the DAT, he states that "The counselor must remember, however, that the value of these tests varies considerably from one situation to another, making validation studies necessary." (p.17)

The research literature reported several prediction studies but none of these considered the variables indicated in the hypotheses of this study, nor the type of setting in which this study was made. The purpose of this study was to provide local information that would enable the ninth grade student to consider his ability in mathematics when choosing his high school science program. O'Hara and Tiedeman (1959) investigated the agreement between certain self-rated and tested characteristics in a sample of Boston high school students. The data showed that discrepancies tended to be greater in the ninth grade and decreased in the higher grades. This led them to conclude that, while ninth graders show some evidence of self-knowledge, they do need counseling in making decisions, especially of an academic or vocational nature.

Statement of the Problem

The purpose of this study was to investigate the following:

1. The relationship between Grade IX final mathematics grades and Grades X, XI, and XII final grades in science.
2. The importance guidance counselors attach to final Grade IX mathematics grades with regard to placement in the high school sciences.
3. The importance high school science teachers attach to final Grade IX mathematics grades with regard to performance in high school sciences.
4. The relationship between Grade IX final mathematics grades and high school program selection, i.e. University Entrance course, General course, and Vocational course.
5. The relationship between Grade IX final mathematics grades and persistence in high school.

In statement (1), the individuals in the sample were not the same for all three categories. The assumption was that not all students completed the three high school grades.

In (3), the choice of the particular high school program at the end of Grade IX was considered. Persistence or successful completion did not affect this part of the study.

In (4), attention was focused on persistence to the conclusion of the high school program that was selected at the end of Grade IX.

Hypotheses

The following null hypotheses were tested:

1. There is no relationship between the Grade IX final mathematics grades and final grades in Biology.

2. There is no relationship between the Grade IX final mathematics grades and final grades in General Science.

3. There is no relationship between the Grade IX final mathematics grades and final grades in Chemistry.

4. There is no relationship between the Grade IX final mathematics grades and final grades in Physics.

5. There is no relationship between the Grade IX final mathematics grades and the choice of the University Entrance, General, or Commercial Course.

6. There is no relationship between Grade IX final mathematics grades and persistence in high school.

7. Guidance counselors do not consider Grade IX final mathematics grades to be important in helping students to select high school science courses.

8. High School science teachers do not consider Grade IX final mathematics grades to be important for students' performance in the high school science courses.

Delimitations of the Study

1. This study is confined to a sample of 250 students who successfully completed Grade IX at a single Winnipeg high school.

2. This study is confined to the period June 1965 with regard to the predictor variable and continued through to September 1968 with regard to the criterion variables.

3. This study is confined by the fact that the high school from which the sample is taken does not provide programs of study in the Vocational or Occupational areas at the Grade XII level.

Limitations of the Study

1. The findings of this study are limited in that no consideration is given to sex differences of the sample.

2. The findings of this study are limited by the extent to which instruction by different teachers influence performance in mathematics and science.

3. The findings of this study are further limited by the extent to which non-standardized instruments of measurement contribute to variability in grades.

4. The findings of this study are further limited by the absence of validity and reliability coefficients of the instruments which were used to provide data for both predictor and criterion variables.

5. The findings of this study are further limited by the fact that no consideration is given to the age of the students in the sample, nor to the possibility that some may have repeated grades.

6. The results of this study are also limited by the extent to which non-intellective factors influence performance.

Significance of the Study

Counselors and administrators are frequently engaged in helping students make intelligent decisions about course selection. This includes predicting academic success in key subjects. Unfortunately, the data available to counselors are inadequate. Aptitude test scores are available but doubts exist regarding their usefulness in the local setting. This study proposes to provide significant information based on local data which deal with the selecting of high school science courses.

Discussions with the administration of the high school where this study was done emphasized the need for local data in the area of high school science course selection. The personal files of the students in the sample were made available because of the potential value of this investigation. The value of employing local data in the area of prediction was emphasized in other investigations. Reference will be made to such supporting evidence in the Review of Related Literature.

There is concern in both the United States and Canada that the enrollment in high school sciences, especially physics, is decreasing from year to year. In a recent study carried out in Alberta to investigate the reasons for decreasing enrollment in high school physics, Caron (1971) found that students had heard negative statements about physics which they tended to believe. Some of these negative statements were: student must be good in mathematics to be good in physics; there is little connection between physics and a career; physics is just a bunch of formulas; physics is slanted toward boys; and physics is a very difficult subject. This could mean that the decreasing enrollment may be due, in part, to unfounded prejudices. The findings of the current study should supply valid information as to the relationship between ability in mathematics and performance in high school physics.

Probably the most common complaint of the high school science teacher is the poor mathematical background of his students. Grove and Grove (1952) conducted an organized research study at an Alabama high school in which they correlated algebra with chemistry and trigonometry with physics. Their findings supported a case for greater integration of mathematics and science. The results of the current study should provide local evidence in this connection.

Generally, studies have shown that student attitude toward school is influenced to a great extent by the level of his social class (Rosenfeld, 1965 and Guest, 1968). The cause of withdrawal from school is based on many related factors and many researchers (Williams, 1966; Totten, 1967; and Guest, 1968) agree that the factors of academic achievement, male sex, lack of participation in school activities, academic retardation and socio-economic status contribute to the individual's decision to withdraw from school. While the limitations of this study do not allow for broad generalizations, one of its objectives is to provide information as to the relationship between ability in one subject area and persistence in high school.

Definition of Terms

1. Secondary education: Secondary education includes all types of formal schooling between the completion of grade six and grade twelve.
2. Secondary school: Secondary school is defined as all institutions providing formal schooling for grades seven through twelve inclusive.
3. Differential Aptitude Tests: These are also referred to as DAT. The DAT are made up of a battery of eight tests. These are administered during the ninth grade. They are designed to appraise fundamental intellectual abilities.

4. High school science program: Courses in science that are offered in Grades X, XI, XII.

5. Persistence: Persistence is operationally defined as attending school from September of one year to the end of June of the following year to the completion of the chosen high school program.

6. Predictor variable: The final mathematics grade upon successful completion of the ninth grade.

7. Criterion variables: Criterion variables include
   (a) Type of high school program
   (b) Persistence in high school
   (c) Performance in each of the high school science subjects.

8. Non-standardized instruments: Refer to teacher or teacher-committee-made tests.

9. Aptitude tests: Tests that serve to predict subsequent performance.

10. Achievement tests: Tests that represent a terminal evaluation of the individual's status at the end of training.

11. Clinical prediction: This refers to a judgment arrived at by a psychologist after considering a certain body of data.

12. Actuarial prediction: This is made by combining quantitative data to derive a score which is used to make a prediction.

13. Linear relationship: One in which equal increases in the predictor variable are accompanied by equal increases in the variable to be predicted.

14. Global prediction: This is done by the use of a single, overall measure of ability and/or academic performance.

15. Multidimensional prediction: This is done by the use of a number of specific dimensions of ability and/or performance.

Organization of the Study

Chapter II will contain a review of the literature relevant to this study. In Chapter III a description of the population studied, a detailed description of the instruments used, and the research procedure will be included. The findings of the study will be presented in Chapter IV. The final chapter will consist of a summary of the study, discussion of the conclusions, and implications and recommendations. The significant appendices and references are included at the end of this study.

CHAPTER II

REVIEW OF RELATED LITERATURE

Extensive research has been carried out in the field of predicting academic success, especially at the college level. In this review of the professional literature only those areas relevant to the present study will be considered. The areas under consideration were restricted to the following: (1) the ability of the junior high school student to make academic decisions, (2) tests used in prediction, (3) local research, (4) design of the study, (5) achievement as related to persistence in school, and (6) the effect of non-intellective factors in prediction.

The Junior High School Student: Ability to Make Academic Decisions

If the ninth grade student is to benefit from test interpretation and other related information, some consideration must be given to his maturity as an important factor in decision-making. O'Hara and Tiedeman (1959), in a study previously cited, reported the following correlation between self-estimates and test-estimates of grade nine boys: general values .56, and aptitudes .44. In grade twelve the correlations were: general values .63, and aptitudes .69. The researchers concluded that self-concepts are clarified as boys pass through grades nine to twelve.

Spaights (1965) examined the relationship between actual and perceived achievement levels of junior high school students. Incongruent relationships between the actual and the perceived achievement levels of students at this age level were found. Spaights concluded that a substantial number of junior high students are unable to rate themselves in a reasonably accurate way. He observed that bright pupils tend to rate themselves less accurately than their less able classmates because the bright students underestimated their achievement.

Super (1960), in a paper read at the Institute of the Vocational Advisory Service of New York, stated that grade nine students were psychologically ready to consider the prevocational and vocational phases of their education, but he cautioned that the emphasis should be placed on exploration rather than preparation as far as vocational decisions were concerned. Thompson (1966) designed a study to explore Super's belief that the ninth grade student is in the vocational exploration stage. In his study he included both boys and girls at the ninth grade level. His findings strongly supported Super's suggestion.

Interests, abilities, values, and stability of decisions are factors that should be considered in prediction. Gribbons (1964) compared junior high students with tenth graders. He found that tenth graders were more aware of their interests and values than the junior high students. In a similar comparative study Montesano and Geist (1964) concluded that senior boys used abilities more than interests in making decisions of an occupational or academic nature. Flanagan and Cooley (1966) made a follow-up study of the stability of vocational choice and found that a vast amount of change took place over the period from grade nine to grade twelve. In these and other investigations a common conclusion is, that while the ninth grade student is aware of his academic and vocational problems, he is not psychologically ready to make such crucial decisions.

Tests Used in Prediction

The professional literature dealing with prediction of academic achievement contains many studies which suggest that reliable predictions can be made from the performances of students on measures of aptitude and mental ability. Super (1957), in a survey previously cited, while agreeing with the value of the Differential Aptitude Tests in counseling, emphasized that considerable caution was necessary in interpretation because of the existence of confusing and conflicting validity data. He suggested that the DAT should be validated against more carefully selected and analyzed criteria of educational achievement.

Goldman (1961) supported the view of Wesman and Bennett (1951), part authors of the DAT Manual, that with test batteries including the DAT, differential prediction of grades from subscores had not been very effective. Cronbach (1960), expert in the field of psychological testing, agreed that multifactor tests added little to the predictive power over that which was provided by general measures of ability. Berdie (1954) made a longitudinal comparison of aptitude, achievement, interest, and personality tests and confirmed Cronbach's finding in his conclusion that little improvement could be made in predicting grades by using differential aptitude scores. Eells (1961) investigated the effectiveness of differential prediction and supported the criticisms expressed. He added that the use of long, complicated, differential batteries was not justified.

The findings regarding differential prediction appear to be inconsistent. Lavin (1965) attributed this apparent contradiction to differences in definitions of criteria. Some support for prediction of subgroups also appears in the literature. Frederiksen and Melville (1954) stressed the concept that not all members of a group are equally predictable and that by subdividing a group the efficiency of prediction was increased. Ghiselli (1954), and McArthur and Stevens (1955) conducted separate investigations. Their findings also supported the view that differential prediction of subgroups was more efficient.

Shaycoft (1967) reported the findings of a comprehensive study of cognitive growth during high school. She concluded that there was a substantial growth in cognitive skills between grades nine and twelve, both in raw scores and group variability. She suggested that scores in specific subject areas provided reliable data for predicting performance in similar cognitive areas between grades nine and twelve. Travers (1955) came to similar conclusions with regard to predicting academic performance.

Subject scores or past grades are good predictors of academic success. Cronbach (1955) pointed out that if one were interested in predicting school grades, a scholastic aptitude test added little to the contribution of data provided by previous grades. He further stated that a highly valid achievement test added little to a teacher's knowledge of a student. Segel (1934), Travers (1949), and Marks and Murray (1955) in separate investigations found that high school average was more prognostic of college success than general mental tests. Berdie (1955) in a more detailed research came to the conclusion that high school percentile rank was among the best predictor both for total grades and grades in each subject area.

Any objective method of predicting success in the various high school subjects would be quite valuable to high school guidance workers in the academic counseling of their students. The literature contains few studies on academic prediction that were conducted at the secondary school level. Long (1957) analyzed the relationships between various junior high school data and five areas of high school performance at a Seattle high school. He concluded that the best overall predictor of success in high school was grade point average in junior high mathematics. Flanagan (1959) and Jacobs (1965) carried out separate investigations and concluded that data provided by arithmetic tests were the best single predictor of performance in high school.

Local Research

The review of significant literature would be incomplete without the inclusion of substantial support for investigations in the local setting. Travers (1949), after reviewing several prediction studies showed that, at the high school level, specific tests designed for predicting achievement in specific courses provided more accurate prediction than tests with broader purposes. In the same study Travers claimed that once high school was reached, there was evidence that a student's grades in a particular subject area could best be predicted from his previous grade in the same or related fields.

The authors of the Differential Aptitude Test Manual have recommended further local research. Bennet, Seashore, and Wesman (1956), the authors of this Manual have shown by validity studies that the Verbal Reasoning and Numerical Ability Tests of the DAT battery were the best predictors of high school science courses. They cautioned that this was useful knowledge but that it should be considered as a guide and not a principle. In a further description of the data the authors stated that "The data herein represent general experience, but most important to any individual school is its own experience." (p.85)

Dyer (1957), Vice-President for Research, Educational Testing Service, in presenting a case for local research stated that the local setting always had features peculiar to itself which could not be reached by the centrally-organized prediction studies found in the available literature. He suggested that local school files contained a good supply of personal data which needed to be organized and set to work.

More recently, Merwin and Gardner (1962) reviewed several research studies dealing with prediction. They found support for the idea that past achievement was frequently the best predictor of future performance. However, content area was emphasized in their study. They concluded that the value of the past achievement as a predictor of future learning depended largely on the relationship between the content being measured and the content in the future learning situation. In a later study, Merwin (1964) observed that the way in which test results were used in an individual school system could only be assessed using validity evidence obtained in the local school setting.

It is necessary to caution counselors that statistical presentations of relationships between test performance and future success are based on group averages. These may or may not be suitable for predicting the success of individual students. Rough estimates of success and supplementary data should also be considered.

Design of Study

Correlational studies include research projects in which an attempt is made to discover or clarify relationships through the use of correlation coefficients. Borg (1963) listed some of the advantages of the correlational approach. He claimed that the principal advantage of this method was that it permitted the measuring of a number of variables and their interrelationships simultaneously. Furthermore, a knowledge of the degree of relationships as provided by the correlation coefficient afforded more useful information about the variables being studied than did the causal-comparative approach.

The conflict between the correlational and experimental approaches has been the subject of much discussion. Cronbach (1957) contrasted both approaches and noted that most test development and interpretation had followed the correlational tradition. He pointed out that, while both approaches had certain weaknesses, the correlational approach took into consideration the individual differences of people. This was an aspect in which the experimentalist showed little interest. In a later study Borg (1963) reported on a similar comparison. He noted that the correlational approach took place in a more realistic setting than did the laboratory-oriented experimental approach.

While the correlational approach receives more endorsement in studies of prediction, it is important to note that the relationship between the size of a correlation coefficient and its predictive value is not a proportional one. Franzblau (1958), in his textbook on statistics, notes that lower correlation figures are of almost no value in prediction. He claims that coefficients below .40 are not even 10 percent better than chance while a correlation of at least .66 is required to yield a prediction which is 25 percent better than chance.

Many studies have been conducted to compare the correlation coefficients computed both by the global measure and the multidimensional measure. These studies provided data that endorsed the use of global measures. The investigators reported that at the high school level ability and grades were correlated at about .60. Travers (1949) found correlations in the range of .50 and .75 between the eighth and tenth grade levels. Gough (1953) obtained correlations ranging between .62 and .80 with three samples of high school students. Jacobs (1959) in a separate study reported similar findings. Cronbach (1955) reported one study which showed correlations between ability and grades at .55.

Wolking (1955) conducted studies from which he concluded that multidimensional tests of abilities did not necessarily predict most highly for the content areas in which the prediction was expected. He reported that the highest correlations were about .50, which were much lower than coefficients obtained with the use of global predictors. In similar investigations Jacobs (1959) came to the conclusion that differential aptitude measures were not superior to global ability measures for predicting grades in specific courses.

A somewhat significant problem involves the question of clinical versus actuarial prediction. A review of studies in which the statisticians' findings were compared with those of the clinicians' was done by Meehl (1954). He reported that even though the results seemed to vary considerably between one study and another, in no distinct case did the clinicians predict more accurately than the psychometricians. Horst (1956) seemed to take the position that clinical test interpretation was a relatively unquantified equivalent of statistical interpretation.

Achievement and Persistence

There are many factors associated with persistence in school. Among these factors problems of an academic nature characterize the profile of the dropout. Guest (1968) made a study of school withdrawals within the Winnipeg School Division Number 1 and came to the general conclusion that "lack of success at school was characteristic of most of the students who withdrew." (p.47) Major studies related to school withdrawal have all identified poor school achievement and grade repetition as contributing to the high school dropout rate. Studies which deal with the characteristics of the school or the instructional staff which make up the context out of which the dropout comes were not available.

Canadian investigators based their conclusions regarding school withdrawal on the social and educational characteristic of dropouts. The Social Planning Council of Metropolitan Toronto (1961), whose findings were noted by Guest (1968), suggested that "poor academic achievement is a leading factor in voluntary withdrawals." (p.48) The Report of the Provincial Committee on Aims and Objectives of Education in the Schools of Ontario (1968) gives a description of the dropout as one who "seems to be having difficulty mastering reading, which magnifies all his academic difficulties as time goes on," ... (p.44).

Similar findings are reported in studies made on withdrawal in the United States (Cook 1954; Jacques 1956.)

Poor achievement in school as a factor related to school withdrawal received support from several investigations. Guest (1968) found that being over-age for the grade will identify from half to two-thirds of the potential dropouts. He emphasized that this symptom was quite applicable to the Winnipeg situation. Williams (1966), in working with smaller samples of students, found that it was difficult to identify relatively permanent characteristics related to persistence in school but the recurrent attributes common to high school dropouts were not difficult to catalogue.

Predicting the potential dropout has been the concern of many investigators. Prediger (1965) tried to predict college dropouts from measures of academic aptitude and achievement as well as from biographical data. He found that academic measures had more predictive value than biographical data. Guest (1968) investigated the relationship between subject areas and persistence. He concluded that dropouts tend to show poor performance in both mathematics and reading.

Many studies support the claim that counselors place too much emphasis upon the results of standardized tests. Totten (1967) made recommendations about improving what he called the "holding power" of the school. He suggested that the potential dropout usually did poorly on standardized tests. Furthermore, any guidance based on these test results would be unfair since the tests themselves did not seem to analyze the true potential of the dropout. Generalizations from research literature have their value but the student should be considered in the particular context from which he is a dropout.

The Effect of Non-Intellective Factors in Prediction

It is recognized that there are many variables which influence the academic achievement of students which cannot be objectively measured. An analysis of the literature pertaining to differences in achievement among students necessitated a consideration of the non-intellective factors, even though this study recognizes such factors as one of its limitations.

Some students enjoy a high degree of academic success which could be explained on the basis of intelligence test scores. However, there are other students of comparable intellectual ability who consistently achieve below what is expected of them. Much of the research in this area pertained to the personal correlates of achievement and underachievement.

Zoolalian (1965), in a study conducted with ninth grade students, reported that an important non-intellective variable related to achievement was the student's self-concept. In the same investigation he concluded that how one viewed himself and his competency in relationships of a social nature would seem to have an effect on his level of achievement in certain subject areas. Gowan's (1955) study in which high achievers showed greater ability in making social adjustments was reinforced by the findings of Zoolalian (1965).

French (1965) used aptitude factors, information variables, and personality variables to predict, both differentially and absolutely, grades in several high school subject areas. His findings suggested that only interest preference measures were highly satisfactory for differential prediction. In a similar investigation Berdie (1954) found that vocational interest tests differentiated better among curricular groups than did other types of tests. Also, success in the chosen curriculum was predicted more successfully with interest tests than with either aptitude or achievement tests.

Travers (1949) found that interest tests were of some value for predicting grades in courses within areas of interests. Cronbach (1949) concluded from research on interest tests and prediction of grades that interest measures could improve the prediction of grades even though the results of these measures showed low correlations with grades. Warnken and Seiss (1965) investigated the effectiveness of using personal records in prediction studies. Their findings showed that cumulative records of young children could be used in predicting schizophrenic conditions and interest patterns. The professional literature does not contain many studies of this type. One study by Lavin (1952) showed some disagreement. He stated that the relationships between academic performance and personality variables were quite weak.

Summary

There was general agreement that the grade nine student was aware of his academic and vocational problems but at the same time was not psychologically prepared to make decisions without the necessary guidance. The role of the counselor becomes important here but he can be of little assistance without the use of valid predictive information.

Correlation studies conducted in the local setting were shown to be of considerable value in predicting academic performance. Studies done on the dropout problem indicated that too much emphasis was placed on the results of standardized tests. The consensus was that counseling by competent personnel should involve the use of a combination of predictive data. Past performance combined with results of standardized tests and a consideration of non-intellective factors should provide a valid basis for predicting academic performance.

Most studies reported in the literature were conducted at the college level. Those conducted at the secondary school level concentrated on the university bound high school student. Little was reported about the junior high or elementary school student as far as prediction was concerned. There is need for much research in this area.

CHAPTER III

METHOD OF THE STUDY

Chapter III consists of a description of the samples used in the study, followed by an outline of the instruments employed. The method and statistical procedure are likewise described.

Description of the Sample

The population sample consisted of grade nine students selected from one secondary school in the City of Winnipeg. This school is organized according to the six-year plan, meaning that it is made up of grades seven to twelve. The students who successfully completed grade nine in June 1966 and began a grade ten program in September 1966 were the only ones considered in the sample.

In September 1965, when the students in the study were registered for the academic year, 319 students comprised the grade nine population. These students were placed in eleven different classrooms on the basis of academic ability, achievement level in the grade eight course, and the number of languages selected for study. One of these classes was an 'all-boys' class and one an 'all-girls' class. The average enrolment per class was thirty students and the ratio of male to female approximated one to one. The mean age was fifteen years.

Academic ability was determined by the use of standardized tests such as the Dominion Test of Learning Capacity. These tests were administered before the student entered grade eight. The cumulative record of each student contains such information. Achievement in grade eight was rated according to performance in language arts, science, mathematics, social studies, and a 'second' language. French and Latin were offered as 'second' languages.

In June 1965, 255 students were promoted to grade ten on the basis of satisfactory completion of the grade nine course. To a great extent, success in the course was based upon performance in final examinations prepared by the Manitoba Department of Education. A subject mark of fifty percent was required to obtain a standing considered satisfactory for promotion to another grade.

The information required for this study was available for 250 students, and this number formed the final sample. In determining the size of the sample, consideration was given to the concept that before a sample will serve as a good basis for making estimates of population parameters, it must be representative of the population. Because the sample included a large percentage of the population, it was regarded as representative. The size of the samples used in testing hypotheses one to six is given in Table 1.

It was necessary to get information from high school science teachers and guidance counselors with regard to their opinion on the importance of grade nine mathematics. The sample was chosen from the Winnipeg School Division Number 1. There were sixty-four high school science teachers and seventy-two counselors in the junior and senior high schools. It was considered necessary to retain the total number of cases in these samples because of the likelihood of a low percentage of responses.

TABLE 1

SIZE OF STUDENT SAMPLES USED IN TESTING HYPOTHESES 1 - 6

	H_o#1	H_o#2	H_o#3	H_o#4	H_o#5	H_o#6
Biology 200	55					
201	20					
300	56					
301	25					
General 100		70				
Science 101		132				
201		48				
301		34				
Chemistry 200			130			
300			93			
Physics 200				71		
300				54		
U.E. Course					135	
Gen. Course					69	
Comm. Course					35	
Graduates						178
Dropouts						72
Total	156	284	223	125	239	250

H_o = Null Hypothesis

U.E. = University Entrance

Gen. = General

Comm. = Commercial

Instrumentation

The grade nine mathematics grades are referred to as the independent or predictor variable in this study. The scores in the high school sciences, the choice of the high school program, and persistence in school are considered as the dependent or criterion variables. The data for dependent and independent variables were obtained from the cumulative record files of the school which provided the sample for the current study.

In order to test hypotheses seven and eight it was necessary to get information from high school science teachers and guidance counselors. Permission was granted by the Winnipeg School Division Number 1 and the Winnipeg Teachers' Association to collect the necessary data. A letter of transmittal and questionnaire (Appendix A and B) were sent to the sixty-four science teachers and the seventy-two guidance counselors in the sample. Fifty science teachers (78 percent), and fifty-five counselors (76 percent) responded. A table of actual responses is given in Appendix C.

The final grade in each academic subject referred to as variables in this study was a composite mark. Uniformity in the derivation of the final mark was maintained throughout the grade in each subject by combining the results of a final examination in the subject with the results of measurements made throughout the academic year. Teacher-made tests were used in each subject throughout the year as a means of continuous evaluation. These tests were valid to the extent that there was agreement between the achievement test and the content which was taught.

The course outline provided by the Manitoba Department of Education (Appendix D) was closely followed by teachers in each subject area. The textbooks in each subject were identical for all students included in the sample. It was obvious that there would have been much variability in method of instruction, but the final level of achievement in a subject was measured by a common examination.

During the period covered by this study, the Manitoba Department of Education initiated a trend toward decentralization of authority. The responsibility of achievement testing, except in grade twelve, was given to the individual school. The result was that each school began to construct and score its own examinations. The secondary school in which this study was made maintained uniformity in evaluation by forming committees within each department for the constructing of examinations. Each subject teacher was involved in test constructing and scoring, so an entire grade wrote the same examination in a particular subject. More questions of the objective type were included in the examination papers in order to provide for greater uniformity in scoring.

Final examinations, whether set by the Manitoba Department of Education or the individual school, were of a two-hour duration with a maximum length of three hours. The scope of these examinations was the work of the entire year or the complete course as outlined in Appendix D. Examinations were administered in June. The final grades were reported on a percentage basis and a 'passing grade' was set at fifty percent of the cumulative total.

Statistical Procedure

The appropriate statistical techniques were employed in the analysis and testing of the data. The facilities of the University of Manitoba Computer Centre were used in making all major computations.

Hypotheses 1 through 4 dealt with relationships between the predictor variable and performance in high school science courses. When the relationship between two variables is linear, the correlation between scores may be expressed by the 'product-moment' coefficient of correlation. The Pearson product-moment correlation coefficients were computed for each of Hypotheses 1 through 4. It was understood that the major assumption underlying the use of this technique is that of 'linearity.' This meant that if data were to follow some curve other than a straight line, the correlation coefficient would underestimate the amount of association.

Hypothesis 5 dealt with the relationship between the predictor variable and the choice of high school program. The analysis of variance utilizing multiple linear regression was employed in testing Hypothesis 5. In Hypothesis 6 a relationship between the independent variable and a nominal-dichotomous measurement was computed by employing the zero-order correlation technique.

The data for testing Hypotheses 7 and 8 were collected from responses on the questionnaire previously noted. The categories were narrowed down to more general terms and reported as percentages.

CHAPTER IV

RESULTS AND DISCUSSION

The findings of the study are presented in this chapter. Each null hypothesis proposed in Chapter I is restated. The statistical technique and a summary statement follow each hypothesis. The conclusion involves a general discussion based on the results of this study with some reference to investigations previously cited.

Results

> Hypothesis 1. There is no relationship between the Grade IX final mathematics grades and final grades in Biology.

Pearson product-moment correlations were computed for each of four separate variables in this case. Table 2 shows significant correlations for Biology 200 and 300 at the .001 level of confidence. Slight correlations are recorded for Biology 201 and 301. The null hypothesis is rejected on the basis of significant correlations for Biology 200 and 300. The null hypothesis is retained for Biology 201 and 301 because the correlation coefficients .293 and .099 were not significant at any suitable confidence level.

TABLE 2

CORRELATION BETWEEN GRADE IX MATHEMATICS GRADES AND GRADES IN BIOLOGY

Variable	N	r	p
Biology 200	55	.484***	s
Biology 201	20	.293	ns
Biology 300	66	.489***	s
Biology 301	25	.099	ns

*** Correlation significant at the .001 level.

<u>Hypothesis 2</u>. There is no relationship between the Grade IX final mathematics grades and final grades in General Science.

The Pearson product-moment correlation coefficient was calculated for four variables in Hypothesis 2. The data in Table 3 indicate a significant relationship between General Science 100, 101, and 201 and Grade IX mathematics scores. These data do not support the null hypothesis. A slight correlation is recorded for General Science 301. This is not significant at any acceptable level of confidence. Therefore, the null hypothesis showing that there is no significant relationship between Grade IX mathematics scores and General Science 301 is retained.

TABLE 3

CORRELATION BETWEEN GRADE IX MATHEMATICS GRADES AND GRADES IN GENERAL SCIENCE

Variable	N	r	p
General Science 100	70	.636***	s
General Science 101	132	.519***	s
General Science 201	48	.405**	s
General Science 301	34	.175	ns

*** Correlation significant at the .001 level.

** Correlation significant at the .01 level.

> <u>Hypothesis</u> 3. There is no relationship between the Grade IX final mathematics grades and final grades in Chemistry.

An inspection of Table 4 shows that the null hypothesis is rejected at the .001 level of significance. The Pearson method was used to compute correlations for two separate variables as shown in Table 4. The correlation coefficients .670 and .645 are significantly high.

TABLE 4

CORRELATION BETWEEN GRADE IX MATHEMATICS GRADES AND GRADES IN CHEMISTRY

Variable	N	r	p
Chemistry 200	130	.670***	s
Chemistry 300	93	.645***	s

*** Correlation significant at the .001 level.

Hypothesis 4. There is no relationship between the Grade IX final mathematics grades and final grades in Physics.

The Pearson r's in Table 5 indicate a relationship between each of the two separate variables and Grade IX mathematics. In this case the null hypothesis is rejected at the .001 confidence level.

TABLE 5

CORRELATION BETWEEN GRADE IX MATHEMATICS GRADES AND GRADES IN PHYSICS

Variable	N	r	p
Physics 200	71	.530***	s
Physics 300	54	.599***	s

*** Correlation significant at the .001 level.

<u>Hypothesis 5</u>. There is no relationship between the Grade IX final mathematics grades and the choice of the University Entrance, General, or Commercial Course.

An analysis of variance using multiple linear regression was carried out to test Hypothesis 5. In Table 6 an F ratio of 64.80 is reported. The table of F distribution showed 64.80 to be significant at the .001 level of confidence. Since a significant difference existed between group means, it was necessary to locate the groups that contributed to the difference. Scheffé's method for groups of unequal sample sizes (Appendix E) was used to test the contrasts. Table 7 reports the relevant data. An inspection of the data in Table 7 shows that there is a significant difference between Grade IX mathematics scores and choice of high school program.

TABLE 6

ANALYSIS OF VARIANCE BY LINEAR REGRESSION TO SHOW RELATIONSHIP BETWEEN GRADE IX MATHEMATICS GRADES AND CHOICE OF HIGH SCHOOL PROGRAM

Source	SS	DF	MS	F
Regression	19250.40	2.	9625.20	64.80***
Deviation	36691.41	247.	148.55	
Total	55941.81	249.	224.67	

*** Significant at .001 level.

TABLE 7

MULTIPLE COMPARISON BETWEEN MEANS USING SCHEFFÉ'S TEST FOR UNEQUAL SAMPLE SIZES

Groups	Means	Contrasts	$d_{1}(F:\alpha = .01)$
U.E.	$\bar{X}_1 = 72.8$	$\bar{X}_1 - \bar{X}_2 = 17.8$	4.5
Gen.	$\bar{X}_2 = 55.0$	$\bar{X}_1 - \bar{X}_3 = 22.5$	
Comm.	$\bar{X}_3 = 50.3$	$\bar{X}_2 - \bar{X}_3 = 4.7$	

U.E. = University Entrance Program
Gen. = General Program
Comm. = Commercial Program

<u>Hypothesis 6</u>. There is no relationship between Grade IX final mathematics grades and persistence in high school.

The simple correlation or zero-order correlation coefficient was computed. An r of .463 was observed to be significant at the .001 confidence level. The null hypothesis is rejected on this basis.

<u>Hypothesis 7</u>. Guidance counselors do not consider Grade IX final mathematics grades to be important in helping students to select high school science courses.

Table 8 shows that counselors consider the Grade IX final mathematics grades to be significantly important when assisting students to choose courses in general science, chemistry and physics. The null hypothesis is rejected on the basis of the large percentage values. The data for the biology courses support the null hypothesis. Further analysis of these data did not seem essential.

TABLE 8

THE IMPORTANCE GUIDANCE COUNSELORS ATTACH TO GRADE IX MATHEMATICS SCORES -- REPORTED AS PERCENTAGES

Categories	General Science				Chem.		Physics		Biology			
	100	101	201	301	200	300	200	300	200	201	300	301
Important	87	67	67	70	86	86	96	91	38	13	29	18
Little or No Importance	11	15	13	12	7	7	4	4	42	51	38	47
No Opinion	2	18	20	18	7	7	0	5	20	36	33	35

Hypothesis 8. High School science teachers do not consider Grade IX final mathematics grades to be important for students' performance in the high school science courses.

The data in Table 9 indicate that a significant percentage of high school science teachers consider the Grade IX mathematics grades to be important in the performance of students in general science, chemistry, physics, and Biology 200. The null hypothesis is rejected on this basis. The data for Biology 201, 300 and 301 support the retention of the null hypothesis.

TABLE 9

THE IMPORTANCE HIGH SCHOOL SCIENCE TEACHERS ATTACH TO GRADE IX MATHEMATICS SCORES - REPORTED AS PERCENTAGES

Categories	General Science				Chem.		Physics		Biology			
	100	101	201	301	200	300	200	300	200	201	300	301
Important	82	48	52	66	80	74	70	72	66	22	12	26
Little or No Importance	4	12	8	8	0	2	2	4	8	22	24	20
No Opinion	14	40	40	26	20	24	28	24	26	56	64	54

Discussion

The present study sought to investigate relationships between the predictor variable and the criterion variables. The grade nine mathematics grades were compared with three major criterion variables: performance in high school science subjects, choice of high school program, and persistence in high school to the conclusion of the chosen program of studies. A sampling of the opinion of high school science teachers and guidance counselors with regard to the importance they place on grade nine final mathematics scores was carried out.

The high school science subjects which form the criterion variables were partitioned into grade levels to achieve the valuable contribution that a longitudinal study provides. As far as practicable, these same variables were partitioned as to whether the course was part of a university entrance program (-00), or part of the general course (-01). This technique allowed for the separation of Hypotheses 1 to 4 into twelve variables. Frederiksen and Melville (1954) showed that the efficiency of a predictive relationship is increased by subdividing groups. Travers (1969) recommended partitioning as a very desirable technique which could be used to establish more valid relationships.

The results reported for Hypothesis 1 showed significant correlation coefficients for three out of four variables in general science. Correlations ranging from .41 to .64 are considered as acceptable depending upon the purpose for which they are intended. The relatively low and non-significant correlation of .175 for General Science 301 may be due in part to fluctuations in the sample (Borg 1967). Another possible source of discrepancy that could contribute to low correlations is found in the grades themselves. This is attributable to errors in measurements. Lavin (1965) considered this source as uncontrollable in investigations of this nature.

The higher correlations shown for General Science 100 and 101 indicate a significant relationship between grade nine mathematics scores and these two subjects. Ability in grade nine mathematics could be directly related to performance in these two general science courses.

A note of caution is in order at this point. While there could be causality involved in the performance of students in grade ten general science, no measure of a causal relationship was made. Hence, no claim is made other than to an associative relationship.

There were two high school sciences at the 301 level shown in this study. Both General Science 301 (r=.075) and Biology 301 (r=.099) have small sample numbers. These correlations were found to be insignificant at all the levels of confidence utilized in this part of the study. An examination of the Biology 301 course clearly shows that ability in mathematics is not a prerequisite for success in this course.

However, the same line of reasoning is not acceptable when an inspection is made of the General Science 301 course. Ability in mathematics is definitely an asset to success in this course. The low correlations in these two subjects, and mainly in General Science 301, could be due to the fact that there could be homogeneity in the groups. Correlation is a function of group variability and where the variability factor is small the correlation would also be low (Jacobs 1959). In predicting academic achievement with a high school placement test, Impellitteri (1967) explained low correlations on the basis of homogeneity of the sample.

Physics and chemistry teachers at the high school level would agree that these subjects do require ability in mathematics. The findings of this study indicate a significant relationship between grade nine mathematics and physics and chemistry. Correlations ranging between .53 and .60 for physics and between .65 and .67 for chemistry were found to be significant at the .001 confidence level. In a paper dealing with conditions necessary for scholastic achievement, Frost (1965) noted that if there is an increasing similarity in content between predictor and criterion tests, then it is quite reasonable to expect significantly higher correlations.

The somewhat consistent correlation between grade nine mathematics scores and physics and chemistry scores may be attributed to the fact that the chemistry and physics courses are of the -00 level, hence will be taken only by students who have registered in the university entrance program. This suggests in a general sense that these students were of a high academic caliber. The non-intellective factors do have a great influence on performance especially in the university entrance courses. Shaycoft (1967) agreed with Travers' (1955) findings that scores in specific subjects at the junior high level provided quite reliable predictive data for performance in related areas as high as the grade twelve level.

Caron (1971) investigated the reasons for the decreasing enrollment in high school physics and reported an opposite view that "you do not have to be good in mathematics to be good in physics" (p.176).

Teachers of high school biology courses would agree that ability in mathematics is not a crucial prerequisite for success in biology. Again, the university entrance courses, Biology 200 and 300, show correlations significant at the .001 confidence levels. The significance of these consistent relationships could be related to reasons similar to those offered in the explanation for the other university entrance courses. No significant correlations in the range .10 to .29 were reported for Biology 201 and 301. The homogeneity of these two groups, coupled with the small sample size, could have contributed to the findings of no significant relationship.

The professional literature dealing with studies on student withdrawal provide a wide variety of reasons for dropouts. The consensus is that poor achievement in school characterizes the potential dropout. The findings of this study show a significant relationship between grade nine mathematics scores and persistence in high school. No inference is made as to causal relationship between mathematics scores and withdrawal from school, but the correlation shows that performance in mathematics at the grade nine level could add to the dropout's profile of poor achievement. The findings agree with Guest (1968). He found that dropouts performed poorly in mathematics and reading.

The analysis of variance by regression showed a significant relationship between grade nine mathematics scores and choice of high school program. Even though the sample size decreased between university entrance on the one hand and general and commercial courses on the other, the differences between means were significantly large enough to provide a meaningful relationship. The consistency observed in the relationship between the predictor variable and the high school sciences would be related in some way to the findings from the analysis of variance.

As indicated by the survey, there seems to be a general agreement in the opinion of guidance counselors and high school science teachers as to the importance both groups attach to grade nine final mathematics grades. The responses totalled over seventy percent in both cases, so that a claim of representativeness is in order. Both groups agreed that grade nine mathematics grades were important as far as general science, physics, and chemistry are concerned. For some unexplainable reason, both counselors and science teachers saw grade nine mathematics as being important for performance in Biology 200.

The purpose of this study was to provide information that could be of value to counselors and students when they are faced with the problem of selecting high school courses. The counselor should be aware of the fact that prediction is a completely actuarial operation that does not require any specific knowledge or understanding beyond the statistical relationships discovered between the predictor and criterion variables. The precision of the estimates and the practical importance of the results of correlational studies could be assessed from an inspection of the confidence intervals.

The guidance counselor has to decide whether and to what extent a correlation could be used to predict performance in a meaningful way for groups or for individuals. The size of the correlation coefficient is usually of some concern. Goldman (1961) reported that coefficients in the range .40 to .60 were successfully used in predicting high school and college grades. Frost (1965) found that a battery of tests showed a correlation of .57 with achievement in college physics and mathematics.

Anyone using the results of correlational studies should realize that they are dealing with quite imprecise predictions, and decisions based solely on such studies are not recommended. Some consideration should be given to the interval between the prediction and the event to be predicted, noting that the longer the interval the smaller are the chances of making a successful prediction. The results of this investigation could be of practical value when used with as much relevant information about each individual as could be obtained. Long (1957) found that junior high mathematics scores were the best predictors of success in high school. Flanagan (1959) and Jacobs (1965) reported that arithmetic scores were the best single predictor of high school performance.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The overall goal of this study was to provide additional information for the use of counselors and students in selecting courses for a high school program of study. Specifically, the purpose was to determine the relationship between grade nine final mathematics grades and: performance in the high school science subjects; choice of high school program; and persistence in high school. Another purpose was to determine the importance guidance counselors and high school science teachers placed on the grade nine final mathematics grades.

Analysis of the relationships involved the following: The relationships between grade nine final mathematics grades and

1. performance in General Science 100, 101, 201, and 301
2. performance in Chemistry 200 and 300
3. performance in Physics 200 and 300
4. performance in Biology 200, 201, 300, and 301

5. choice of high school program -- university entrance program, general program, commercial program
6. persistence in high school to the completion of the program that was selected.

A review of literature covered the following areas of research: the ability of the junior high school student to make academic decisions; tests used in prediction; local research; design of the study; achievement as related to persistence in school; and the effect of non-intellective factors in prediction.

The sample included 250 grade nine students for whom scores were available in grade nine mathematics and the particular science subjects taken at each of the grade ten, eleven, and twelve levels. The relationships between the predictor variable and the high school science subjects were determined by computing the Pearson product-moment correlation in each case. A zero-order or simple correlation coefficient was determined between the grade nine mathematics scores and persistence in high school. In each case the correlation coefficient was tested at the appropriate significance interval.

The relationship between the predictor variable and choice of high school program was determined by the analysis of variance utilizing multiple linear regression method. A significant F ratio was found and tested by a quick calculation method developed by Williams for Scheffé's test of mean score differences for unequal sample sizes. The data collected from a questionnaire which sampled the opinion of guidance counselors and high school science teachers were analyzed and reported as percentages.

The results of the study were as follows:

1. Significant relationships were found for General Science 100, 101 and 201 with the highest correlation between the predictor variable and General Science 100. A very low and insignificant relationship was found for General Science 301.
2. Significantly higher correlation coefficients were found for Chemistry 200 and 300.
3. The correlation coefficients for Physics 200 and 300 showed a significant relationship.
4. Biology 200 and 300 were significantly correlated with the predictor variable. No relationships were found to exist for Biology 201 and 301.
5. The choice of high school program were found to be significantly correlated with the grade nine mathematics grades.

6. Persistence in high school was found to be significantly related to grade nine mathematics grades.
7. There was general agreement among guidance counselors that grade nine mathematics grades were important for performance in general science, chemistry, and physics.
8. High school science teachers generally agreed that grade nine mathematics was important for performance in general science, chemistry, and physics.

Conclusions

The results of this study indicate that there is a positive and significant relationship between grade nine final mathematics grades and performance in the high school science subjects generally. An indirect comparative study of the correlation coefficients for the physical sciences and biology shows that there is a 'greater' relationship between ability in mathematics, as measured by the grade nine final mathematics grades, and performance in the physical sciences. A similar comparison between the correlation coefficients for the university entrance courses and the general courses shows that there is a 'greater' relationship on the side of the university entrance courses.

The relationship between grade nine final mathematics grades and the choice of high school program was determined. The results would support the conclusion that a significant relationship does exist. On closer examiniation of the group means, it is observed that students in the group with the highest means were registered in the university entrance program; those with the second highest in the general course program; and those with the lowest group means were students in the commercial or vocational program.

Poor academic achievement is a major factor in student withdrawal from school. The findings of this study show that there is a significant relationship between the grade nine final mathematics grades and persistence in high school. Completion of the high school program of studies was the criterion used in this aspect of the investigation.

Guidance counselors assist students to decide on the high school program in which they intend to register. The findings of this study indicate that counselors do consider the grade nine final mathematics scores when a program of studies is selected. They seem to place more importance on mathematics as a prerequisite to success in the physical sciences.

The high school science teachers agreed that ability in mathematics, as is evident from the grade nine final mathematics grades, is important for successful performance in the high school sciences. A comparative study shows that high school science teachers, like guidance counselors, consider mathematics more important in the physical sciences than in biology.

Recommendations

1. More longitudinal studies are needed in order to provide data regarding the consistency of performance and the degree to which it is predictable over a period of time.
2. The prediction of performance through non-intellective factors--personality and socio-environmental factors--should be studied. Results of such a study would provide more information towards the understanding of the 'under-achiever' problem.
3. Guidance counselors should be provided with the means to statistically analyze data for each major subject with the long range plan of developing a 'pool' of valid predictive information.
4. An inter-disciplinary approach should be tried in teaching mathematics and science at the junior high level with a follow-up study of the performance in high school science subjects.

5. This study could be repeated. A correlation between the grade nine mathematics grades and the Numerical Ability data from the DAT battery could be done prior to the rest of the study. Sex differences should be included. Expectancy tables or academic prediction scales could be developed.
6. Separate comments made by high school science teachers on the questionnaire indicate a lack of knowledge on the part of students in basic arithmetic. It is recommended that an attempt be made to transfer the mathematical concepts which are taught on a symbolic basis to social and scientific problem solving.
7. Studies should be made to determine the effect of such variables as absenteeism, truancy, part-time work, and health on academic performance.

APPENDICES

APPENDIX A

LETTER OF TRANSMITTAL

510 Hay Street,
Winnipeg, R3L-2L6,
November 24, 1972.

Dear

The attached questionnaire is an attempt to sample the opinion of professionals with regard to the importance attributed to mathematics relative to performance in science at the high school level. This "opinion sample" forms a part of an investigation into the relationship between grade nine mathematics and high school program selection, high school science performance, and persistence in school.

We would appreciate it if you will complete the questionnaire and return it in the stamped, self-addressed envelope prior to December 11. The completion of this research depends upon the analysis of your responses. We will be pleased to send you a summary of the questionnaire results if you desire.

Thank you for your cooperation.

Sincerely yours,

D. Gajadhar.

L.J. Eide, (Ph.D.),
Advisor.

APPENDIX B

QUESTIONNAIRE

QUESTIONNAIRE

These are the instructions for completing the questionnaire which seeks to sample your opinion on the importance of grade nine final mathematics achievement scores for performance in the high school science subjects.

On the following page is a list of high school science courses. Please indicate by a check mark (✓) in the appropriate column the importance you place on grade nine final mathematics scores for performance in each of the science courses.

Example:

Science Course	Very Important	Imp.	Neutral or No Opinion	Little Importance	No Imp.
A. General Science 100	✓				
B. Biology 300			✓		
C. Chemistry 200		✓			
etc.					

Imp. = Important/Importance

In the above example the check mark,

(i.) in the first row indicates that grade nine final mathematics score is 'very important' for performance in General Science 100.

(ii.) in the second row indicates that there is 'no opinion' relative to performance in Biology 300.

(iii.) in the third row indicates that grade nine mathematics score is 'important' for performance in Chemistry 200.

Subject Area: ______________________ Ref. No. ______

The Importance of Grade IX Mathematics in High School Science Performance

Science Course		Very Important	Important	Neutral or No Opinion	Little Importance	No Importance
A. General Science	100					
	101					
	201					
	301					
B. Biology	200					
	201					
	300					
	301					
C. Chemistry	200					
	300					
D. Physics	200					
	300					

APPENDIX C

RESULTS OF QUESTIONNAIRE

THE IMPORTANCE GUIDANCE COUNSELORS ATTACH TO GRADE IX MATHEMATICS SCORES -- ACTUAL RESPONSES

Categories	General Science				Chemistry		Physics		Biology			
	100	101	201	301	200	300	200	300	200	201	300	301
Very Important	21	6	4	6	24	23	50	46	0	0	2	0
Important	27	31	33	32	23	24	3	4	21	7	14	10
No Response	1	10	11	10	4	4	0	3	11	20	18	19
Little Importance	6	8	7	7	4	4	2	2	19	24	16	20
No Importance	0	0	0	0	0	0	0	0	4	4	5	6

THE IMPORTANCE HIGH SCHOOL SCIENCE TEACHERS ATTACH TO GRADE IX MATHEMATICS SCORES -- ACTUAL RESPONSES

Categories	General Science				Chemistry		Physics		Biology			
	100	101	201	301	200	300	200	300	200	201	300	301
Very Important	30	3	7	8	31	30	31	33	3	2	5	2
Important	11	21	19	25	9	7	4	3	8	4	8	7
No Response	7	20	20	13	10	12	14	12	28	32	27	32
Little Importance	2	6	4	4	0	1	1	2	10	11	9	7
No Importance	0	0	0	0	0	0	0	0	1	1	1	2

APPENDIX D

DESCRIPTION OF COURSES

Description of Courses

The Manitoba Department of Education publishes a booklet called the "High School Program of Studies" on an annual basis. The June final examinations are based on the content of the courses as described in this booklet.

A description of the courses which were used as variables in this study is given in this section. For ease of identification, course numbers are used in Grades X, XI, and XII subjects. These are three digit numbers; for example, 100, 201, 301. The 10, 20, and 30 refer to Grades X, XI, and XII respectively. The suffix "0" is used for courses that make up the university entrance program; and "1" is used to designate courses which come under the general course program.

The course descriptions which follow were taken from the "High School Program of Studies" published by the Manitoba Department of Education. During the period (1965-1969) covered by this study, changes were made in course structure and content, and new courses were introduced either on a pilot or permanent basis. Accuracy of course description was maintained by referring to the "High School Program of Studies" of the appropriate year:

Grade IX mathematics course: 1965-1966 publication
Grade X science courses: 1966-1967 publication
Grade XI science courses: 1967-1968 publication
Grade XII science courses: 1968-1969 publication.

Grade IX Mathematics (1965-1966)

The following topics were included in this course:

1. Sets
2. Properties of Operations--Numbers of Ordinary Arithmetic
3. Rational and Irrational Numbers--Operation of Addition
4. Subtraction, Multiplication and Division of Real Numbers
5. Open Expressions
6. Open Rational Expressions
7. Exponents and Radicals
8. Geometry: Congruence, Constructions and Circles

General Science 100 (1966-1967)

The following topics and relevant experiments were included in this course:

1. How Do Scientists Work?
2. What Are Things Made Of?
3. How Can Materials Be Changed?
4. How Do We Use and Control Fire?
5. How Do We Control Heat?
6. How Do We Provide Our Home With a Good Water Supply?
7. How Do Simple Machines Help Us Do Work?
8. How Do We Harness the Energy of Nature to Do Our Work?

9. How Do We Obtain and Use Electrical Currents?
10. How Do We Use Energy for Communications?
11. How Do We Provide Transportation?
12. How Can Science Help Us Keep From Wasting Nature's Wealth?

<u>General Science 101</u> (1966-1967)

The following topics and prescribed laboratory investigations were included in this course:

1. Chemistry Improves Man's Living
2. Matter
3. Atoms and Our Understanding of Chemistry
4. Combination of Atoms
5. Oxygen and Its Properties
6. Hydrogen and Its Properties
7. Chemical Equations
8. Solutions and Ionizations
9. Acids, Bases and Salts
10. Chemistry of Cosmetics
11. Chemistry of Home Decorations
12. Chemistry of Gardening
13. Static Electricity
14. Magnetism
15. Measurement
16. Systems of Measurement
17. Making Measurements
18. Work, Power, Energy and Machines

<u>Chemistry 200</u> (1967-1968)

Prescribed laboratory investigations and the following topics were included in this course:

1. Chemistry: An Experimental Science
2. A Scientific Model: The Atomic Theory
3. Chemical Reactions
4. The Gas Phase: Kinetic Theory
5. Liquids and Solids: Condensed Phases of Matter
6. Structure of the Atom and the Periodic Table
7. Energy Effects in Chemical Reactions
8. The Rates of Chemical Reaction
9. Equilibrium in Chemical Reactions
10. Solubility Equilibria

<u>Physics 200</u> (1967-1968)

This course was comprised of prescribed laboratory investigations and the following topics:

1. Time and Measurement
2. Space and Its Measures
3. Functions and Scaling
4. How Light Behaves
5. Reflection and Images
6. Refraction
7. The Particle Model of Light
8. Introduction to Waves

9. Waves and Light
10. Interference
11. Light Waves

Biology 200 (1967-1968)

This course was comprised of prescribed laboratory investigations and the following topics:

1. Life from Life
2. Basic Structure
3. Basic Functions
4. Living Chemistry
5. The Physiology of Cells
6. The Reproduction of Cells
7. The Balance of Nature
8. Viruses
9. Bacteria
10. Small Organisms of Great Economic Importance
11. Molds, Yeasts, and Mushrooms
12. The Trend Toward Complexity
13. The Land Turns Green
14. Photosynthesis
15. Stems and Roots
16. Reproduction in Flowering Plants

Physical Science 201 (1967-1968)

This course was made up of laboratory investigations and the following topics:

1. The Nature of Matter
2. Mechanics of Gases
3. Mass Relations in Chemical Reactions
4. Solutions in Water
5. Acids, Bases and Salts
6. Fuels and Heating
7. Light
8. Sound
9. Direct Current Electricity
10. Introduction to Nuclear Physics

Biology 201 (1967-1968)

The laboratory work was designed to follow the following topics in the theory:

1. Introduction to the Study of Biology
2. Effects of Environment on Man
3. General Survey of the Plant Kingdom
4. Higher Plants
5. General Survey of the Invertebrates

Chemistry 300 (1968-1969)

This course was made up of prescribed laboratory investigations and the following topics:

1. Methods of Chemistry
2. Nature of Matter
3. Atoms
4. Chemical Bond
5. Stoichiometry
6. Gases
7. Liquids
8. Solids
9. Solutions
10. Chemical Kinetics
11. Chemical Equilibrium
12. Electrochemistry
13. Aqueous Solutions
14. The Alkali Metals
15. The Halogens
16. Nuclear Structure and Radioactivity

Physics 300 (1968-1969)

A prescribed laboratory program was part of this course. The following were the topics:

1. Motion Along a Straight-Line Path
2. Motion in Space
3. Newton's Laws of Motion
4. Motion at the Earth's Surface
5. Universal Gravitation and the Solar System
6. Momentum and the Conservation of Momentum
7. Work and Kinetic Energy
8. Potential Energy
9. Some Qualitative Facts About Electricity
10. Coulomb's Law and the Elementary Electric Charge
11. Energy and Motion of Charges in Electric Fields
12. Electric Circuits
13. The Magnetic Field
14. Electromagnetic Induction and Electromagnetic Waves
15. Exploring the Atom
16. Photons and Matter Waves
17. Quantum Systems and the Structure of Atoms

Biology 300 (1968-1969)

The course included laboratory investigations and the following:

1. The Diversity Among Animals
2. Digestion in Multicellular Animals
3. Transportation Within Multicellular Animals
4. Respiration in Multicellular Animals
5. Excretion in Multicellular Animals
6. Co-ordination in Multicellular Animals
7. Animal Support and Locomotion
8. Reproduction in Animals
9. The Development of Animals
10. The Analysis of Development
11. Heredity
12. Evolution
13. Ecology--An Introduction

Physical Science 301 (1968-1969)

This course included laboratory investigations and the following:

1. Periodic Table
2. The Sodium Family
3. Halogen Family
4. A Study of the Metal Industries
5. Colloidal Chemistry
6. The Hydrocarbons

7. Textiles and Paper
8. Hydrocarbon Substitution Products
9. Heat
10. Force and Motion
11. Electro-Magnetic Induction

<u>Biology 301</u> (1968-1969)

This course included laboratory investigations and the following:

1. General Survey of the Vertebrates
2. Study of the Organ System of Man
3. Biology of Heredity--Genetics
4. The Nature of Life

APPENDIX E

QUICK CALCULATION OF CRITICAL DIFFERENCES FOR SCHEFFÉ'S TEST FOR UNEQUAL SAMPLES

Dear Sir:

"Quick Calculations of Critical Differences for Scheffé's Test for Unequal Sample Sizes"

The typical beginning researcher faces the use of Scheffé's test as a multiple comparison method with an attitude similar to that portrayed on the popular television program "Laugh-In": there is some good news and some bad news. First the good news: you can perform any 'a posteriori' contrasts you wish, and still retain the selected probability. Now the bad news: if you have unequal 'n's', then you have a lot of work to do. The purpose of this presentation is to reduce the bad news.

When two means are being contrasted, Scheffé's test is given by

$$S^2 = \frac{\left(\bar{X}_i - \bar{X}_j\right)^2}{MS_w\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}, \qquad (1)$$

with S^2 being compared to $(k - 1)F_{\alpha:k-1,N-k}$, where k is the number of groups, N the total number of subjects, and o the significance level. Then, it can be shown by algebraic manipulation that the 'smallest' possible difference between means that will result in a significant difference is

$$d_1 = \left[\frac{2MS_w(k - 1)F_{\alpha:k-1,N-k}}{n_L}\right]^{\frac{1}{2}}$$

where n_L is the group with the largest n. If the difference between two means is smaller than d_1, there is no further need to consider that difference. Likewise, a difference (d_2) can be found such that any difference between means larger than d_2 will be significant:

$$d_2 = \left[\frac{2MS_w(k - 1)F_{\alpha:k-1,N-k}}{n_s}\right]^{\frac{1}{2}}$$

where n_s is the group with the smallest n. The use of (1) will be necessary only for those differences between means that lie between d_1 and d_2.

Sincerely yours,
John D. Williams
Div. of Educational
Measurement and Statistics
University of North Dakota
Grand Forks, N.D.

BIBLIOGRAPHY

BIBLIOGRAPHY

Anastasi, A. Psychological Testing (Third Edition). London: The Macmillan Company, 1969.

Bennett, G.K., Seashore, H.G. and Wesman, A.G. Differential Aptitude Tests Manual, Forms L and M (4th Edition). New York: The Psychological Corporation, 1966.

________. "The Differential Aptitude Tests: An Overview." Personnel and Guidance Journal, 1956, 35, 81-91.

Berdie, R.F., "Aptitude, Achievement, Interest, and Personality Tests: A Longitudinal Comparison." Journal of Applied Psychology, 1955, 39, 103-114.

Bloom, B.S. and Peters, F.R. The Use of Academic Prediction Scales For Counseling and Selecting College Entrants. New York: The Free Press of Glencoe, Inc., 1961.

Boney, J.D. "Predicting the Academic Achievement of Secondary School Negro Students." Personnel and Guidance Journal, 1965, 44, 700-708.

Borg, W.R. Educational Research: An Introduction. New York: David McKay, 1967.

Campbell, W.G. Form and Style in Thesis Writing (Third Edition). Boston: Houghton Mifflin Company, 1969.

Caron, G.F. "Students' Reasons For Electing or Rejecting Enrollment in Grade XII Physics." Masters Thesis, University of Manitoba, Winnipeg, 1971.

Cook, E.S. "An Analysis of Factors Related to Withdrawal from High School Prior to Graduation." Journal of Educational Research, 1954, 50, 191-196.

Cronbach, L.J. Essentials of Psychological Testing (Second Edition). New York: Harper and Row, 1960.

________. "The Two Disciplines of Scientific Psychology." American Psychologist, 1957, 12, 671-684.

Dyer, H.S. "The Need for Do-It-Yourself Prediction Research in High School Guidance." Personnel and Guidance Journal, 1957, 36, 162-167.

Eells, K. "How Effective is Differential Prediction in Three Types of College Curricula?" Educational and Psychological Measurement, 1961, 21, 459-471.

Fisher, R.A. and Yates, F. Statistical Tables for Biological, Agricultural and Medical Research. New York: Hafner Publishing Co. Inc., 1953.

Flanagan, J.C. "Identification, Development and Utilization of Human Talents." Cooperative Research Project No. 635, Pittsburgh: University of Pittsburg. Reported by Bligh, H.F., "Trends in the Measurement of Educational Achievement." Review of Educational Research, 1965, 32, 45-46.

________ and Cooley, W.W. Project Talent: One-year follow-up studies. Pittsburg: University of Pittsburg, 1966.

Franzblau, A.N. A Primer of Statistics for Non-Statisticians, New York: Harcourt, Brace and World, Inc., 1958.

Frederiksen, N. and Melville, S.D. "Differential predictability in the use of test scores." Educational and Psychological Measurement, 1954, 14, 647-656.

French, J.W. "Comparative Prediction of High School Grades by Pure-Factor Aptitude, Information, and Personality Measures." Educational and Psychological Measurement, 1964, 24, 321-329.

Frost, B.P. "Some Conditions of Scholastic Achievement." Canadian Education and Research Digest, 1965, 5, 267-272.

Gelatt, H.B. and Clarke, R.B. "Role of Subjective Probabilities in the Decision Process." Journal of Counselling Psychology, 1967, 14, 332-341.

Ghiselli, E.E. "Differentiation of individuals in terms of their predictability." Journal of Applied Psychology, 1956, 40, 374-377.

Glass, G.V. and Stanley, J.C. Statistical Methods in Education and Psychology. New Jersey: Prentice-Hall, Inc., 1970.

Goldman, L. Using Tests in Counseling. New York: Appleton-Century-Crofts, Inc. 1961.

Gough, H. "What Determines the Academic Achievement of High School Students?" Journal of Educational Research, 1953, 46, 321-331.

Gowan, J.C. "The Underachieving Gifted Child: A Problem for Everyone." Exceptional Children, 1955, 21, 247-249.

Gribbons, W.D. "Changes in Readiness for Vocational Planning from the Eighth to the Tenth Grade." Personnel and Guidance Journal, 1964, 42, 908-913.

Grove, E.L. and Grove, E.L. "An Experiment In The Integration of Mathematics and Sciences." School Science and Mathematics, 1952, 52, 467-470.

Guest, H.H. A Study of Student Withdrawals From Schools In the Winnipeg School Division No. 1. Winnipeg: 1968.

Horst, P. "Educational and Vocational Counseling from the Actuarial Point of View." Personnel and Guidance Journal, 1956, 35, 164-170.

Impellitteri, J.T. "Predicting Academic Achievement with the High School Placement Test." Personnel and Guidance Journal, 1967, 44, 140-143.

Jacobs, J.B. "Aptitude and Achievement Measures in Predicting High School Academic Success." Personnel and Guidance Journal, 1959, 37, 334-341.

Jacques, W.T. "Hastings High School Works on the Drop-Out Problem." Personnel and Guidance Journal, 1956, 35.

Lavin, D.E. The Prediction of Academic Performance. New York: Russell Sage Foundation, 1965.

Long, J.R. "Academic Forecasting In The Technical-Vocational High School Subjects." Personnel and Guidance Journal, 1959, 37, 666-668.

Manitoba, Department of Youth and Education. A Proposal For the Reorganization of the Secondary Schools of Manitoba. Winnipeg, 1970.

Marks, E. and Murray, J.E. "Non-additive Effects In The Prediction of Academic Achievement." Educational and Psychological Measurement, 1955, 25, 1097-1104.

McArthur, C. and Stevens, L.B. "The validation of expressed interests as compared with inventoried interests: a fourteen-year follow-up." Journal of Applied Psychology, 1955, 39, 184-189.

Meehl, P.E. Clinical Versus Statistical Prediction: A Theoretical Analysis and a Review of the Evidence. Minnesota: University of Minnesota Press, 1954.

Merwin, J.C. "Review of the Differential Aptitude Tests." Personnel and Guidance Journal, 1964, 43, 396-401.

________ and Gardner, E.F. "Development and Application of Tests of Educational Achievement." Review of Educational Research, 1962, 32, 40-56.

Montesano, N. and Geist, H. "Differences in Occupational Choice Between Ninth and Twelfth Grade Boys." Personnel and Guidance Journal, 1964, 43, 150-154.

O'Hara, R.P. and Tiedeman, D.V. "The vocational self-concept in adolescence." Journal of Counselling Psychology, 1959, 6, 292-301.

Ontario, Department of Education. The Report of the Provincial Committee on Aims and Objectives of Education in the Schools of Ontario. Toronto: The Publications Office of the Ontario Department of Education, 1968.

Rosenfeld, R. "Junior High Programs For Potential Dropouts." The School Counselor, 1965, 12, 167-172.

Prediger, D.J. "Prediction of Persistence in College." Journal of Counselling Psychology, 1965, 12, 62-67.

Segel, D. "Prediction of Success in College." Bulletin No. 15, U.S. Office of Education. Washington: U.S. Government Printing Office, 1934.

Shaycoft, M.F. "The High School Years: Growth in Cognitive Skills." Interim Report No. 3, Project No. 3051, Pittsburg: University of Pittsburgh, 1967.

Spaights, E. "Accuracy of Self-Estimation of Junior High School Students." The Journal of Educational Research, 1965, 58, 416-419.

Super, D.E. "Multifactor Tests: Summing Up." Personnel and Guidance Journal, 1957, 36, 17-20.

Super, D.E. "The Critical Ninth Grade: Vocational Choice or Vocational Exploration." Personnel and Guidance Journal, 1960, 39, 106-109.

Thompson, O.E. "Occupational Values of High School Students." Personnel and Guidance Journal, 1966, 44, 850-853.

Thorndike, R.L. and Hagen, E. Measurement and Evaluation in Psychology and Education (Third Edition). New York: John Wiley & Sons, Inc., 1969.

Totten, W.F. "Improving School Holding Power." Michigan Education Journal, 1967, 45, 39-40.

Travers, R.M.W. An Introduction to Educational Research (Third Edition). London: The Macmillan Company, 1969.

________. Educational Measurement. New York: The Macmillan Company, 1955.

Warnken, R.G. and Seiss, T.F. "The Use of the Cumulative Record in the Prediction of Behaviour." Personnel and Guidance Journal, 1965, 64, 231-237.

Wesman, A.G. and Bennett, G.K. "Problems of Differential Prediction." Educational and Psychological Measurement, 1951, 11, 265-272.

Williams, J.D. "Quick Calculations of Critical Differences for Scheffé's Test of Unequal Sample Sizes." The American Statistician, 1970, 24, 38-39.

Williams, V. "Difficulties in Identifying Relatively Permanent Characteristics Related to Persistence in College." Journal of Counseling Psychology, 1966, 13, 108.

Wolking, W.D. "Predicting Academic Achievement with the Differential Aptitude and Primary Mental Abilities Test." Journal of Applied Psychology, 1955, 39, 115-118.

Zoolalian, C.H. "Factors Related to Differential Achievement Among Boys in Ninth-Grade Algebra." Journal of Educational Research, 1965, 58, 205-207.