A STUDY IN THE PREDICTION OF STUDENTS' PERFORMANCE IN FIRST-YEAR MATHEMATICS COURSES AT MEMORIAL UNIVERSITY OF NEWFOUNDLAND

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BY

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ABSTRACT

The main purpose of this study was to investigate the extent to which Grade XI marks could be used to predict achievement in first year mathematics courses for students at Memorial University of Newfoundland. Data related to high school and university performance were collected for the freshman class of 1976-1977 at Memorial. Correlation coefficients were used to determine the appropriateness of the various potential predictors of achievement. The Grade XI composite mathematics mark, which is the average of the public examination mark and the mark awarded by the school for the year's work, was identified as the best single predictor in most cases. In an attempt to establish suitable cut-off marks for entry into first-year mathematics courses, bivariate and multivariate regression methods were used to generate predictor equations. For students who had completed the Grade XI Honours Mathematics program, a mark of 65 was sufficient to predict a passing grade in either Mathematics 1010 or Mathematics 1011. For students completing the Grade XI Matriculation Mathematics program, a mark of 77 was needed to predict a pass in Mathematics 1010. It was concluded that while the Grade XI Honours course provides adequate preparation for university mathematics courses, the gap between the Grade XI Matriculation course and the introductory course at Memorial was substantial. In all cases, the standard error of estimate revealed in the predictor equations was sufficiently high to suggest a need for flexibility rather than rigidity in the application of cut-off marks.

The study also examined the university records of Grade XI Honours Mathematics graduates who had been permitted to by-pass the usual first-semester mathematics course and proceed directly to the introductory calculus course. It was concluded that the performance of these students in this course and in subsequent mathematics courses justified the advanced placement they had been given. Furthermore, since these students had acquired in high school an adequate mastery of the material in Mathematics 1010, the data lent support to the plan to award them university credit, subject to conditions laid down by the Mathematics Department at Memorial.

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CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

Each September the Mathematics Department of the Memorial University of Newfoundland faces the problem of placing incoming freshmen into the most suitable courses, based upon their intended faculty and their prior achievement in mathematics. For all but prospective primary and elementary Education students, the normal first semester course is Mathematics 1010, a pre-calculus course in algebra and trigonometry. Mathematics 1200 is the same course, but it meets for an extra hour each week; it is intended for those students who are judged to need extra time and individual attention. Mathematics 101F is a non-credit course designed for students whose past performance would indicate little or no chance of success in the regular courses. It is a remedial course which attempts to prepare weak students for Mathematics 1010. After completing Mathematics 1010, students may take Mathematics 1021 (a course in finite mathematics) or Mathematics 1011 (an introductory calculus course). The latter is a prerequisite for most subsequent mathematics courses and is taken by the majority of students.

Until very recently, all Newfoundland students seeking admission to Memorial University had been exposed to the same high school mathematics courses. It was possible to make reasonably accurate judgments about their level of preparation on the basis of their

Grade XI marks. This was especially true when all Grade XI students wrote a common public examination administered by the provincial Department of Education.

In 1976, the first graduates of a new high school mathematics program entered Memorial University. This tri-level program consists of a basic stream, a matriculation stream and an honours stream. Students from the latter two are eligible for admission to Memorial University. However, their preparation in mathematics is quite different. Honours Grade XI students have already covered much of the work of Mathematics 1010, whereas matriculation students have covered less material than did their counterparts in the old two-level program. Consequently, the problem of appropriate student placement is more difficult than before. It is further complicated by the system under which final Grade XI marks are determined.

Currently, students may be accepted by Memorial University on the basis of their school principal's recommendation if their average school marks are at least 75%. Such students are not required to write public examinations. Similarly, students attending those schools which participated in a pilot study of total accreditation do not write public examinations. For these students, the final marks awarded for their Grade XI achievement are the sole responsibility of the school. For students who do write public examinations, there is a system of shared evaluation in which the final mark awarded is the average of the public examination mark and the mark awarded by the school. The school mark in turn, is generally a composite of marks obtained on several tests given throughout the year. Since schools vary in their grading practices and their standards, the same mark awarded by different schools may not be indicative of equal levels of achievement.

The main purpose of this study was to attempt to identify from among the available data on incoming students ~~the~~ best predictors of success in freshmen mathematics courses, in particular, Mathematics 1010, 1200 and 1011. In addition to determining the correlation coefficients between predictor and criterion measures, regression equations which could be used as a basis for establishing suitable cut-off marks for entry into Mathematics 1010 and 1011 were sought.

A second purpose of the study was to provide data related to the performance in university mathematics courses of students who completed the Grade XI Honours Mathematics course. It was hoped that such data might be useful in making decisions with respect to advanced placement, and possible university credit, for these students.

BACKGROUND AND RATIONALE

Streaming at Memorial University

The Foundation Program at Memorial University was prompted by a desire to improve the chances of success in university for more students. For many years, university authorities had been concerned with the high failure rate, especially among students in their first and second years. During a seven-year period beginning in 1961, extensive research into the problem was carried out by Dr. Arthur

Sullivan, who was then Head of the Department of Psychology at Memorial. In an address to faculty which was later published in the MUN Gazette, Sullivan (1968) reported that during these years, 75 per cent of first year students failed one or more courses. Furthermore, in the Faculty of Arts and Science, only 30 per cent of entering students graduated after four years.

In an article on the Foundation Program, Dr. M. O. Morgan (1968), then Vice-President (Academic) of Memorial, described Sullivan's research as having gone beyond the compilation of statistics to seek causes for the high failure rate and to try and discover a basis upon which accurate prediction of success or failure could be made. Although many factors contributed to the problem, lack of adequate preparation was identified as the major one. However, there appeared to be no acceptable formula for changing entrance requirements without excluding a large number of successful Grade XI students from entering Memorial. A University Senate Committee was set up to study the problem. It decided that more emphasis on introductory courses was needed, and proposed that the University be divided into a Senior Division and a Junior Division. The Junior Division would operate on a tri-semester system. Non-credit "foundation" courses would be established in English, French, mathematics, chemistry and physics. It was hoped that these courses would help students over the difficult transition from high school to university work and strengthen the basic skills of students with specific academic problems. Morgan (1968) described the Foundation Program as one which would take into account the individual differences of incoming students. No extra time would be required of the more able and better prepared students, while the others would be given the opportunity of overcoming their specific weaknesses in the minimum period of time.

In establishing guidelines as to which students should take foundation courses, the University used the results of the research carried out since 1961. In particular, prediction of success in various subjects was based on correlations between university marks and marks obtained in Grade XI examinations and in specialized tests.

The Foundation Program was introduced in September of 1968. It was marked by a reduction in class size, an increase of lecture time to four periods per week for first-year courses, an emphasis on teaching and on tutorial help for weak students, and a comprehensive program of student counselling. Following a review of the role of the Junior Division in 1975, its main spheres of interest were re-affirmed as the provision and co-ordination of teaching at the first year level, the provision of appropriate academic counselling for students who have not declared a major, and the development of programs of instruction suited to the needs of first year students.

In the first few years of the Foundation Program, students who were placed in foundation courses had the work of two semesters spread over three terms. When Memorial University adopted the semester system in the Fall term of 1970, foundation courses became self-contained one-semester courses. They carry no credit but are intended to remedy specific weaknesses which, if not corrected, would reduce the possibility of successful completion of a university program of studies.

The placement of students is presently based on their Grade XI performance. The record of each student is examined and if he has an unsatisfactory mark in the subject in question he is tentatively assigned to a foundation course. Placement tests are written during the first week of the term and if the student attains a sufficiently high mark, he may be transferred to a regular credit course. Cut-off marks are decided upon by the individual departments of the university.

In the first years of the Foundation Program many incoming students were placed in foundation courses. For example, in 1969, of students seeking entry into Mathematics 101, the regular first year course at the time, 29.9 per cent were placed in foundation sections. In 1970 and 1971 respectively, the percentages were 22.1 and 20.3. They were greatly reduced when the courses numbered "1200" were introduced in mathematics, chemistry and physics. Mathematics 1200, first offered in the Fall of 1971, was originally designed for students who had been away from the study of mathematics for more than a year and who would need more extensive review of high school material than was normally provided. Later it was extended to those students whose past performance suggested that, while they might not need a full semester of remedial work, they would nonetheless profit from the slower pace and extra review provided by a course that met for five rather than four hours a week. In 1972, 16.7 per cent of first-year algebra students were placed in sections of Mathematics 1200, 72.7 per cent in the regular Mathematics 1010 and only 10.6 per cent in foundation sections. Proportions remained close to these during the years 1972 to 1975.

Streaming in high school mathematics

The Mathematics Department at Memorial University was faced with the need to adjust its criteria for student placement when the first graduates of the tri-level mathematics program finished high school. Until 1974, there was a two-level approach to high school mathematics in Newfoundland. Students took either the "academic" matriculation course or a general course intended for students who would go to trades schools or directly into the labour force. In 1974, a tri-level approach was introduced, wherein the existing courses were modified and an honours stream added.

The designation of the different levels of mathematics instruction currently used in Newfoundland schools is Basic, Matriculation and Honours. Somerton (1977) reported that the recommendation of the Newfoundland Department of Education was that approximately 15 per cent of students be placed in the basic stream, 70 per cent in matriculation and 15 per cent in honours. The matriculation course was to be the core academic program, intended for the majority of students. It would allow students of average or below average ability to be exposed to the main topics in algebra, arithmetic, geometry and trigonometry. The basic program would replace the former general course for students who did not require a theoretical type of mathematics. The honours course was designed to be a more enriched and challenging program suitable for students of superior ability in mathematics. The content of the Grade XI Honours course is similar to that of Mathematics 1010, the introductory course in algebra and trigonometry at Memorial.

In 1976, the first graduates of the new high school program entered university. Students from the honours stream who had attained a mark of 80 per cent or higher were permitted to bypass Mathematics 1010 and to take Mathematics 1011 as their first university mathematics course. Of the students who chose to do this, approximately 97 per cent passed the course. Of the honours students who took Mathematics 1010, approximately 93 per cent passed. In the Fall semester of 1977, the pass rates for the two groups of honours graduates were 95 per cent and 87 per cent respectively. It would seem, therefore, that students from the honours stream in high school are generally well-prepared for immediate entry into the calculus course at Memorial. However, there seems to be a trend toward declining enrollment in the honours course. In 1976, there were 1142 honours students and 4837 matriculation students who sat for public examinations - a ratio of about 1 to 4. In 1977, the figures were 648 honours and 5132 matriculation candidates - a ratio of nearly 1 to 8. It should be noted that there was a decline in the total number of public examination candidates in mathematics. This would be due in part to the fact that four large Newfoundland schools participated in a pilot study of total accredidation, so that none of their students wrote public examinations. There may also have been an increase in the number of students from other schools who were admitted on their principal's recommendation. Nevertheless, the decline in the number of Honours Mathematics candidates was much more substantial than in the Matriculation group. The Mathematics Department at Memorial views the situation with alarm. In order to provide incentive for able students to take the enriched course, it has recommended to the appropriate university authorities that students who successfully complete Mathematics 1011 (or its equivalent) as their first university mathematics course be awarded two academic credits rather than one.

Since the high school matriculation stream is intended for the majority of Grade XI students, it must cater to the needs of students of widely varying abilities. This is especially true in those schools where enrollment is too small to justify teaching all three levels. The matriculation stream must strike a middle course - adequate for the college-bound but not so rigorous as to be unsuitable to the majority. Consequently, it is more moderate in its demands than was its predecessor.

Mathematics Department records show that many of the students coming from the matriculation stream are not sufficiently well-prepared for the regular university mathematics courses. In the December 1977 examinations, 31.7 per cent of students who wrote the final examination in Mathematics 1010/1200 failed the course. This was the worst showing since the Junior Division was established and substantially worse than the preceding five years when December failure rates in the course ranged from 14.7 per cent to 22.1 per cent. Moreover, performance in mathematics was worse than in other subject areas. December 1977 records for the other seven most popular first semester credit courses show failure rates ranging from 5 per cent to 17 per cent.

It would appear that larger numbers of poorly prepared students are entering mathematics courses at Memorial University. No doubt there are many reasons for this, both academic and social. Whatever the reasons, the university needs some indicator of probable success in order to place students properly. This study attempted to measure the relative effectiveness of Grade XI Matriculation Mathematics, Grade XI Honours Mathematics and Grade XI overall average marks as predictors of success in university mathematics courses.

For incoming students, the university is normally provided with a single mark in each subject area. This mark is the final score awarded, either by the school alone (the principal's recommendation) or as a composite of school and public examination scores. For those students who write public examinations, the provincial Department of Education has a record of the marks awarded separately by their Department and by the individual school. Since the possibility existed that one of these components was more closely correlated with university marks than was the composite score, these were considered separately for those students for whom they were available.

Not all schools in Newfoundland offer all three mathematics streams. The question of whether an honours program can be offered by a particular school may be influenced by such considerations as enrollment, teacher availability and student interest. The size of the

Grade XI student body was assumed to be the largest single factor in this decision. Since it was also the most accessible, a measure of school size was considered as a variable in the study.

Ideally, one would like to use measures of ability and attitude in a study such as this. However, these data were not readily available. For the study to be useful, it was felt that it should consider only those data which are or can be made available since these are the data that the university mathematics department must use in its placement decisions. If these were shown to be inadequate, an argument could be made for the use of a placement test to be administered by the university to all incoming students.

In summary, then, the main problem to which this study addressed itself was that of placing incoming university students into the mathematics courses for which they are best suited. Using data on students who entered Memorial University in September 1977, the relationship between grades obtained in university mathematics courses and grades obtained in high school was examined. It was hoped that such an investigation would help establish a set of criteria for admission into the various first year mathematics courses offered at Memorial University.

CHAPTER II

REVIEW OF RELATED LITERATURE

INTRODUCTION

The principal purpose of this study was to try and identify the best available predictors of success in first year mathematics courses at Memorial University. To establish a background for this investigation, the research literature related to prediction was examined. The findings of those studies that dealt with mathematics, and particularly with first-year college mathematics, are reported here.

The secondary purpose of the study was to investigate the performance in university mathematics of those Grade XI students who had completed the Honours Mathematics course. In this connection, it seemed appropriate to examine an already well-established high school program designed for superior students. A review of literature related to the Advanced Placement program which was introduced into some United States high schools in 1955 is included here.

PREDICTION

The problem of placing students in the mathematics streams for which they are best suited is an old one. The first attempts at predicting success were prompted by a need at the Junior High School level to decide which students should take algebra and geometry and which ones were ill-equipped for such studies.

Early studies tended to try and base classification on the results of intelligence tests. However, Orleans (1934) reported that the obtained correlations clustered between 0.40 and 0.60, indicating that while IQ was a factor, it was certainly not the only one. He constructed preliminary learning tests designed to be analytic of the skills judged to be necessary for the study of mathematics. In general, he obtained slightly higher correlations with achievement than those obtained between IQ and achievement.

Lee and Hughes (1934) experimented with several predictors - standardized aptitude tests, IQ tests and teacher ratings. They found that aptitude tests gave the best single prediction of success in algebra and geometry. When multiple correlations were used, the best prediction resulted from a combination of algebraic aptitide and teacher ratings. They suggested that even when correlations were not high enough for accurate prediction, the extreme scores were significant for guidance purposes.

After a review of existing research, Douglass (1935) concluded that success in mathematics was best predicted by a combination of variables - a good prognosis test, average marks in the previous year, and IQ. Other useful variables were the previous teacher's estimate of student ability, marks in the previous year's work in mathematics, age and character-trait ratings. However, achievement could be predicted with only a fair degree of accuracy. In a later article summarizing existing research in the area, Douglass and Kinney (1938) described this degree of prediction accuracy as "quite servicable in guidance and in homogeneous or ability grouping." While most of the studies they reported were with students entering high school, there was one study of college freshmen. In that study, the investigators collected data on 387 students at the University of Oregon. They found low positive correlations between marks in high school mathematics and marks in fourteen different college fields. The Pearson coefficient of correlation between high school mathematics and college mathematics marks was 0.46. The correlation ratio representing a curvilinear relationship was 0.55. The highest obtained correlation ratio, 0.59, was between college marks in mathematics and average high school marks in all subjects. They concluded that college marks in mathematics could not be accurately predicted from the data ordinarily available.

Over the last few decades, college mathematics students as a group have grown in number and in variety of abilities, backgrounds, and vocational goals. As a consequence, there has been a growth in the variety of first year mathematics courses being offered. There is therefore a greater need for a second basis on which to direct freshmen into courses that are appropriate to their needs, interests and abilities, courses whose level of difficulty would be such as to challenge but not frustrate. While it has long been acknowledged that there are many factors which influence a student's performance, it was the advent of computers that made possible more sophisticated analysis of these variables. In particular, in recent years multiple regression techniques involving several variables have been widely used by researchers in their prediction studies.

Wick (1965) attempted to identify the factors associated with success in first year college mathematics. At the same time, he sought to determine whether the new programs inspired by the School Mathematics Study Group were as effective preparation as the traditional ones. He found no significant difference in the quality of preparation between the two groups. In predicting success, the single best predictor was the high school mathematics record. The average over Grades 10 to 12 gave the highest correlation with success in college algebra; Grade 12 mark was the best predictor for calculus; all linear correlations were relatively low (0.38 to 0.59). The use of multiple regression techniques provided considerable improvement over the use of a single predictor variable. The multiple correlation coefficients were considered high enough (ranging from 0.30 to 0.75 with median 0.64) to warrant the use of prediction based on multiple regression equations for selection and placement of students. Wick also developed a table of estimates of the probabilities that the predicted grade would actually be achieved.

Wampler (1966) set out to select several measures of aptitude which could be used in predicting performance in college mathematics. He administered eleven tests designed to measure eight aptitude factors to a group of twenty-two first year calculus students. A standardized calculus test served as criterion measure. All scores were submitted to linear regression analysis and, after appropriate sorting, the most useful combination was identified. The variables selected were five scores measuring induction, number facility, syllogistic reasoning, verbal comprehension and spatial orientation. The multiple correlation coefficient for this combination was 0.95.

Howlett (1969) addressed the problem of dealing with Michigan Technical University first-year students who were not adequately prepared for the course in analytic geometry with vectors. In particular, he sought a way to identify such students without needing to give an additional battery of tests during the first week. His subjects were 1000 freshmen; his predictor variables were scores on a variety of standardized achievement tests together with class rank. Like Wick and Wampler, he used multiple regression procedures. The correlation values obtained were significant. Still he cautions that "one can never really foresee the reasons why or how a person will act or perform in different environmental situations. (p. 657) Hence, placement of students should be on a recommendation basis rather than a command basis. Furthermore, the recommendations should be made early enough so that the student could choose his course of action and act on it as soon as possible. He suggested summer institutes at the university or refresher courses in the high schools. In this connection it can be noted that while Memorial places students at the time of registration, all prospective freshmen are interviewed by Junior Division faculty during the previous spring in order to give them some idea of the courses in which they will enroll.

Placement problems are more severe in institutions that do not have their own specific entrance requirements. Morgan (1970) reported on a method of predicting success in a first year college mathematics course at a college with an "open door" admissions policy. No entrance examinations were given, and all placement was done on a departmental basis. This placement procedure is similar to that used at Memorial. In Morgan's study, the Mathematics Department used an arbitrary cut-off point on the Cooperative Mathematics Test to place students in the introductory course or a remedial course. However, in the 1966-67 academic year almost 50% of the students assigned to the introductory course received grades of D, F or Drop. This attrition rate pointed to a need to identify more effectively those students needing remedial work. Using multiple regression techniques, Morgan produced an equation whose multiple correlation coefficient was 0.65. It was used to establish a critical score for placement. The variables used were scores on the Cooperative Mathematics Test, number of years of high school mathematics, mean grade in high school mathematics and age (in months beyond 17 years).

There is little doubt that students' past grades improve the predictive efficiency of other measures. Several studies have tried to determine whether student-reported grades are as useful as school-reported grades in this matter. An experiment by Hanna, Bligh and Lenke (1970) with eighth-grade students led to the conclusion that students rank themselves in much the same way as their actual grades do. This is consistent with earlier reports where student-reported and school-reported grades had correlations between 0.91 and 0.93. It would seem that not much validity is lost by relying on student reports when it is not feasible to get, match, and record data from school records.

Many colleges in the United States use standardized achievement tests in their admission and placement of students. Among the more popular tests in current use are the Scholastic Aptitude Test (SAT) of the College Entrance Examination Board with mathematical and verbal subtests, and the American College Testing (ACT) program which contains academic tests covering the four subject areas of English, mathematics, social studies and natural sciences.

An attempt to determine the predictive validities of standardized tests and high school grades was made by Parsons (1967). In this study he examined the correlations between nine predictor variables (SAT subtests and total, ACT subtests and composite scores and HSRG - the average of high school recommendation grades) and measures of college achievement. He found that the HSRG had the highest predictive validity for the first semester GPA (grade point average) with a correlation of 0.41. The standardized tests, however, had slightly higher validity for predicting grades in specific courses. In the case of mathematics, the correlations were 0.47 for both the SAT and ACT total scores.

A later study by Siegelman (1971) was more longitudinal, in that it attempted to analyze the degree of association between SAT scores, high school average and college achievement as measured by GPA during four years of college. His subjects were 80 males and 95 females enrolled in liberal arts and fine arts. He noted an extremely low correlation between SAT scores and GPA for males as opposed to females. However, the relationship of high school averages to GPA was reasonably consistent for both groups.

Both Parsons and Siegelman were concerned with overall performance of students in all subject areas. Gussett (1974) directed his attention specifically to mathematics. Using a random sample of 142 students enrolled in freshman mathematics in a women's college, he tried to determine the validity of SAT scores in predicting college grades. His investigation showed substantial correlations between earned mathematics grades and the SAT verbal, mathematical and total scores. The correlations were 0.48, 0.62 and 0.63 respectively, all of which were significant at the .01 level.

The results of these studies indicate that while the predictive power of standardized tests varies across institutions, such tests do provide useful information to college admissions officers. Braswell (1978) sums up the present situation in the following way:

> "The most important evidence of students' readiness for college is their high school record. However, because secondary schools differ greatly in their course offerings, academic standards and grading practices, colleges often find a standard measure of ability useful when they evaluate the applications of prospective students from different secondary schools." (p. 168)

He goes on to say that while SAT scores have declined in recent years, their ability to predict college grades has increased slightly.

In the past, Memorial University has generally relied entirely on high school records in its admission and placement of students. Now that varied programs and shared evaluation have been introduced, it may be that more standardized measures of ability or achievement will need to be used.

ADVANCED PLACEMENT

In Newfoundland, the placement problem for students leaving Grade XI Honours Mathematics is quite different from that for Matriculation Mathematics graduates. While the latter are frequently too poorly prepared to cope with the regular introductory course, Mathematics 1010, the former already have covered successfully much of that content.

The policy at Memorial has been to allow those students whose performance in Grade XI Honours Mathematics was satisfactory, to proceed directly to Mathematics 1011 if they so desired. Indeed, the better students are encouraged to do so. It is hoped that this advanced placement will permit good mathematics students to get into advanced work as soon as possible. So far, these students have done very well; they seem to be well prepared for beginning calculus. As yet, however, there has been no university credit given at Memorial for the extra work they have completed in high school. This lack of incentive has been put forward by teachers as one reason for the decline in the number of students completing the honours program. The issue of whether credit should be given is currently being debated within the university.

One motivating force behind the introduction of the honours mathematics program into local schools was a concern for providing challenging mathematics for bright students. The problem it created for the university was how best to acknowledge the superior preparation of those students. In this matter, it is interesting to examine the American experience with the Advanced Placement Program sponsored by the College Entrance Examination Board. The initiators of that program were also motivated by a desire to enrich the mathematics education of bright students. Moreover, they were aware in advance that the success of their efforts would depend on college recognition of the superiority of their courses. A brief history of the Advanced Placement Program and its success would seem to be relevant to the present local situation.

In a description of the development of the Advanced Placement Program, Pieters and Vance (1961) identified two studies as having led most directly to the program. They were the study on "General Education in School and College" directed by Alan Blackmer of Phillips Academy, Andover, and the study on "School and College Study of Admission with Advanced Standing" under Gordon Chalmers of Kenyon College. Both studies got underway in 1952 with support from the Ford Foundation. They were concerned with the evidence that many bright students were bored in late high school or early college by the repetition of work they had already covered. They felt that providing more opportunity for advanced study in high school was preferable to sending those students to college at an early age. Thus, the Advanced Placement Program was based on the assumption that some Grade XII students can do college freshman work. But, unless the colleges would reward such work, there would be needless duplication and a retarding of the vertical progress of students in a given field. It was therefore important that the courses offered would be acceptable to the colleges as equivalent to their own courses.

In Mathematics, a committee of scholars and teachers under the leadership of Professor H. W. Brinkmann of Swarthmore College was asked to outline a program which would be equivalent to one year of college work. The committee felt that, for the good student, the entire high school curriculum could be redesigned as a three-year program ending in the Advanced Placement course which would be a full year of calculus with analytic geometry. Leading college mathematicians were called upon to assure that the syllabus was thorough, the examination searching, the grading fair and as rigorous as in the college courses. This safeguard was continued with an examination committee meeting semi-annually to set policy, discuss revisions of the syllabus and construct the examinations.

One measure of the significance of the Advanced Placement Program is the increase in the number of students sitting the examination. In Mathematics, 285 sat the Advanced Placement examination in 1955, 2908 in 1960, 14379 in 1970 and 17044 in 1975. Pieters and Vance (1961) made the following claim:

> "Most colleges and universities welcome advanced placement students in mathematics. Many give both credit and advanced placement. Some give advanced credit only .... Fortunately, more colleges each year are giving credit, whether the student continues with his mathematics training or not. This is extremely significant. The colleges are doing this for two reasons. They are aware of the high standards set by the program and are reasonably confident of students' knowledge. Also, the colleges wish to encourage secondary schools and capable teachers at this level by recognizing publicly the college mathematics taught in secondary schools." (p. 205)

A more specific investigation of the extent to which colleges recognized the Advanced Placement Program was made by Lefkowitz (1971). She examined the experience of a large New York high school by sending questionnaires to students who had taken the Advanced Placement course during the first nine years it was offered. Of the 182 respondents, 52 per cent had been offered advanced placement, 32 per cent had been offered both credit and advanced placement, while 48 per cent had been made no offer at all. These percentages were for a nine-year period. It is interesting to note that in the last two years surveyed, only those students who scored below 3 on a 0 to 5 scale received no offers. Presumably, the acceptability of the course took some time to establish. In a more recent survey, Jones, Kenelly and Kreider (1973) found that 71 per cent of all students taking the Advanced Placement course scored 3 or greater on the rating scale and would therefore be regarded as qualified. Only 9 per cent would definitely get no recommendation. Other information from the Lefkowitz questionnaire indicated that 27 per cent of the respondents majored in science, 21 per cent in mathematics and 14 per cent in engineering. In commenting on the course, fully 90 per cent said they would recommend it to others. While only a few stated that they received their degrees earlier as a result of advanced placement, many said that it provided them with an opportunity to take additional courses in mathematics or in other areas of interest.

Bergeson (1967) claimed that several investigations which examined college performance of Advanced Placement Program students concluded that their performance was above average. However, he pointed out, these students would be assumed to be above the norm academically to begin with and would therefore be expected to do well. He made an attempt to answer the questions of whether accelerants sacrificed high achievement in college courses as a result of skipping introductory courses. To do this, he compared the academic performance of matched regular-progress students with that of accelerated students in subject areas where they had received credit. Over a three-year period, 108 pairs of students were matched on sex, SAT sub-scores and participation in the grade criterion course. Chi-square analysis showed that the difference between groups was not significant at the 0.05 level. He concluded that students who had participated in the Advanced Placement course and consequently by-passed some preliminary courses in college did as well in subsequent courses as their regular progress counterparts.

The success of the Advanced Placement Program was also attested to by Jones (1975), who claimed that the program's record is excellent and that the Advanced Placement Program students are among the most successful in higher education. Furthermore, he claimed that, despite early fears, college standards were not destroyed nor the integrity of the degree compromised.

It should be noted that the Advanced Placement Program is not without critics. For example, Grossman (1962) questioned the whole philosophy of acceleration. He claimed that the objectives of the program have broadened - many Advanced Placement students have no intention of majoring in mathematics, science or engineering and therefore have no need of calculus as a tool; many take Advanced Placement Mathematics in order to avoid college mathematics altogether. Furthermore, "in the majority of cases, the opinions of college Mathematics teachers are not too complimentary regarding the background and ability of the Advanced Placement students." (p. 561) Grossman suggested that enrichment with a variety of topics (matrices, computer science, probability, etc.) would be preferable to trying to get a head start on college calculus. Grossman's stated misgivings about the goals and the quality of the program should serve as a warning that any high school course which has the potential of providing advanced placement or college credit to its graduates should be closely monitored so as to assure that high standards are maintained.

Jones (1975) acknowledged that there are problems associated with Advanced Placement, the main ones being the variety among the colleges' credit-granting policies. Another is the question of weighting scores in deciding class rank. This latter problem is a serious one locally, where post-secondary institutions other than Memorial make no distinction between mathematics streams. Jones' advico was that extra weight be given Advanced Placement work and that this should be clearly discernible on the school transcript.

When comparing the United States Advanced Placement Program to the Newfoundland Honours Mathematics course, there are some important differences. The first is in content. The American Advanced Placement course is a Grade XII course in calculus; the Newfoundland high school program ends with a Grade XI course in algebra and trigonometry. Grade XII Advanced Placement students are doing work normally covered in a full year college course. Depending on their performance and the college they attend, they may be offered one or two semesters of credit and/or advanced placement. Locally, Grade XI students in the honours stream cover most of the content of a one-semester college course in algebra and trigonometry. If their achievement is good, they are offered advanced placement but no credit. The question of credit is presently under discussion, and a tentative solution has been proposed. A new linked course, numbered 150 A/B has been approved for the academic year 1978-79. The course content includes the material from Mathematics 1010 and 1011. Grade XI Honours Mathematics graduates are given the opportunity to register for the second half of this course and to receive two credits upon its successful completion. To qualify for admission to Mathematics 150B, students are required to write a test administered by the

Mathematics Department of the University and based on the material covered in Mathematics 1010.

A major difference between the American Advanced Placement Program and the Newfoundland Honours Mathematics program is the amount of involvement of the colleges in the high school program. American college teachers, from the beginning, had input into the syllabus, the construction of the examination and the grading. On the other hand, the Mathematics Department at Memorial does not set the syllabus for the Grade XI Honours course. It plays no part in the construction or the marking of the examination. In fact, since students can be admitted to Memorial on their principal's recommendation, there is no comprehensive examination that is taken by all Honours students.

In the beginning, the American Advanced Placement Program was deliberately designed to match the typical college course as closely as possible, and arrangements with the colleges for credit and/or advanced standing were made before the course was offered in the high schools. Locally, the Honours course was one component of a reorganized tri-level mathematics program. The planning stages were not marked by such close consultation with the university nor by prior arrangements for acknowledging the superior mathematics training of the graduates of the Honours course.

In spite of the differences between the two situations, the principle of rewarding superior high school preparation is a significant common factor. It seems true to say that college performance of Advanced Placement students in the United States has been more than satisfactory. Likewise, the performance of Grade XI Honours Mathematics students in Newfoundland who have been admitted to Mathematics 1011 has justified the advanced placement given. The pressing question now is whether university credit should be awarded.

SUMMARY

The literature related to prediction suggests that the most accurate prediction of academic success can be made when one uses a number of predictor variables, including measures of ability, aptitude and past achievement. In virtually all the reported studies concerned with the performance of college freshmen, high school grades appear as a variable. Indeed, it has been claimed by Braswell (1978) that the high school record is the most important indicator of readiness for college work. High school grades were used as the principal predictors in this investigation not only because of their demonstrated usefulness, but also for the very practical reason that they are readily available and currently used by Memorial University in admitting and placing students.

The experience of the Advanced Placement Program in the United States indicates that it is possible for students to do college work while still in high school and subsequently to bypass introductory college courses without damage to their academic progress. This study investigated the records of accelerated students in mathematics courses at Memorial University, with a view to determining whether advanced standing and credit were justified for such students.

CHAPTER III

DATA AND PROCEDURE

PREDICTION

The principal purpose of this study was to determine the power of various measures of high school achievement in predicting performance in first year university mathematics courses. The courses under consideration were the following:

Grade XI Matriculation Mathematics - This course is the final year of the matriculation program in mathematics. This program, the core academic program of the high school, covers topics in algebra, trigonometry and geometry. It is meant for the majority of students and is expected to prepare them for a variety of pursuits at the post-secondary level.

Grade XI Honours Mathematics - This is the culmination of the honours program, intended for the top 15 per cent of high school students. It is a course in algebra and trigonometry and covers much of the content of Mathematics 1010.

Mathematics 1010 - This is a course in pre-calculus mathematics. Its basic theme is the study of functions including algebraic, logarithmic, exponential and trigonometric functions. It is the first semester mathematics course taken by most students at Memorial and is a prerequisite for all subsequent courses, except Mathematics 1150 and 1151. The latter are special courses for students intending to become primary or elementary school teachers.

Mathematics 1200 - This is the same course as Mathematics 1010, with the same final examination. However, it meets for an extra hour each week and is taken by students who have been away from the study of mathematics for more than a year or who have demonstrated weakness in the subject.

Mathematics 101F - This is a non-credit foundation course, intended to improve the proficiency of students who have entered Memorial with poor marks in the subject. It provides review of high school material and introduces topics to be covered in Mathematics 1010.

Mathematics 1011 - This is the first course in calculus for students at Memorial University. It provides an intuitive introduction to limits and continuity, studies the rules of differentiation, the applications of the derivative and gives a brief introduction to integration.

A specific purpose of this study was to establish criteria for admission into Mathematics 1010 or 1200. This was done by using regression equations to help determine reasonable cut-off marks for entry from Grade XI Matriculation Mathematics into those courses rather than Mathematics 101F. It was hoped thus to avoid placing students into a course which they were very likely to fail. For students graduating from the Grade XI Honours Mathematics program, prediction of success in Mathematics 1010 and 1011 was sought. All analysis was done separately for the three categories of students under consideration. The categories were the following:

Type 1 - students from Grade XI Matriculation who took Mathematics 1010 or 1200 in their first semester at Memorial.

Type 2 - students from Grade XI Honours who took Mathematics 1010 in their first semester.

Type 3 - students from Grade XI Honours who took Mathematics 1011 in their first semester.

SUBJECTS

The subjects for the prediction study were students who took Grade XI in Newfoundland schools in 1976-77 and who took either Mathematics 1010, 1200 or 1011 at Memorial University in the Fall semester of 1977. Students in Mathematics 1010 or 1200 were grouped together, since these were equivalent courses.

The main part of the study was directed towards students who wrote Grade XI Public Examinations. A separate analysis was also made for students who had entered Memorial on their school principal's recommendation.

There was no random sampling of students. All students for whom the required data were complete, were included in the study. Students for whom any of the relevant information was missing were excluded. Also excluded were students whose reported final grade in Mathematics at Memorial was zero. Since the final grade awarded in first year mathematics courses is a composite of term mark and final examination mark, it was assumed that any student who received a grade of zero had in fact dropped the course. There were five students who were excluded from the study for this reason.

VARIABLES

The criterion variable was the mark obtained in the mathematics course taken during the first semester at Memorial, either Mathematics 1010, 1200 or 1011. This mark is normally the average of the mark obtained in the final common examination and the mark awarded for term work. When the term mark is less than the final exam mark, it is the latter which is awarded as final mark. For the study, these marks were obtained from records in the Office of Junior Studies at Memorial.

The predictor variables used were the following measures of high school achievement:

Grade XI Public Examination Score in Mathematics (PUBLIC)

These examinations are administered by the provincial Department of Education. They provide a common measure of achievement for all students throughout the province who take them.

Grade XI School Examination Score in Mathematics (SCHOOL)

This is the mark awarded by the school for the year's work. It is generally based on several tests administered throughout the year. For those students who do not take the public examinations, it is the mark submitted to Memorial as the entrance mark.

Grade XI Composite Score in Mathematics (COMPOSITE)

This is the average of the PUBLIC and SCHOOL scores and is the mark submitted by the Department of Education to Memorial as the entrance mark for all public examination candidates.

Grade XI Overall Average (GR. XI AVE.)

This is the average of the marks obtained in the five Grade XI subjects used to fulfil the university's entrance requirements. The subjects must include English, mathematics, a laboratory science, either a language or a subject in the social studies area, and an elective.

For students who wrote public examinations, all mathematics scores were made available to the investigator through the cooperation of the Division of Instruction of the Department of Education. All other information was obtained through the Division of Junior Studies at Memorial.

School size was considered to be a possible factor in the predictive power of Grade XI Matriculation or Honours Mathematics marks. It was assumed that school size would influence the decision on whether both the honours and matriculation streams could be offered. This decision would in turn affect the make-up of the matriculation class. The size of the Grade XI enrollment in all Newfoundland schools was obtained from records at the provincial Department of Education. A preliminary classification of school size in multiples of twenty was made. The distribution for the 166 schools involved is presented in Table 1. Subsequently, the schools were grouped into four categories of approximately equal size, as

Group 1 (0-20) Gr. XI students) -- 50 schools

Group 2 (21-40 Gr. XI students) -- 47 schools

Group 3 (41-80 Gr. XI students) -- 40 schools

Group 4 (81-480 Gr. XI students) - 29 schools

TABLE 1

Distribution of schools by Grade XI class size.

Grade XI Enrollment	0-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200	201-220	221-240	241-260	261-280	281-300	301-320	321-340	341-360	361-380	381-400	401-420	421-440	441-460	461-480
Number of Schools	50	47	27	13	6	5	6	1	0	4	0	0	2	1	1	0	0	1	0	0	1	0	0	1

It was assumed that Group 1 schools were not likely to be in a position to offer the honours course in mathematics, and that the probability of its being offered would increase with school size. Also, while Group 4 had the smallest number of schools, it would account for most of the students by virtue of the large Grade XI enrollment. Subsequent analysis of data on the main group of students in the study, namely those who took public examinations in 1977, showed the following distribution.

TABLE 2

Distribution of Grade XI public examination candidates in mathematics by school size.

SCHOOL SIZE	MATRICULATION	HONOURS	TOTAL
1	15	1	16
2	79	6	85
3	96	39	135
4	207	181	388
	397	227	624

PROCEDURE

The main analysis employed in this study was regression analysis. This is a statistical technique for analyzing the relationship between a dependent or criterion variable and a set of independent or predictor variables. One of the main uses of the technique as a descriptive tool is to find the best linear prediction equation and evaluate its prediction accuracy.

The program used was the SPSS Regression Subprogram written by J. Kim and F. Kohout and appearing in Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975). A potential problem to which the authors call attention is that of multi-collinearity or very high intercorrelations among the independent variables. They point out that the greater the intercorrelation of the independent variables, the less the reliability of the relative importance indicated by the partial regression coefficients. They claim that when extreme multi-collinearity (i.e. intercorrelations in the 0.80 to 1.0 range) exists, there is no acceptable way to perform regression analysis using those variables. They suggest as possible solutions, the creation of a new variable which is a composite of the highly correlated variables, or the inclusion of only one of the set in the analysis.

The nature of the predictor variables available for this study was such as to make high intercorrelations very likely. It was therefore decided to precede any regression analysis by a study of the zero-order correlations among the variables and to use this in deciding which variables to include in the regression equations. The SPSS subprogram PEARSON CORR was used. It computes Pearson product moment correlation coefficients for pairs of interval-level variables. The Pearson r measures the strength of the relationship and indicates the "goodness of fit" of a linear regression line to the data. The computed r-values were tested against the null hypothesis: $\rho = 0$.

The PEARSON CORR subprogram also supplies means and standard deviations for each variable. These statistics were useful in giving an overall picture of the level of performance in the courses under consideration for the various groups of students.

School size was coded as an ordinal but not an interval variable. As such, it was less appropriate as a variable for the regression analysis than were the various examination scores. Therefore, it was decided to investigate the difference in performance among school size categories as a preliminary step. This was done by performing one-way analysis of variance using school size as the independent variable. The dependent variables for these analyses were the criterion variable MUN MATH and the predictor variable COMPOSITE. The SPSS subprogram ONEWAY was used. It outputs a standard analysis of variance summary table showing sums of squares, degrees of freedom, mean squares, the F-ratio formed by dividing the between-group mean square by the within-group mean square, and the significance of the obtained F. The null hypothesis to be tested in each case was that there was no significant difference in means on the dependent variable among the school size groups.

The results of this analysis gave some indication that school size might be a factor influencing the predictive power of Grade XI composite Mathematics scores in at least some cases. In an attempt to confirm this, the analysis of variance was followed up with a t-test on the decline in scores from high school to university, (i.e. Grade XI COMPOSITE minus MUN MATH) for the relevant groups.

Once the preliminary analyses were complete, the regression analysis was begun. It was hoped that such analysis would identify appropriate cut-off marks for entry into Mathematics 1010, so that only students with a reasonable chance of success would be admitted into the course.

It was felt that the least complicated criteria for admission would be obtained by using a simple bivariate equation involving only one predictor variable. Such equations were generated, using the Grade XI Composite Mathematics mark as predictor, for all three student types - Grade XI Matriculation to Math 1010, Grade XI Honours to Math 1010, Grade XI Honours to Math 1011.

Multiple regression equations were also generated, using Grade XI Composite Mathematics score and Grade XI overall average as the two predictors. The SPSS subprogram REGRESSION was used. Since the bivariate analysis had already been done, simple rather than stepwise regression was used. The program, in addition to supplying the regression coefficients for the equation, outputs the multiple correlation coefficient R, R^2 and the standard error of estimate SEE.

The multiple R can be regarded as a simple r between the actual and the predicted values of the criterion variable. R^2 measures the percentage of the variance in the criterion variable that is accounted for by the combination of predictors. It reflects the overall accuracy of the prediction equation. Accuracy in absolute units is reflected by the SEE, which can be interpreted as the standard deviation of the residuals. In the bivariate analysis, the regression coefficient B is the slope of the regression line and indicates the expected change in the criterion Y with a change of one unit in the predictor X. In multivariate analysis, the partial regression coefficient B_i stands for the expected change in Y with a change of one unit in the predictor X_i where the other predictors are held constant.

In addition to the students who wrote public examinations, there was a large number of students who had entered Memorial from accredited schools or on their principal's recommendation. There were 148 such students for whom all relevant data were available. Means, standard deviations, correlations and regression equations were obtained for these students in separate analyses.

All computations were performed by the Computing Services at Memorial University on NLCS IBM 360/370 computer. Results are reported in Chapter 4.

FOLLOW-UP OF GRADE XI HONOURS GRADUATES

The secondary purpose of the study was to provide information on the performance in university mathematics courses of those students who moved directly from Grade XI Honours Mathematics into Mathematics 1011, thus bypassing the usual first semester course. It was expected that such information might be useful to those who are responsible for making recommendations with respect to advanced placement and possible credit for successful Grade XI Honours Mathematics students.

SUBJECTS

The first graduates of the Honours program entered Memorial University in September, 1976. Students who were enrolled in Mathematics 1011 in the Fall term, and whose student numbers identified them as 1976 entrants were selected as subjects. While the pre-university records of these students were not examined, it was assumed that, except for a small number of students from outside the province, they would be graduates of the Grade XI Honours program who had been permitted to by-pass Mathematics 1010. All information used in selecting these students and in investigating their academic achievement was obtained from records of the Registrar's Office at Memorial. Students on the Corner Brook campus were included in these data.

For the students who entered Memorial in September, 1977, information was obtained directly from the Office of Junior Studies at Memorial. From their records, it was possible to identify Grade XI Honours graduates who took Mathematics 1011 in their first semester and to examine their achievement in their first year of university work.

DATA

There were several questions of interest. The first and most important was relative to the performance of these students in Mathematics 1011, namely, could such students be reasonably sure of success in that course? To examine this matter, the mean scores were calculated and the distribution of grades noted for the students concerned in each of the years 1976 and 1977.

It was hoped that granting advanced placement to Grade XI Honours graduates would make it possible for interested students to take alternate courses in mathematics at the first year level or beyond. A second question, therefore, was related to the number of mathematics courses taken by these students after their first semester. Records of mathematics courses taken and grades obtained were available for 1977 entrants for the first and second semesters of the 1977-8 academic year, and for 1976 entrants for three semesters of 1976-7 and the first two semesters of 1977-8.

It was also of interest to determine whether these students were pursuing their university studies in areas related to mathematics. Since first year students are frequently quite indefinite about their faculty and major, data related to these factors were collected only for the 1976 entrants, who have now completed their second year of study. A breakdown of faculty and major was made for those students who had specified their choice.

The relevant information is reported in Chapter 4.

SCOPE AND LIMITATIONS

The subjects for the prediction study were drawn from 1977 entrants to Memorial University from Newfoundland high schools. Only students who took Mathematics 1010, 1200 or 1011 in their first semester were included. This meant that there were two major groups of first year mathematics who were deliberately excluded from the investigation.

The first of these was the group of students who took Mathematics 1150 as their first semester mathematics course. This is a specialized course for prospective primary and elementary school teachers. Its content is less heavily dependent of a mastery of high school algebra and trigonometry than is the case with other first-year courses. Moreover, the rate of student success in Mathematics 1150 has been generally satisfactory. It was felt, therefore, that there was no immediate need to establish criteria for entrance into this course other than an interest in pursuing a teaching career.

The other major group not specifically considered was the group of students enrolled in Mathematics 101F. This course was designed for students who were judged ineligible for immediate entry into Mathematics 1010 or 1200. Consequently, any criteria used to admit students into these courses would automatically determine who would be required to take the foundation course.

It was hoped that a thorough examination of the Grade XI and first semester university record of one year's class of students would reveal information that would be useful in decision making in other years. However, it must be acknowledged that any attempt to generalize from the class of a given year to that of another year must be made with extreme caution. A large number of variables affect student achievement and some of these may change substantially from one year to the next.

It is in the matter of variables that the most serious limitation of this study lies. The only data normally available on students entering Memorial are scores on achievement tests. Past achievement is generally acknowledged to be the best single indicator of future success; it is also the most easily quantified of the variables believed to influence achievement. Still, it accounts for only a portion of the variance in student scores on achievement tests. Factors like ability, attitude, aptitude, study habits, socio-economic status are apt to influence how well students do. Unfortunately, these factors are harder to measure than is achievement. In the case of entrants to Memorial, no data related to these variables are available. Consequently, none were used in this study, so that the relative contribution of these factors to the variance on scores in university mathematics courses remains undetermined.

This study shares a limitation inherent in any prediction study. Such studies can, at best, estimate within broad limits, what certain groups of students are likely to achieve. No predictor equation can tell what an individual student will achieve. Therefore, those who use the results of this or any prediction study should do so with caution, recognizing their limitations and being prepared to allow flexibility in their application.

CHAPTER IV

RESULTS

PREDICTION STUDY: PUBLIC EXAMINATION CANDIDATES

The major group of students considered in the prediction study were those who had completed Grade XI public examinations in June 1977 and who registered for Mathematics 1010, 1200 or 1011 at Memorial University in September, 1977. There were 624 such students for whom the relevant data were complete. A summary of the results of the analysis of data for these students is provided in the tables below.

All analysis was done separately for each of three student groups classified as shown in Table 3.

TABLE 3

Classification of students according to mathematics courses taken in high school and at Memorial.

GROUP	Grade XI and University Mathematics	Number of Cases
1	Matriculation - Math. 1010 or 1200	397
2	Honours - Math. 1010	130
3	Honours - Math. 1011	97

The first step in the data analysis was the determination of the coefficients of correlation among the variables. These are reported in Table 4 (page 47). The variables are Grade XI overall average, mathematics mark awarded by the school (SCHOOL), mathematics mark obtained in the public examination (PUBLIC), average of school and public examination marks (COMPOSITE) and mark in mathematics course taken at Memorial (MUN MATH). In examining correlation of the predictor variables with the criterion variable, MUN MATH, it can be noted that the highest correlation coefficient was obtained from the COMPOSITE score for the first two groups. For the third group, the PUBLIC score yielded the highest coefficients. All correlations were significant at the .001 level, indicating that the variables were suitable for use as predictors of success in college mathematics. However, the predictor variables were highly correlated with each other. In all three groups, the correlation between SCHOOL and COMPOSITE scores and between PUBLIC and COMPOSITE scores exceeded 0.86. Indeed, high correlation had been expected here in view of the way in which the composite score was calculated. Because of this multicollinearity, it was decided not to include all three Grade XI mathematics scores in the regression analysis but to use only the COMPOSITE score. Not only was this score a good correlate of the MUN MATH score for all three groups, but it is also the mark that is routinely supplied to Memorial as entrance mark for public examination candidates.

A measure of overall performance in the courses under consideration is provided by the means and standard deviations of scores. These data are reported in Table 5.

TABLE 4

Coefficients of Correlation among variables for the three groups of public examination candidates.

	STUDENT TYPE	N	GR. XI AVE	SCHOOL	PUBLIC	COMPOSITE	MUN MATH
GR. XI AVE	1	397	1	0.66	0.57	0.68	0.57
	2	130	1	0.68	0.58	0.69	0.58
	3	97	1	0.73	0.64	0.75	0.51
SCHOOL	1	397		1	0.64	0.88	0.61
	2	130		1	0.66	0.90	0.63
	3	97		1	0.62	0.87	0.39
PUBLIC	1	397			1	0.93	0.65
	2	130			1	0.92	0.70
	3	97			1	0.93	0.61
COMPOSITE	1	397				1	0.70
	2	130				1	0.73
	3	97				1	0.57
MUN MATH	1	397					1
	2	130					1
	3	97					1

TABLE 5

Means and Standard Deviations on predictor and criterion variables for the three groups of public examination candidates.

	Group 1 (M - 1010) N = 397		Group 2 (H - 1010) N = 130		Group 3 (H - 1011) N = 97	
VARIABLE	Mean	S.D.	Mean	S.D.	Mean	S.D.
GR. XI AVE	74.3	8.3	75.2	7.8	81.3	7.1
SCHOOL	82.5	9.6	80.0	9.9	88.6	7.3
PUBLIC	75.3	12.1	70.6	11.5	82.0	9.6
COMPOSITE	78.6	9.8	75.1	9.8	85.1	7.6
MUN MATH	52.1	19.1	64.2	16.8	73.6	15.6

The range of achievement on the criterion variable was greater than on any of the predictors and this is revealed in the means and standard deviations. Entrance to Memorial requires a passing grade in mathematics and an overall average of at least 60. Consequently, all predictor variables involve marks of at least 50, while the MUN MATH scores range from 5 to 100. In all three groups, the standard deviation is highest for MUN MATH and the mean lowest. In Group 1, for example, the mean on the COMPOSITE score was 78.6 with a standard deviation of 9.8. Thus, assuming normal distribution, approximately 68 per cent of the matriculation students would have scores between 68.8 and 88.4 on that variable. For the same group of students, the mean score on MUN MATH was only 52.1 with standard deviation of 19.1, so that about 68 per cent would be expected to score between 33.0 and 71.3. The difference in means was large - a drop of 26.5 from Grade XI to MUN MATH. For Group 2 students, there was again more variance on the MUN MATH score than on any other variable. The means were 75.1 for COMPOSITE score and 64.2 for MUN MATH, a decline of 10.9. In Group 3, means on COMPOSITE and MUN MATH were 85.1 and 73.6 respectively, a difference of 11.5. All means were higher for the latter group than for the other two, a reflection of the fact that these were the superior students from the high school honours stream.

In order to determine whether school size was a factor in student achievement, analysis of variance was performed for the criterion variable MUN MATH and for the principal predictor COMPOSITE, using school size as the independent variable. School size categories were based on the size of Grade XI enrollment during the school year 1976-7, as reported in Table 2 (page 35). The results of this analysis are shown in Tables 6 and 7 (page 50).

In no case was the difference between groups as reflected in the F-ratio significant at the .01 level. Nevertheless, there were some apparent discrepancies in mean scores. In the case of matriculation students there was evidence of some differences among school size groups on the variable COMPOSITE score, but these differences were not apparent on the variable MUN MATH. For Grade XI Honours Mathematics students, however, the reverse was true. Means on COMPOSITE scores were very close for all school-

TABLE 6

Analysis of Variance on COMPOSITE scores, with school size as independent variable.

SCHOOL SIZE		GROUP 1 N	GROUP 1 Mean	GROUP 2 N	GROUP 2 Mean	GROUP 3 N	GROUP 3 Mean
1	0-20	15	79.0	1	68.0	0	
2	21-40	79	81.3	2	74.5	4	86.3
3	41-80	96	79.2	24	74.5	15	83.5
4	> 80	207	77.3	103	75.3	78	85.3
Total		397	78.6	130	75.1	97	85.1
F-RATIO		3.464		0.218		0.385	
F-PROB		0.0164		0.8838		0.6813	

TABLE 7

Analysis of Variance on MUN MATH scores, with school size as independent variable.

SCHOOL SIZE		GROUP 1 N	GROUP 1 Mean	GROUP 2 N	GROUP 2 Mean	GROUP 3 N	GROUP 3 Mean
1	0-20	15	52.3	1	50	0	
2	21-40	79	55.8	2	67.5	4	72.5
3	41-80	96	52.4	24	56.5	15	63.7
4	> 80	207	50.6	103	66.1	78	75.5
Total		397	52.1	130	64.2	97	73.6
F-RATIO		1.402		2.466		3.865	
F-PROB		0.2417		0.0653		0.0244	

size categories, with F-ratios of 0.218 and 0.385 for Groups 2 and 3 respectively. But there were noticeable, though not significant, differences on the variable MUN MATH, where the F-ratios were 2.466 and 3.865. For the Group 2 students (H - 1010), means were 67.5 and 66.1 for school size categories 2 and 4, and 56.5 for category 3. For the Group 3 students (H - 1011), means were 72.5 and 73.6 in categories 2 and 4, but only 63.7 for category 3. Since the mean scores on the prediction variable COMPOSITE were almost the same for the three school size categories, the data seemed to indicate that category 3 students were experiencing, on the average, a greater decline in mathematics scores than were students from either smaller or larger schools. This possibility was investigated further by means of a t-test. The variable examined was the difference between grades earned in high school and at college - COMPOSITE minus MUN MATH - for graduates of the Grade XI Honours program. Since the number of students in categories 1 and 2 was very small, ranging from 0 to 4, only school size categories 3 and 4 were considered. The hypothesis tested was that there was no significant difference in mean decline in scores between the two school size groups. Results of the t-test appear in Table 8 (page 52).

For both groups of Grade XI Honours graduates, the differences between school size groups on the variable COMPOSITE minus MUN MATH were significant at the 0.01 level. Mean decline in scores were about 10 points more for students belonging to category 3 than for

TABLE 8

t-test on COMPOSITE minus MUN MATH
for school size categories 3 and 4.

	Group 2 N - 1010		Group 3 N - 1011	
	SCHOOL SIZE 3	SCHOOL SIZE 4	SCHOOL SIZE 3	SCHOOL SIZE 4
N	24	103	15	78
Mean difference COMPOSITE-MUN MATH	18.1	9.2	19.9	9.8
t-value	3.51		2.87	
probability	.005		.005	

those from category 4 schools. This suggested that the predictive power of the COMPOSITE score might be less for schools where the Grade XI enrollment was between 41 and 80 than for other schools. However, only 39 of the 624 students under consideration were graduates of the Grade XI Honours course in schools of that size. For the majority of students, the results of the data analysis related to school size seemed to indicate that this was not an important variable in predicting achievement. Indeed, for the graduates of the Grade XI Matriculation program, the differences between the mean score on COMPOSITE and the mean score on MUN MATH were quite close for all four school size categories, ranging from 25.5 to 26.8. Consequently, it was decided that school size should not be included as a predictor variable in the regression analysis.

On the basis of the preliminary analysis of data, it was decided to confine the regression analysis to two stages - simple bivariate analysis, using Grade XI composite mathematics score as the only predictor, and multivariate analysis using Grade XI composite mathematics score and Grade XI overall average as predictors. Both these variables were significantly correlated with the MUN MATH scores, with r-values ranging from 0.51 to 0.73. At the same time, their correlations with each other, ranging from 0.68 to 0.75 were not so high as to preclude joint use in a regression equation. Moreover, there was a practical advantage to the use of these predictors since they are the scores that are most accessible to those involved in student placement.

Results of the regression analysis appear in Tables 9 and 10 (page 54), where y denotes the criterion variable MUN MATH, x_1 the Grade XI composite mathematics score, x_2 the Grade XI overall average, and $\hat{y}$ the predicted score on the criterion variable.

Table 9 provides the statistics for the simple bivariate regression analysis for the subjects who were public examination candidates.

The reported R's are the simple r-values of Table 3. R^2 indicates the proportion of variance in the criterion accounted for by the predictor. SEE is the standard error of estimate.

For students entering Mathematics 1010 or 1200 from Grade XI Matriculation, the prediction equation was $\hat{y} = 1.37\ x_1 - 55.43$. The correlation coefficient between the predictor COMPOSITE and the criterion MUN MATH was 0.70. The predictor accounted for

TABLE 9

Bivariate Regression Analysis for public examination candidates, using COMPOSITE as the predictor variable.

	R	R^2	SEE	Prediction Equation
Group 1	0.70	0.49	13.6	$\hat{y} = 1.37\ x_1 - 55.43$
Group 2	0.73	0.53	11.5	$\hat{y} = 1.26\ x_1 - 30.58$
Group 3	0.57	0.33	12.8	$\hat{y} = 1.17\ x_1 - 25.63$

49 per cent of the variance in the criterion. The weight of the regression coefficient 1.37 was significant at the 0.01 level, as were all the B-values in subsequent equations. On the basis of this equation, a Grade XI student would need a score of 77 in order to predict 50 in Mathematics 1010/1200. However, the standard error of the estimate for this group was quite high, making accurate prediction impossible. For example, the regression equation predicts a MUN MATH score of 54 from a Grade XI COMPOSITE score of 80; taking SEE into account, one can predict that approximately 68 per cent of students with 80 on Grade XI Matriculation Mathematics would score between 40 and 68 in Mathematics 1010. Such a wide range of scores makes it very difficult to anticipate what an individual student will achieve. The statistics do point to a large gap between Grade XI Matriculation Mathematics and Mathematics 1010/1200 scores. The mean score for this group of students in the Grade XI Mathematics course was 78.6. For a

student scoring at the mean, the predicted mark in Mathematics 1010/1200 would be 52.1 - a drop of 26.5 points.

For students entering Mathematics 1010 from Grade XI Honours Mathematics, the prediction equation was $\hat{y} = 1.26\ x_1 - 30.58$. The predictor, with a correlation of 0.73 with MUN MATH, accounted for 53 per cent of the variance in the criterion. On the basis of this equation, a student would need a Grade XI mathematics mark of 64 to predict a pass in Mathematics 1010. For a student whose Grade XI mark was at the mean for the group, 75.1, the regression equation would predict a MUN MATH score of 64.2. More accurately, taking SEE into account, approximately 68 per cent of such students would have MUN MATH scores between 53 and 76.

For students entering Mathematics 1011 from Grade XI Honours Mathematics, the prediction equation was $\hat{y} = 1.17\ x_1 - 25.63$. The correlation coefficient was 0.57 and the predictor accounted for only 33 per cent of the variance in MUN MATH. The equation would require an x_1-value of 65 to predict 50 in Mathematics 1011. A student scoring at the mean for the group, 85.1, would have a predicted score of 73.5 in Mathematics 1011. Taking SEE into account, about 68 per cent of students scoring at the mean would have scores between 61 and 86 in their university mathematics course.

Results of the multivariate analysis are reported in Table 10. The multiple R gives the highest possible correlation between a least-squares linear composite of the predictor variables and the criterion variable. R^2 indicates the portion of the variance in the criterion accounted for by the combination of predictors.

TABLE 10

Multivariate Regression Analysis for public examination candidates, using COMPOSITE and GR. XI AVERAGE as predictors.

Group	R	R^2	SEE	Prediction Equation
1	0.71	0.51	13.4	$\hat{y} = 1.14\ x_1 + 0.41\ x_2 - 67.51$
2	0.74	0.55	11.4	$\hat{y} = 1.08\ x_1 + 0.34\ x_2 - 42.07$
3	0.59	0.34	12.7	$\hat{y} = 0.86\ x_1 + 0.43\ x_2 - 35.16$

The R^2 values for the three groups of students were 0.51, 0.55, and 0.34. These represented improvements of only 1 or 2 per cent over the simple bivariate analysis in the proportion of variance in the criterion that was accounted for. These improvements were not significant, especially in view of the large standard errors involved. Prediction could be made almost as confidently with one variable as with two.

A satisfactory Grade XI average for admission to Memorial University on a principal's recommendation is 75. According to these prediction equations, a student entering Memorial with an overall average of 75 would need 77 in Matriculation Mathematics to predict a passing grade in Mathematics 1010/1200; a student from the Grade XI Honours Mathematics course would need 62 to predict a pass in Mathematics 1010 and 61 to predict a pass in Mathematics 1011. These compare to required scores of 77, 64 and 65 respectively for the three groups if the Grade XI overall average were not taken into account.

For Group 1 students, the mean Grade XI overall average was 74.3 and the mean Grade XI composite mathematics score was 78.6. A student scoring at the mean on these variables would have a predicted score of 53 in Mathematics 1010/1200. A Group 2 student scoring at the mean on both predictors would have a predicted score of 65 in Mathematics 1010. A Group 3 student scoring at the mean for his group would have a predicted score of 73 in Mathematics 1011.

PREDICTION STUDY: STUDENTS WHO DID NOT WRITE PUBLIC EXAMINATIONS

A separate data analysis was done for the group of Grade XI students who entered Memorial on their principal's recommendation or from accredited schools. Since these students did not write public examinations, the only scores used were the Grade XI overall average and the Grade XI Mathematics mark awarded by the school. There were 148 such students for whom all relevant information was available. Data related to their performance are reported in Tables 11, 12 and 13.

TABLE 11

Coefficients of correlation among variables for students who did not write public examinations.

Variable	Student Type	N	GR. XI AVE	GR. XI MATH	MUN MATH
GR. XI AVE	1	78	1	.70	.36
	2	57	1	.77	.64
	3	13	1	.65	.49
GR. XI MATH	1	78		1	.36
	2	57		1	.72
	3	13		1	.69
MUN MATH	1	78			1
	2	57			1
	3	13			1

All correlation coefficients were significant at the 0.01 level with the exception of the correlation between Grade XI AVERAGE and MUN MATH for the students classified as Type 3, (Gr. XI Honours - Math 1011). It should be noted that the number of students in this group was only 13.

As was the case with the public examination candidates, there was a greater range of achievement on the criterion variable than on either of the predictors. Means were lower on the criterion and standard deviations higher. There was a noticeable difference between the relative achievement in high school and university mathematics courses between students from Group 1 and those from Groups 2 and 3. For Group 1, the statistics indicate that approximately 68 per cent of students scored between 67.8 and 87.8 on their Grade XI Matriculation Mathematics. In their first university course,

TABLE 12

Means and Standard Deviations on predictor and criterion variables for students who did not write public examinations.

	Group 1 (N = 78)		Group 2 (N = 57)		Group 3 (N = 13)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
GR. XI AVE	75.8	7.1	81.7	6.4	84.8	3.8
GR. XI MATH	77.8	10.0	79.3	10.9	85.9	4.9
MUN MATH	48.1	18.3	72.2	19.8	81.2	13.4

Mathematics 1010/1200, the average score obtained was only 48.1, a drop of 29.7 from the high school mean score. The students from the honours mathematics stream fared much better on their university mathematics courses. In Group 2, the mean on Grade XI Honours Mathematics was 79.3 and on Mathematics 1010, 72.2, a decline of only 7.1 points. In Group 3, the means on Grade XI Honours Mathematics and on Mathematics 1011 were 85.9 and 81.2 respectively, a decline of only 4.7 points. The vast difference in relative performance was no doubt due in large part to the fact that it was the superior students who took the honours course in high school. A large portion of the students in Groups 2 and 3 had done well enough in high school to be admitted to the university on their principal's recommendation. On the other hand, many of the students in Group 1 were accepted by Memorial on the basis of their school marks, because their school was participating in a pilot study of accreditation. These students had only to meet the minimum university entrance requirements and need not have qualified for a principal's recommendation. Hence, there was likely to be a more normal distribution of mathematical ability in this group than in the other two.

Multivariate Regression Analysis was used to generate prediction equations for those students who did not write public examinations. The predictor variables x_1, x_2 are the Grade XI Mathematics mark and the Grade XI overall average respectively. As before, $\tilde{y}$ represents the predicted score on the criterion variable. Results of the analysis are reported in Table 13.

TABLE 13

Multivariate Regression Analysis for students who did not write public examinations, with Gr. XI mathematics score and Gr. XI overall average being used as predictors.

GROUP	R	R^2	SEE	Prediction Equation
1	.39	.15	17.0	$\hat{y} = 0.38\ x_1 + .56\ x_2 - 24.26$
2	.73	.54	13.6	$\hat{y} = 1.04\ x_1 + .60\ x_2 - 59.29$
3	.69	.48	10.6	$\hat{y} = 1.77\ x_1 + .26\ x_2 - 92.20$

The multivariate correlation coefficients R were significant at the 0.01 level. However, only in the case of students entering Mathematics 1010 from Grade XI Honours did the combination of predictor variables account for more than half of the variance in the criterion. For Group 3 students, entering Mathematics 1011 from Grade XI Honours, it accounted for 48 per cent of the variance, while for the largest group of students, those graduating from the matriculation course, it accounted for only 15 per cent of the variance in the scores on Mathematics 1010/1200. For this group of students, the low R^2 value, together with the high standard error, seriously limit the confidence with which the predictor equation can be applied.

According to the three prediction equations, a student entering Memorial with an overall average of 75 would need 85 in Grade XI Matriculation Mathematics to predict a pass in Mathematics 1010/1200;

a student from Grade XI Honours Mathematics would need a score of 62 to predict a pass in Mathematics 1010 and 69 to predict a pass in Mathematics 1011. The corresponding required scores for the main group of students, the public examination candidates, were 77, 62 and 61.

For Group 3 students, the means on Grade XI Mathematics and Grade XI overall average were 85.9 and 84.8 respectively. A student scoring at the mean on both these variables would have a predicted score of 81.9 in Mathematics 1011. A student in Group 2 who scored at the means, 79.3 and 81.7, would have a predicted score of 72.2 in Mathematics 1010. A student in Group 1, who scored at the means for his group, 77.8 and 75.8, would have a predicted score of 47.8 in Mathematics 1010 or 1200. For both groups of Grade XI Honours graduates who did not write public examinations, the predicted performance in their university mathematics course was better than for their public examination counterparts. For graduates of the Grade XI Matriculation course, however, predicted performance was worse for those students admitted on their school marks than it was for those who wrote public examinations.

In making comparisons, it should be noted that it was the Grade XI composite mathematics mark that was used in the prediction equations for the initial analysis on public examination candidates. For those students, the mean mark in mathematics awarded by the school exceeded the mean composite mathematics mark by about 4 points. Had SCHOOL rather than COMPOSITE score been used in the equations for those students, the results may have been closer for the two sets of multiple regression equations.

FOLLOW-UP OF ACCELERATED STUDENTS

The following results relate to the secondary purpose of this study - a follow-up on the mathematics achievement of the Grade XI Honours students who took Mathematics 1011 in their first semester at Memorial.

In order to determine the success of these students in Mathematics 1011, means were recorded and the distribution of grades tallied. The results appear in Table 14. The 1976 data were obtained through the Registrar's Office and include students from the Corner Brook campus. The 1977 data are for students on the main campus only.

TABLE 14

Means and Grade Distributions on Mathematics 1011 for accelerated students.

	N	Mean	A	B	C	D	F
Fall 1976	148	75.7	82	40	13	8	5
Fall 1977	105	75.8	52	29	16	3	5

The reported scores are for students who took Mathematics 1011 as their first university course and for whom at least two semesters' data were available. No comparison with other groups of Mathematics 1011 students was attempted because no other group could be considered equivalent in mathematical ability, training or past achievement. The students under consideration, having been enrolled in an honours stream, would be among the best high school mathematics students. Their mathematics preparation would be superior to that of students who did not take the honours high school program. Furthermore, since they had bypassed Mathematics 1010 their Grade XI Mathematics scores would have been at least 70. To compare them with any other group of Mathematics 1011 students would be unrealistic and misleading. It was therefore decided that their scores should be examined on their own and not in relation to those of their fellow students. Their high level of achievement is evident from Table 14 The 1976 entrants had a mean score of 75.7; 96.6 per cent passed the course, with 54.5 per cent being awarded an A grade. In 1977, 95.2 per cent passed the course. The mean score was 75.8 and 49.5 per cent obtained A grades.

The mathematics achievement of these students in subsequent courses is reported in the next two tables. In Table 15 the courses taken by the 1977 entrants in their second semester are reported. The number of such students enrolled and the mean score obtained in each of twelve mathematics courses are indicated.

TABLE 15

Mean Scores in mathematics courses taken by 1977 accelerated entrants.

Course No.	1011 repeat	1010	1150	1151	1021	2500	2050	2012	2082	2600	2601	2700
N of students	4	1	2	1	28	4	8	1	46	5	2	1
Mean	63.8	90	77.5	85	71.1	72.5	66.9	65	75.2	76	77.5	35

In courses where more than one student was involved, mean scores ranged from 63.8 to 77.5. The overall mean for the 103 scores was 72.8. Of the 105 students for whom second-semester data were available, there were 6 students who took no further mathematics, 95 who took one course and 4 who took two mathematics courses.

For the 1976 entrants, records were available over five semesters. The relevant data appear in Table 16 (page 67).

The 148 students under consideration took a total of 408 mathematics courses, an average of 2.8 courses each. These data do not include computer science courses nor mathematics courses offered within the School of Engineering. In courses where more than one student was involved, mean scores ranged from 63.3 to 86.3. The overall mean for the 260 scores was 80.7.

The records of the 1976 entrants were further examined to see whether these students were pursuing their university studies in mathematics or in areas related to mathematics. Not all students had specified their faculty and/or major, even after four semesters of study. Of those who had, the choices reported appear in Table 17 (page 68).

Half the students who named a faculty had chosen Science, with a further 30 per cent choosing Commerce. Of the 94 students who declared a major, 11.7 per cent chose mathematics or computer science, 28.7 per cent chose a laboratory science, and a further 29.8 per cent named commerce or accounting as their major.

TABLE 16

Mean Scores in mathematics courses taken by 1976 accelerated entrants.

Course	1011 repeat	1010	1150	1151	1021	2500	2501	2510	2050	2052	2012	2082	2013	2083	3032
N	3	1	3	3	81	34	3	18	34	4	16	50	3	6	1
Mean	63.3	85	80	73.3	82.0	82.5	80	82.5	73.8	72.5	74.7	86.3	83.3	72.5	85

TABLE 17

Faculty and Major chosen by 1976 accelerated entrants.

Faculty	Science	Commerce	Pre Eng	Arts	Educ/Phy Ed	Med/Nursing
Number	51	31	4	6	6	4

Major	Math	CompSc	Physics	Bio	Chem	Biochem	Psych	Comm/Acct	Other
Number	5	6	7	10	7	3	1	28	27

The statistics reported in this chapter provide some information on the mathematics achievement of a group of first-year students at Memorial University. In particular, the data analysis involved in this investigation was directed towards revealing relationships between high school marks and performance in university mathematics courses. The implications of the findings are discussed in Chapter 5.

CHAPTER V

DISCUSSION AND CONCLUSIONS

PREDICTION

The main problem considered by this study was that of placement of incoming university students into an appropriate mathematics course. In particular, it sought to establish suitable cut-off marks for entry into Mathematics 1010 and Mathematics 1011. In the past, placement has been based on the student's overall Grade XI average and his Grade XI Mathematics marks. These marks are generally arrived at by averaging the mark awarded by the school and that obtained on the final public examination. Since it was expected that one of these components might be more highly correlated with the university mark than was the composite score, a breakdown of mathematics marks was obtained for all public examination candidates. Hence, the potential predictor scores to be used were the Grade XI overall average, the Grade XI mathematics mark on the public examination, the mathematics mark awarded by the school, and the average of both mathematics scores. Correlation coefficients were calculated in order to determine the appropriateness of these scores as predictors of university achievement. Subsequently, bivariate and multivariate regression techniques were used to generate predictor equations that could be useful in advising incoming students.

All the potential predictor scores were significantly correlated with the criterion, with the composite mathematics score having the largest correlation coefficient for two of the three student groups under consideration, namely those students entering Mathematics 1010 or 1200 from Grade XI Matriculation or Grade XI Honours. It would therefore seem to be unnecessary for the university to seek a breakdown of the composite mathematics score into its school and public examination components. The composite score embodies these two scores and provides a higher correlation than either does alone for the student groups which represent about 85 per cent of the entrants under consideration.

Correlations of the predictor variables with the criterion were lower for students in Group 3 - those entering Mathematics 1011 from Grade XI Honours - than for the other groups. This may be due in part to the smaller number of cases and also to the more extreme nature of the data here. Only students whose Grade XI mark exceeded 75 were actively encouraged to take Mathematics 1011 as their first semester course. In fact, the mean composite mathematics score for this group was 85. The reduced variation in the independent variable would affect the correlation and make the fit of the regression line more difficult to make.

For students who did not write the public examinations, the correlations were generally lower than for the main group of students. They were, however, significant at the .01 level in all but one case.

Thus, any of the Grade XI scores considered were sufficiently correlated with MUN Mathematics marks to be considered as possible predictors of achievement. It is convenient that one of the best candidates is the mathematics score which is routinely supplied to the university by the Department of Education. It is therefore recommended that this score continue to be used in advising students in their choice of university mathematics courses.

The School Size Variable

Of the potential predictors that were considered in this study, only one was not an examination score, namely that of school size. For the analysis related to this variable, schools were grouped into four categories, based on the Grade XI enrollment. Only the achievement on the criterion variable and on the Mathematics composite score were investigated.

For the Honours graduates, there was very little difference in means on the COMPOSITE score for the four school size categories. For matriculation graduates the differences, while not significant at the .01 level, were larger. The lowest mean was for school size category 4, that is, schools whose Grade XI enrollment exceeded eighty students. This is probably a reflection of the fact that in these large schools the best students take the honours course, whereas in smaller schools, the honours course may not be offered and the more talented students take matriculation mathematics, thus raising the mean score.

On the criterion variable there was little difference in mean achievement among the four categories of matriculation students, though the category 4 students did slightly worse than the others.

For the Grade XI Honours graduates, however, the differences were large enough to prompt further investigation. The subsequent analysis confirmed that the decline in scores was significantly different for school size categories 3 and 4, where enrollments were respectively 41-80 and greater than 80. The declines in mean score were about ten points more for the middle-size than for the large school.

This may be explained by the restrictions on grouping imposed by class size. Schools belonging to category 4 have at least eighty students enrolled in Grade XI, with several having more than two hundred Grade XI students. These large schools have little difficulty in finding a class of talented mathematics students for an honours course. In schools where the Grade XI enrollment was less than forty, it can be speculated that the few honours students were dealt with in small groups with individual attention and independent study. School size category 3 represents a middle group. It may be that in such schools there was not a sufficiently large number of good mathematics students to form a full class and that some of the students placed in the honours stream were of only average ability. Consequently, the honours course may not have been as rigorous or demanding as it would have been in a class of more homogeneously talented students. Since this factor appeared to affect only a small proportion of students (39 of the 624 students in this study) no attempt was made to incorporate school size into a predictor equation for all entrants. Nevertheless, the discrepancies should be noted by those who make decisions regarding student placement. It is particularly important to note that the differences reported have appeared in the university grades and not on the high school mark, indicating that care must be taken in interpreting the Grade XI Honours Mathematics mark awarded. It may be appropriate to direct most graduates of the honours program from middle-size schools into regular sections of Mathematics 1010 rather than into more advanced courses. University-administered placement examinations should be useful here.

One must acknowledge that the administrative problems of streaming in high school are difficult, especially for medium sized schools where imbalance of class size can result. While there are good academic reasons for keeping honours classes small where the number of talented students so dictates, this may not always be administratively possible. It is not desirable to place poorer students into a program for which they are ill-equipped and which may lead to frustration for them or to a serious watering down of the honours course. Nonetheless, it is true that many average students can cope with the honours course and acquire from it a much better preparation for college mathematics than they would get from the matriculation course. In this connection it is worth noting that, according to the prediction equations generated in this study, a Grade XI Honours mark of 65 predicted as high a score on Mathematics 1010 as did a Grade XI Matriculation mark of 78. Thus it would be unfortunate if schools were to discontinue offering the honours course because the number of talented students fell a little short of what was desired. Nevertheless, when the number of very talented students is quite small it may be better to provide these students with extra work via independent study than to try to offer the honours course to a large number of mediocre students. Obviously, as long as there are two university-bound mathematics streams whose course content and level of difficulty are very different, there will be no easy solutions to the streaming problems faced by high school administrators and the placement problems faced by university authorities.

Means and Standard Deviations on Predictor and Criterion Variables

Some patterns of student achievement can be observed from an examination of the means and standard deviations on all variables. In all groups, the marks awarded by the school exceeded those awarded in the public examination, with differences in means ranging from 6.6 to 9.4. Also, standard deviations were higher on the public examination scores. This is probably a consequence of the fact that the school mark is based on several tests throughout the year, while the public examination is a single comprehensive test on the ~~whole~~ year's work. Not only is more material examined, but there is more stress on students writing a formal, external examination. The weak student, or the mediocre student who lacks confidence in his ability, is apt to score less on such a test than he would on single-topic tests administered in the classroom by his own teacher. It is not surprising that the statistics showed lower means and greater variance on the PUBLIC than on the SCHOOL score. It can be noted that while the correlation with MUN MATH was no better for the PUBLIC score than for the others, the PUBLIC mean marks were numerically closer to the mean scores on MUN MATH than were the means on the other predictor variables. Thus one would need a lower PUBLIC than COMPOSITE score to predict success in university mathematics courses.

The greatest variance and lowest means were on the criterion variable, MUN MATH. Since only those students who pass Grade XI with an overall average of at least 60 are admitted to Memorial, it is to be expected that the mean score for the predictors would be higher than that of the criterion, where marks ranged from 5 to 100. This phenomenon of lowered scores is not reserved to any single subject area. In general, students do find that their marks drop when they enter university. This is partly due to the greater level of difficulty of the work, but partly to other non-academic factors. College life represents a great change from high school, and the adjustments that students must make are apt to influence their studies. Feldman and Newcomb (1970) describe some of these problems. While their studies were based on American colleges in the 1960's, some of their comments appear to be applicable to Newfoundland in the 1970's. They describe freshmen as being novices in an unfamiliar social organization, confronted with new role models and changing norms and values. Leaving his old high school and the community where he was an established member and entering a system where he is a newcomer can leave an adolescent with a "disturbing sense of anonymity". In some cases the problem is compounded - a student from a small school who was deemed outstanding in some way may find his status changed and may need to revise his expectations. The social change, the excitement and difficulty that are part of the freshman year are apt to affect academic achievement. There are other factors which more directly affect how well a student achieves. Study habits which were adequate for high school may need to be changed to suit university courses where more material is covered in a shorter period of time and where the student must take more responsibility for out-of-class work. Failure to make such adjustments is likely to lead to lower grades.

In the case of the mathematics scores reported in this study, the decline in means from high school to college varies substantially among the three groups. For students who entered Mathematics 1010 or Mathematics 1011 from Grade XI Honours, the decline in means was moderate and no cause for alarm. The Mathematics 1011 entrants could be assumed to be among the best students entering the university and would probably have less difficulty than most in adjusting to college work. Those who entered Mathematics 1010 from Grade XI Honours, while not such high achievers as the accelerated students, had covered in high school much of the content of the Mathematics 1010 course. In fact, even the moderate decline in means reported for this group seems rather large in view of the similarity of content of the courses. It may be that familiarity with the content caused some of these students to pay less attention and devote less time and effort to their mathematics than they would have done with new material. This possibility should be considered in placement procedures for Grade XI

Honours graduates. It should be remembered, however, that these students were not the top students from the Honours stream. They were placed in Mathematics 1010 either because their high school marks were not sufficiently high for entry into the calculus course or because they themselves lacked the confidence to enroll in the more advanced course.

The largest decline in mean scores was for the graduate of the Grade XI Matriculation program - a drop in means of about 30 points for both public examination and non-public examination candidates. For the most part, these students would have been drawn from the middle 70 per cent of high school students in mathematical ability. This fact, together with the acknowledged adjustment factors influencing performance, would account for some of the decline. However, the difference seems to be too large to be accounted for by these factors alone. It seems, in fact, to be evidence that in many cases the Grade XI Matriculation course simply does not adequately prepare students for the present introductory course in mathematics at Memorial. This very serious problem will be discussed in connection with the regression analysis, where the patterns suggested by the means and standard deviations are further developed.

Regression Analysis

The analysis related to correlation coefficients, means and standard deviations and the school size factor was preliminary to the regression analysis. The first set of prediction equations was the result of simple bivariate analysis for the public examination candidates. This was potentially the most useful information from the study since it could suggest possible criteria for entry into Mathematics 1010 and 1011 on the basis of Grade XI marks. These predictor equations used only the composite score in Grade XI Mathematics and hence could be easy to apply by those involved in interviewing students prior to registration.

In each of the three equations in this set, the coefficient of x_1, the independent variable, exceeded one. This coefficient represents the slope of the regression line; consequently, the difference between the x_1-value and the predicted score on the criterion variable diminishes as x_1 approaches 100 and increases as x_1 gets smaller. Thus, the decline in predicted scores was much more serious for students scoring below the mean on the predictor, with the probability of success in the university mathematics course diminishing greatly as the Grade XI mathematics score fell below 60. The sample predicted scores which are given below in Table 18 indicate that this decline was particularly serious for the graduates of the Matriculation stream entering Mathematics 1010/1200.

TABLE 18

Some sample predicted MUN MATH scores based on Bivariate Analysis for public examination candidates.

High School Mathematics Score		$x_1 = 60$	$x_1 = 70$	$x_1 = 80$	$x_1 = 90$
Predicted	Group 1	26.8	40.5	54.2	67.9
Score	Group 2	45.0	57.6	70.2	82.8
on MUN MATH	Group 3	44.6	56.3	68.0	79.7

The scores required to predict a passing mark for the three groups were 77, 64 and 65 respectively.

It is interesting that for most students the equations for Groups 2 and 3 predicted almost the same mark in Mathematics 1010 as they did in Mathematics 1011. The data that produced these equations were for two different groups of students. The students in Group 2 were not such high achievers in high school as were those in Group 3. Had they enrolled in Mathematics 1011 they might have done less well than they did in Mathematics 1010. Nonetheless, the scores indicate that there may be room for more flexibility in the admission of honours graduates to the calculus course. It has already been suggested that some of the students who take Mathematics 1010 may be bored with the repetition of material they met in high school and hence less than conscientious in their study of it.

For the academic year 1978-9, a mark of 75 was used as the cut-off mark for entry into Mathematics 150B, the double-credit course equivalent of Mathematics 1011. Furthermore, to qualify for double credit upon completion of this course, students were required to pass a university placement test. Those failing the latter were given the option of continuing with Mathematics 1011 for one credit only, or taking Mathematics 1010. It seems reasonable for the university to require a high level of achievement before considering awarding credit for work completed in high school, and it should continue to do so. At the same time, it should make more use of advanced placement without credit. In this connection it may be noted that it is the practice among some American colleges to offer graduates of the U.S. Advanced Placement Program either credit or advanced placement or both. The results of this prediction study suggest that students who score between 65 and 75 in Grade XI Honours Mathematics be given the option of taking Mathematics 1011 but without extra credit. In particular, students who express a reluctance to repeat familiar material should be encouraged to take the advanced course since for them, a positive attitude toward new material may well outweigh any deficiencies in their preparation. On the other hand, students who are reluctant to bypass the introductory university course should not be pressured to do so. This is especially important for graduates of the middle-size schools who, as a group, experienced a larger drop in marks than did most other students from the honours stream.

The Grade XI Matriculation Mathematics score needed to predict a pass in Mathematics 1010/1200 was 77, suggesting that the cut-off mark of 75 set for the academic year 1977-78 was not unrealistic. The discrepancy between Grade XI marks and predicted marks in college mathematics is extremely large. When a score of 27 is predicted for a student with a Grade XI mark of 60, there is cause for concern. There can be no doubt that the Grade XI Matriculation course and the introductory mathematics course at Memorial are not well-matched. Teachers and students experience frustration with a course in which large numbers of students seem doomed to failure. For the average student, indeed apparently for any student who scores below 80 in Grade XI, there is a serious gap between high school and university mathematics that needs to be bridged. Obviously this may be done by strengthening the Grade XI course, weakening the university course, or using an intermediary course such as the Foundation Mathematics course. Ideally, the university Mathematics Department would wish to see all students enter the university with the kind of preparation supplied by the honours course. While this may not be a realistic expectation for all students, it is probably not unreasonable to expect most students who wish to study university mathematics to cope with more mathematics at the high school level than is presently included in the matriculation program. Thus one solution to the problem would be to strengthen the high school matriculation course so that the difference between it and the honours course is substantially less than is presently the case. However, this is probably not very likely to happen. School authorities see the matriculation stream as catering to the majority of students, about 70 per cent of all Grade XI pupils. Most of these do not go on to university, and if the matriculation course is suited to their needs it is unlikely to change substantially. One can hope that many teachers will try to provide extra work and more challenging material for their bright students in the matriculation stream. When Grade XII is introduced into Newfoundland schools, it should help to bridge the gap. In this connection, it is appropriate that representatives of post-secondary institutions like the university and the technical colleges have input into decisions related to course content in an expanded high school program, at least in those subject areas where high school work provides specific prerequisite foundation for subsequent study at those institutions.

An alternative solution to the present problem is to reduce the content of the present Mathematics 1010 to a level that is more consistent with the ability and prior knowledge of the students who must take it. There are, however, limits on the amount of material that can be deleted without affecting the students' preparation for the calculus. It seems apparent that more and more of the students who enter Memorial from the matriculation stream will need two semesters of pre-calculus mathematics before they take Mathematics 1011. Current practice places weak students in sections of Mathematics 101F, the non-credit Foundation course; consequently, these students must spend two semesters to acquire a single credit in Mathematics.

A compromise solution for bridging the gap between Grade XI Matriculation Mathematics and Mathematics 1010 would be to spread the content of the present Mathematics 1010 course over two semesters and to award credit for each of the two semesters to successful students. This would allow students who need two mathematics credits for their degree to acquire them in their first year. Students seeking admission to degree programs which require calculus would then need to spend three semesters at first-year mathematics. A regular one-semester course in Mathematics 1010 could still be made available to the best graduates of the matriculation course so as not to delay their entrance into such programs. It may be expected, however, that such a proposal would meet with some objection within the university, since it would entail the awarding of university credit for work that has been covered, up to now, in a non-credit remedial course. Nonetheless, the data in this study clearly show that the present introductory course at Memorial is too difficult for many of our incoming students to complete in one semester. Those weaker students will need to spend two semesters at pre-calculus mathematics, with or without credit. For weak students who do not require calculus for their degree, the Mathematics Department at Memorial should consider offering a general course that is not as heavily dependent on high school algebra and trigonometry as is Mathematics 1010.

The multivariate regression analysis provided little change from the bivariate analysis. The R and R^2 values indicated that prediction can be made almost as confidently with one variable as with two. Current practice at Memorial regards a Grade XI overall average of 75 as indicative that a student is good enough to need no foundation courses. For a student with this average the multivariate equations for the 3 groups require Grade XI mathematics scores of 77, 62 and 61 to predict a pass in MUN mathematics. Thus, for the largest group of students, those entering Mathematics 1010 from Grade XI Matriculation there is no change in the suggested cut-off mark. For the two groups of Grade XI Honours students, use of the Grade XI average would slightly lower the required mathematics mark.

For students who did not write public examinations the cut-off marks suggested by the predictor equations for the three groups were 85, 62 and 69 respectively. The mathematics mark used here was the school-awarded mark. It may be recalled that for public examination candidates, this was generally higher than the composite score. Predicted scores for the non-public examination candidates may have been closer to those of the main group if the school-awarded mark had been used in both sets of analysis.

In summary then, the regression equations generated for the two groups of honours graduates indicate that 65 is an appropriate cut-off mark for entry into either Mathematics 1010 or Mathematics 1011. Present practice admits anyone who passes Grade XI Honours into Mathematics 1010. This can hardly be changed. Much of the content of the two courses overlaps and it would be difficult to argue that a student who passes one is unable to cope with the other. The decline in scores indicated by the prediction equation is likely to be due to non-academic factors - to difficulties in adjusting to university, to poor work habits or to a disenchantment or boredom with college mathematics that repeats high school work. A case may be made not for raising the cut-off for entry into Mathematics 1010 but for lowering the cut-off for entry to Mathematics 1011 so that more students who want to begin some new mathematics may do so.

The equations generated for the Group 1 students suggest a cut-off mark of at least 77 for entrance into Mathematics 1010. The high score needed to predict a pass is symptomatic of the discrepency between Grade XI matriculation and university mathematics and points to a need for change.

Having presented the proposed cut-off marks and discussed predicted scores, it is now necessary to caution against their exclusive use in placing students into courses. In all the regression equations, the standard error of estimate was large and the proportion of variance accounted for by the predictors was relatively small. There are many factors which influence student achievement, and those have been investigated by many researchers.

Especially relevant to the local situation is a study of differential characteristics of high and low achievers among third-semester Junior Division students of Memorial made by Simmonds (1972). Among the variables on which he identified significant differences between higher and lower achievers were intelligence, need for order, vocabulary, work methods, study habits, teacher acceptance, study attitudes and study orientation. While it may never be possible to incorporate these variables into prediction equations for placement purposes, those who are responsible for advising students should be aware that factors other than high school achievement can influence performance. It is therefore recommended that cut-off marks not be applied with such rigidity as to preclude all exceptions.

FOLLOW-UP OF ACCELERATED STUDENTS

The performance of Grade XI Honours Mathematics graduates who took Mathematics 1011 as their first university mathematics course has been most satisfactory. The success rate of such students in the Fall semesters of 1976 and 1977 exceeded 95 per cent. This pass rate and the grade distribution attest to the mathematical proficiency of these students. Moreover, the regression equations generated in the prediction study indicated that, for the average student in this group, the predicted score in Mathematics 1011 would be a good passing grade. There can be little doubt that these students were adequately prepared for entrance into the calculus course. Furthermore, their records in subsequent mathematics courses suggest that they did not suffer academically from having by-passed Mathematics 1010.

The high level of achievement of these students was not unexpected. Because of the nature of the Grade XI Honours program, it is the best students who take it - students of high ability and/or interest in mathematics. Moreover, it is the best of the Grade XI Honours graduates who are likely to choose the introductory calculus course as their first mathematics course when they come to Memorial. The results of the follow-up of the 1976 and 1977 entrants in this category certainly give evidence of their ability to do mathematics.

Very few of the students given advanced placement into Mathematics 1011 discontinued their study of mathematics after one semester. Indeed, of the 1976 entrants investigated, over half took three or more courses in mathematics during the academic years 1976-7 and 1977-8. However, less than 6 per cent of the students who had declared a major named it as mathematics. There is room for improvement in this regard, since this group of accelerated students should be a good source of future mathematicians.

It is generally conceded by educators that students should be encouraged to acquire as much knowledge and develop as many skills as they can. In particular, bright students should be provided with enough challenge to make them think and reason and to keep them alert and interested. The high school honours mathematics program was designed to provide challenge and enrichment to students of superior ability in mathematics. Such students should be encouraged to take that program rather than the less challenging matriculation course. However, if the students see the honours course as carrying extra work without reward, they will be less inclined to choose it. This is particularly true when post-secondary institutions make no distinction between the two mathematics courses in their admission policies. Already, there is some evidence of declining enrollment in the honours program.

In an attempt to provide some incentive for good students to take the honours course, Memorial approved for the academic year 1978-9 a scheme by which students entering Mathematics 1011 or its equivalent from the Grade XI honours course, may be given two credits upon its successful completion. For this experimental year, admission to the double credit course was contingent upon a student's having received a mark of at least 75 in Grade XI Honours Mathematics and a passing grade of at least 50 in a special placement test administered by the University Mathematics Department. This test was based on the content of Mathematics 1010, which substantially overlaps the Grade XI Honours Mathematics course.

The level of achievement of the accelerated students investigated in the 1976 and 1977 follow-up indicate that this move towards giving a university credit to highly successful Grade XI Honours graduates is well-founded. Nevertheless, caution should be exercised in this regard. The university is reluctant to award academic credit in instances where it has little or no input into course content, or the setting and grading of examinations. The university's placement examination, especially in the early stages, is justified on these grounds alone. The appropriateness of having such an examination is further indicated by the evidence of inconsistencies in the predictive power of Grade XI Honours marks as revealed in the prediction study. Not all students coming into Memorial with a Grade XI mathematics mark of 75 are equally well-equipped to enter the first calculus course. Still less can they all be assumed to be sufficiently proficient in algebra and trigonometry to get an automatic university credit for Mathematics 1010.

On the basis of this study, the recommendation to the university is that it continue to admit qualified graduates of the Grade XI Honours course into the introductory calculus course and to make provision for the awarding of two credits upon its successful completion. It is further recommended that the passing of a placement test administered by the Mathematics Department of Memorial be a condition for this dual credit. In this respect, we should recall the extensive co-operation of high schools and colleges in the Advanced Placement Program in the United States. It is to be hoped that, while Memorial presently has no direct influence on the content or examinations of the high school course, its placement tests will indicate what it expects of students. This should serve to improve the dialogue between those teaching the pre-calculus course in the university and should help to keep the Grade XI Honours course at a high standard.

SUMMARY OF RECOMMENDATIONS

The following recommendations are related to the placement of students into mathematics courses at Memorial and to areas of further research suggested by this study.

1. The Mathematics Department at Memorial should continue to use the Grade XI composite mathematics mark as the principal predictor of achievement in university mathematics courses.

2. The minimum mark for entry into the present Mathematics 1010 from the Grade XI Matriculation Mathematics stream should be at least 75. Students scoring between 75 and 80 should be advised to consider spending two semesters to acquire one credit in mathematics.

3. The minimum mark for entry into Mathematics 1011 (or its equivalent) from the Grade XI Honours Mathematics stream should be lowered to 65. Double credit upon completion of this course should continue to be contingent upon the student's passing a university-administered placement examination based upon the content of Mathematics 1010. Students failing to qualify for double credit should be encouraged to accept advanced placement without extra credit.

4. All minimum marks should be regarded as guidelines, with flexibility being allowed in their application. University placement examinations should continue to be used to supplement the information from Grade XI marks in doubtful cases.

5. Since classes vary from year to year, criteria may need to be adjusted. It is therefore recommended that bivariate regression analysis using a random sample of students be regularly conducted in order to check the suitability of the minimum marks that are in use.

6. In view of the large numbers of students who experience great difficulty with the present Mathematics 1010 course, the Mathematics Department at Memorial should give serious consideration to the possibility of offering two credit courses in pre-calculus mathematics for first year students. It should also consider offering two semester

credit courses in mathematics intended for those who do not wish to proceed to the calculus.

7. A systematic follow-up of students who have been placed in sections of Mathematics 101F should be made with a view to determining the extent to which this non-credit course is effective in bridging the gap between Grade XI Mathematics and Mathematics 1010.

8. Research should be undertaken to investigate whether the use of other variables such as intelligence, mathematical aptitude, work habits or attitudes would significantly improve prediction of achievement in university courses.

9. Research should be undertaken to determine whether the use of standardized achievement tests would improve prediction enough to warrant their use for placement purposes.

10. Representatives of post-secondary educational institutions should have input into decisions related to curriculum in the high schools. In particular, the appropriate university departments should have substantial influence in deciding content for courses that are intended for university-bound students. This is especially vital in any plans being made relative to the introduction of Grade XII. Since this study was undertaken, the provincial government has declared its intention to have Grade XII brought into Newfoundland high schools in the near future. When this comes about, some departments of the university, including the Department of Mathematics, will need to re-assess their own course offerings and entrance requirements.

Present criteria for entrance into regular courses may no longer be appropriate. Obviously, the addition of an extra year of high school has the potential for greatly improving the academic qualifications of incoming university students. The extent to which this potential is realized will depend in part on the care that is taken in planning the curriculum for the four-year high school.

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