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A Two-Step Approach to Diagnostic Assessment in College Math, Fall 2007

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A Two-Step Approach to Diagnostic Assessment in College Math

Fall 2007

A study of the effect of two-step early assessment and high school pathway on success in first semester mathematics.

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Abstract

This study examines a modified strategy for diagnostic testing and its use as a predictor of performance in college math. A study conducted in 2005 analyzed the results of a single diagnostic test given at the beginning of first semester to all students in the School of Manufacturing Sciences post-secondary programs at Fanshawe College. The range of topics covered by this single test was comprehensive. The attempt to find correlation between the results of this test and grade outcomes in first semester college technology math was inconclusive. The current study examines the results of a system of two similar tests, administered to students of the 2007 Fall intake of the same school. The first of the two tests was given during the first mathematics class of the semester; the second test after approximately two weeks of the semester. The content of the first test was reviewed during lectures in the intervening two week period so that student progress could be gauged with respect to results from the first assessment.

The results of the combined diagnostic test results provide a more effective predictive tool than the results from the 2005 study. Specifically, the findings of this study show that 67.9% of students who failed the diagnostic tests (combined mark) failed first semester mathematics in the Fall of 2007.

The current study and the 2005 study show that both grade 11 and 12 mathematics courses have a significant effect on performance in first semester college mathematics. The pathway MBF3C–MAP4C (11C-12C) is the most common pathway chosen by first semester entrants and further, this pathway is insufficient preparation for first semester college technology mathematics of post-secondary programs offered by the School of Manufacturing Sciences. This study finds that an overwhelming number of students who took the applied stream mathematics course in grade 10 pursued the pathway MBF3C-MAP4C.

Students who chose an alternate pathway culminating in the grade 12C course, MAP4C, fared much better in first semester technology mathematics, suggesting that the choice of grade 11 mathematics course has the greater impact on success in college mathematics.

Both this study and the previous study show that all students who had taken Mathematics for College Technology in grade 12 (MCT4C) passed first semester college technology mathematics in the School of Manufacturing Sciences post-secondary programs in the Fall of 2005 and 2007.

Acknowledgements

The author would like to thank the teachers of the mathematics team of the School of Manufacturing Sciences: Scott Barrie, Kameal Mina, Ted Smith and Bob Wilson for their help in delivering diagnostic tests to the students in first year and to Susan Roney for providing demographic and academic data for all of the first year students in the School of Manufacturing Sciences programs. Thanks to Rod Cameron, John Makaran, Roger Fisher, Leslie McIntosh, Roger Fisher and Greg Weiler for their vision of research at Fanshawe College and specifically, supporting my work in that regard. Thanks to Courtney Brooks and Misha Bower for their diligence and interest in the preparation of the large amounts of data on which this work depends. A debt of gratitude goes to Lynette Carmichael for her help with technical details and finally, to my wife, Eva Henning, whose support, insight, suggestions and proof-reading were invaluable.

1.0 Introduction

1.1 Objectives and Scope

This study focuses on indicators having a significant impact in the non-completion of first semester college math.

The primary objective of this paper is to examine the effectiveness of a new approach to diagnostic testing used in predicting grade outcomes in first semester college technology mathematics. The single diagnostic test administered to the fall 2005 post-secondary program intake failed to distinguish between students with persistently weak mathematics skills and those students whose mathematics skills improved quickly with a review of basic concepts. The question of whether these groups might be more effectively resolved is investigated by analysis of the results of a two-step approach to diagnostic testing.

This study also investigates the effect of pathways taken by students through Ontario high school mathematics programs. Factors impacting the choice of pathway through grade 11-12 mathematics will be examined in addition to the effect of chosen pathways on first semester college mathematics grades.

The School of Manufacturing Sciences* at Fanshawe College offers a diploma/degree at four major post-secondary program levels: techniques programs (1 year), technician programs (2 year) , technology programs (3 year) and one applied degree program (4 year). Proficiency in mathematics is a key to success at all four levels of study.

This study uses data collected for the Fall 2007 student intake group entering technician and technology post-secondary programs in the School of Manufacturing Sciences at Fanshawe College in London, Ontario. These programs have considerable commonality of entrance requirements. Of the 452 students enrolled in School of Manufacturing Sciences programs in the Fall of 2007, 356 entered technician and technology post-secondary diploma programs.

* **In 2009 the School of Manufacturing Sciences became the School of Applied Science and Technology**

1.2 Background

Student achievement in mathematics continues to play a key role in student success in all program categories at the college level. Since the implementation of the new curriculum in Ontario high schools, students have experienced far more difficulty in the transition from high school to college math. Critically, this difficulty is characterized by higher failure and drop-out rates in mathematics and mathematics-based technical courses in first semester. The Ontario high school mathematics curriculum revision process was initiated for the group entering high school in the Fall of 1999. The first cohort emerging from high school with the new curriculum typically began their post-secondary education in 2003. Previous to 2003, it was recommended that students entering technology programs at Fanshawe College have Grade 12 Advanced level Mathematics (MAT4A) or better and that technicians apply with Grade 12 General level Mathematics (MTT4G) or better. Many students had also completed an additional (OAC) year.

With the emergence from high school of this first group of students who had taken the Ontario new curriculum, the need to study the impact of changes in the mathematics curriculum and its effect on student success at college became apparent. Since 2003, students graduating from high school have been entering college with the new curriculum grade 11 and grade 12 mathematics courses (Appendix 1). There have been several minor revisions to courses within the new mathematics curriculum since its implementation including renaming of several courses effective in the Fall of 2007.

1.2.1 2005 Study

A similar study (Henning, 2007) of mathematics preparedness was carried out in 2005 for the School of Manufacturing Sciences Fall intake group. The main focus of this study is a correlation of the results of a single diagnostic test with grade outcomes in first semester technology mathematics. The results concerning the predictive value of the test are inconclusive.

In retrospect, several problems surrounding the specific assessment tool have surfaced. The test was too long and covered a wide range of topics from both primary and secondary school curricula. The test was administered to students during the first lecture

period of the term without prior notice. This, coupled with the fact that many students were "out of practice", contributed to a less than satisfactory result. As a result, many students fared poorly on the diagnostic test but performed well in first semester math. A large percentage of the students who wrote the test failed to complete it. Some may have simply run out of time; others may have simply "given up". Overall, the test results show the expected trend between diagnostic test score and performance in first semester college mathematics for the group; however they are of little value in predicting performance of the individual student in college mathematics (Henning, 2007, p.52).

1.2.2 High School Indicators

Henning (2007) further examines such potential indicators as high school mathematics marks and courses taken in grade 12. This study maintains that marks (in grade 12 mathematics courses) are of little value in predicting outcomes in college mathematics courses. However, the specific grade 11 and 12 mathematics courses taken provide a better insight into the question of preparedness. Fanshawe College and other colleges in Ontario are still in a transition period with respect to mathematics prerequisites due to the intake of mature students who have a variety of old curriculum mathematics courses (Appendix 1).

In 2007, the York-Seneca Institute for Mathematics, Science and Technology Education (YSIMSTE) released its findings of an analysis of grade outcomes in first semester college mathematics and high school preparation at six institutions in the Toronto region. A study entitled *College Mathematics Project 2007 Final Report* (CMP) documents the effects of the major grade 9-12 pathways pursued by a total of 5,912 students (YSIMSTE, 2007, p.37). The report examined the "the mathematics achievement of first-semester college students, particularly in relation to their secondary school mathematics backgrounds" (YSIMSTE, 2007, p.1). A large portion of its findings focuses on the pathway taken by students through high school mathematics programs.

First year candidates entering the School of Manufacturing Sciences post-secondary programs generally applied to college with one or more of the following: an old curriculum grade 12 mathematics course, an OAC mathematics course or a new curriculum grade 12 mathematics course. Currently, as far as grade 12 college stream mathematics courses are concerned, far fewer students graduate from high school with

Mathematics for College Technology (MCT4C) than students who have taken Mathematics for College and Apprenticeship (MAP4C). Most colleges, including Fanshawe College, have been accepting students with MAP4C or MCT4C as the minimum prerequisite for application to their programs.

Cluett et al. (2009), Henning (2007), YSIMSTE(2007) and the current study find that students emerging from the high school grade 12 mathematics course MAP4C experienced the greatest difficulties in attaining success in first semester college technology mathematics.

College applicants who complete either of the grade 12 courses MCT4C (Mathematics for College Technology) and MCB4U (calculus) generally enjoyed the greatest success in college mathematics. However, students applying to technology programs with either of these courses as prerequisites were in a minority. For example, of the 386 students in the Fall 2005 study group, only 56 (or 14.5%) entered technology programs with MCT4C as a prerequisite (Henning, 2007). Further, even if students wanted to take MCT4C, not all high schools in Ontario offered this grade 12 mathematics course (YSIMSTE, 2007).

The results of Henning (2007) and the current study pertaining to high school pathways in mathematics are echoed by the findings of the *College Mathematics Project 2007 Final Report.* This study finds that 60% of "at risk" students in the technology cluster had MAP4C as a prerequisite while less than 30% in this category had MCT4C . Further, only 8.5% of the number of students in the technology cluster (n=3,189) had taken MCT4C (YSIMSTE, 2007, p.41).

As a result, technology departments throughout the system found themselves in a difficult situation. Making MCT4C the basic prerequisite would ensure greater student success but diminish the number of program entrants. A shortage of qualified applicants would have put many programs in jeopardy. As a result, entrance requirements were lowered to accommodate this reality.

The Fall 2007 intake group for the School of Manufacturing Sciences post-secondary technician and technology programs numbered 453 students. Of this number, 371 students or 81.9% of the total intake group entered college with a new curriculum grade 12 mathematics prerequisite compared with 72.0% in 2005. In the Fall of 2007, 351 students (77.5% of the total intake group) entered with both a grade 11 and grade 12 mathematics course from the new curriculum. For the most part, this study focuses on students who have graduated from

high school with new curriculum mathematics courses since this group is notable for its lack of preparedness for college level mathematics.

The YSIMSTE report focuses on this group of recent Ontario graduates (ROGs) whose "secondary school mathematics records can be meaningfully related to their college mathematics achievement" (YSIMSTE, 2007, p.28). The report's findings show that "ROGs were more likely to be "at risk" than non-ROGs, and that this was equally true for preparatory mathematics courses as for regular college-level mathematics courses" (YSIMSTE, 2007, p.34).

1.3 Testing and Data Gathering Procedures

1.3.1 Diagnostic Test Results

The diagnostic test, used in the Fall of 2005 as the basis for the Henning (2007) study, covered a large spectrum of mathematics topics at varying levels of difficulty. In general, the results of the test, when correlated to grade outcome data for first semester college mathematics courses, were inconclusive. As a result, this single diagnostic test administered to students at the beginning of the Fall term in 2005 did not provide a clear picture of the potential for success or "at risk" behaviour in first semester college technology mathematics. Cluett et al. (2009) also conclude that results from a single diagnostic test exhibit a weak correlation with first semester college mathematics grade outcomes.

Due to the inconclusive results of diagnostic testing carried out in 2005 coupled with the recommendation to explore "further diagnostic testing" (Henning, 2007, p.56), a new approach to diagnostic testing was explored: the administration of two similar tests delivered two weeks apart. These tests were delivered to all students taking a first semester mathematics course in post-secondary programs offered by the School of Manufacturing Sciences. However, the nature and content of these more recent tests was significantly different from the vehicle used in 2005 by Henning (2007).

In the Fall of 2007, the first test was given during the first mathematics class of the term. Students were not apprised of the delivery of this test. The time given for completion was

50 minutes. In contrast to the diagnostic test used in 2005, the 2007 diagnostic test, used as the basis of the current study, was much narrower in scope and generally, of a lower level of difficulty. This ensured that nearly all of the students were able to complete the test in the allotted time. The content of the Fall 2007 diagnostic test consisted of five basic mathematics topics: operations with signed numbers, addition and subtraction of numeric fractions, multiplication and division of numeric fractions, operations with percentages and solution/rearrangement of simple equations.

The first test was marked but not returned to the students as it carried no weight in each student's final course mark. The content of this test was reviewed by all students in the subsequent two weeks of mathematics course lecture hours. A second test was administered at the end of the second week of classes. The number and type of questions in each section of the second test were similar to those given on the first test. The tests were designed so that the level of difficulty of comparable questions on the two tests could be easily maintained. In order to provide incentive for students to write the second test, a weight of 5% of the student's final mark was assigned to this test mark. Both tests consisted of 30 single-skill questions.

1.3.2 Other Data

Student high school records, Fanshawe grades and other demographic information was provided by Fanshawe College's Institutional Research and Planning department.

2.0 Results

2.1 Study Sample

This report seeks to draw conclusions concerning the predictive value of diagnostic testing on first semester college mathematics grades and to continue the investigation of the impact on performance of high school new curriculum mathematics pathways that was initiated in 2005. The development of predictive tools would then allow identification of "at risk" student tendencies early in the first semester of study at college. Towards this end, a study sample was developed to allow comparison of these parameters.

2.1.1 Development of the Study Sample

In the Fall of 2007, 335 students enrolled in first semester post-secondary technician and technology programs in the School of Manufacturing Sciences received a grade in a mathematics course according to the scheme shown below in Table 2.1.

Table 2.1 Fanshawe College Grade Scheme

Fanshawe College Passing Grade	Description	Fanshawe College Grade	Description
A+	90 % ≤ Mark ≤ 100 %	F	Fail , < 50 %
A	80 % ≤ Mark < 90 %	I	Incomplete
B+	75 % ≤ Mark < 80%	W	Withdrawn
B	70 % ≤ Mark < 75 %	DR	Dropped
C+	65 % ≤ Mark < 70 %		
C	60 % ≤ Mark < 65 %		
D+	55 % ≤ Mark < 60 %		
D	50 % ≤ Mark < 55 %		

A significant part of the current analysis was conducted using a set of student records which contained all of the following elements:

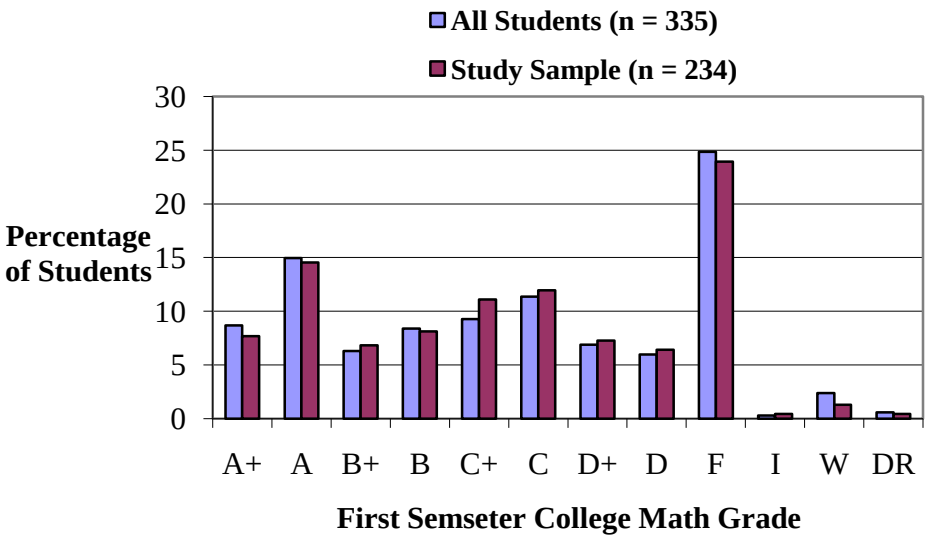
1. A first semester School of Manufacturing Sciences mathematics course grade.

2. High school new curriculum mathematics courses and marks from both grades 11 and 12.

3. Scores from both of the diagnostic tests.

Of the 335 students enrolled in post-secondary programs at the technician and technology level, a sample group of 234 student records was developed which contained all three elements. The purpose of developing a group exhibiting this intersection of elements was to provide the simplest basis for studying possible correlations among these factors. This analysis includes a comparison of high school pathways through grades 11 and 12 mathematics courses with results of the diagnostic tests and a further comparison of first semester college mathematics grades to diagnostic scores. In the succeeding sections, the group of 234 will be referred to as the "study sample". Figure 2.1 gives a comparison of grade distributions for the group of all students enrolled in first semester college mathematics (n = 335) and the study sample (n = 234).

Figure 2.1 **Grade Distribution for All Students versus Study Sample**



The distributions of the grade outcomes of these two groups exhibit sufficient similarity that inferences taken from the study sample might also be applied to the larger (intake) group.

2.2 Pathways

2.2.1 Grade 11 and 12 High School Mathematics Course Codes

Table 2.2 provides a summary of the grade 11 and 12 new curriculum high school mathematics courses that were appropriate to the Fall 2007 intake group prior to entering School of Manufacturing Sciences post-secondary programs. In the discussion throughout, pathways will be referenced by the course codes found in the first column.

Table 2.2 Grade 12 Mathematics Courses 2002-2007

Course Code	Grade Level	Stream	Description
MCR3U	11	U	Functions
MCF3M	11	U/C	Functions and Applications
MBF3C	11	C	Foundations for College Mathematics
MCB4U	12	U	Calculus
MGA4U	12	U	Geometry and Discrete Mathematics
MDM4U	12	U	Mathematics of Data Management
MCT4C	12	* CT	Mathematics for College Technology
MAP4C	12	C	Foundations for College Mathematics

* **In order to allow a distinction to be made between the two grade 12 College level courses, the abbreviated code 12 CT (College Technology mathematics) is introduced for MCT4C. For the duration of this report the abbreviated code for MAP4C will remain as 12C.**

2.2.2 Transition to Grade 11 Mathematics

Of the 234 students in the study sample, 232 had a grade 10 mathematics record of a new curriculum mathematics course: MPM2D (Principles of Mathematics) or MFM2P (Foundations of Mathematics). Figure 2.2 provides a breakdown of the number of students in the academic and applied stream courses at the grade 10 level. Clearly, a majority of students opted to remain in the academic stream at the grade 10 level.

Figure 2.2

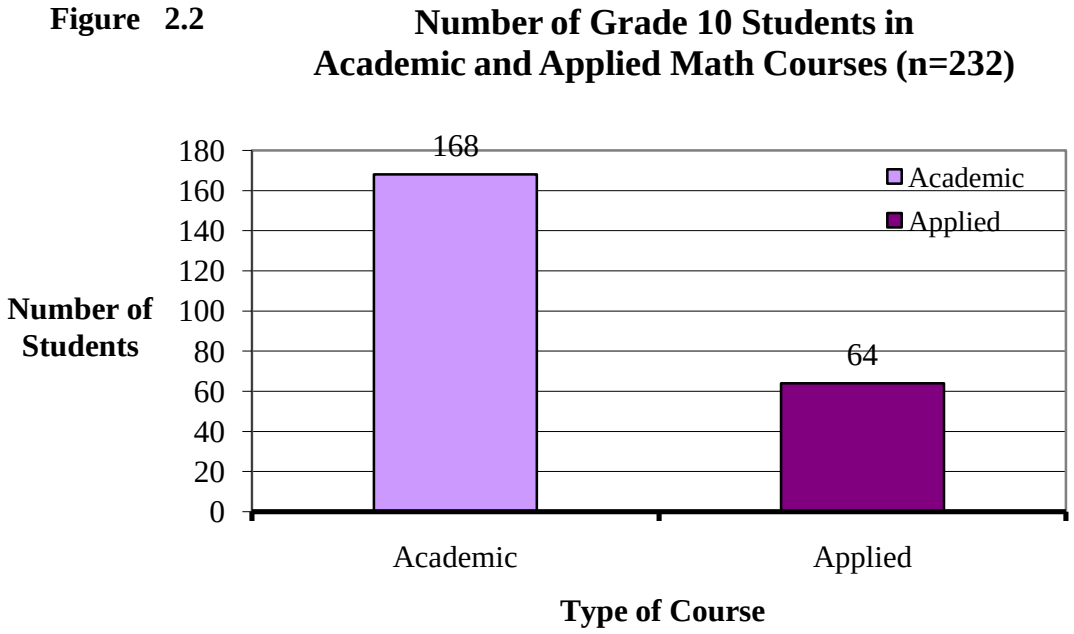


Figure 2.3 illustrates that the grade 11 destinations of these 168 students are a mixture of U, U/C and C streams. Figure 2.4 shows that virtually all of the 64 grade 10 applied stream students opted for the C stream (MBF3C) in grade 11 mathematics. Of this group, 62 students entered grade 11 college mathematics while only 2 students entered grade 11 U/C (MCF3M) mathematics.

Figure 2.3 **Grade 11 Destination Math Course for Students Exiting Grade 10 Academic Math (n=168)**

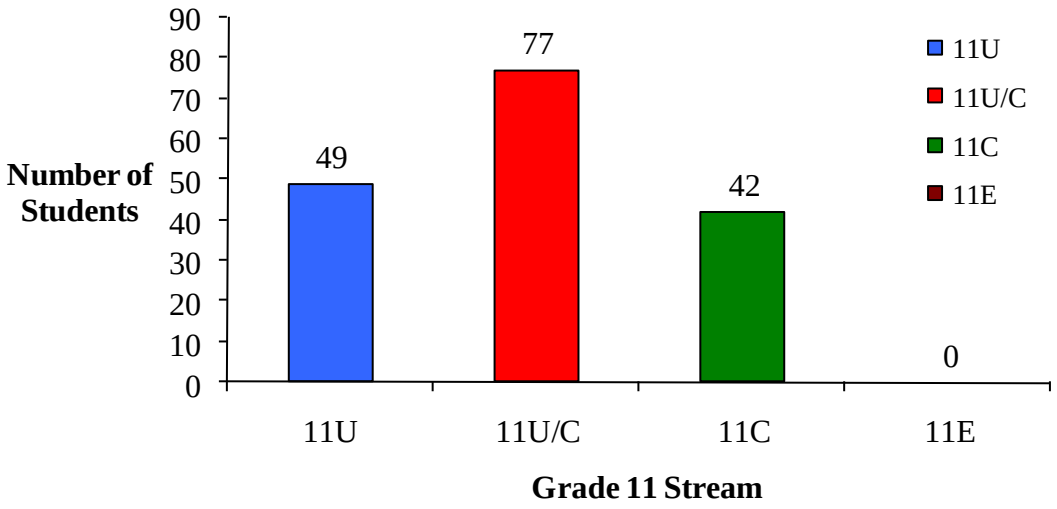
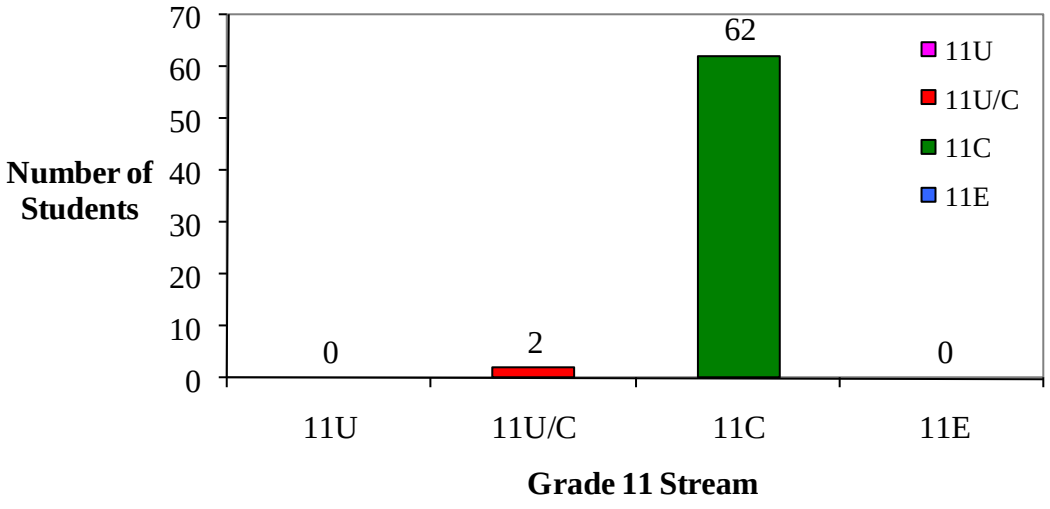


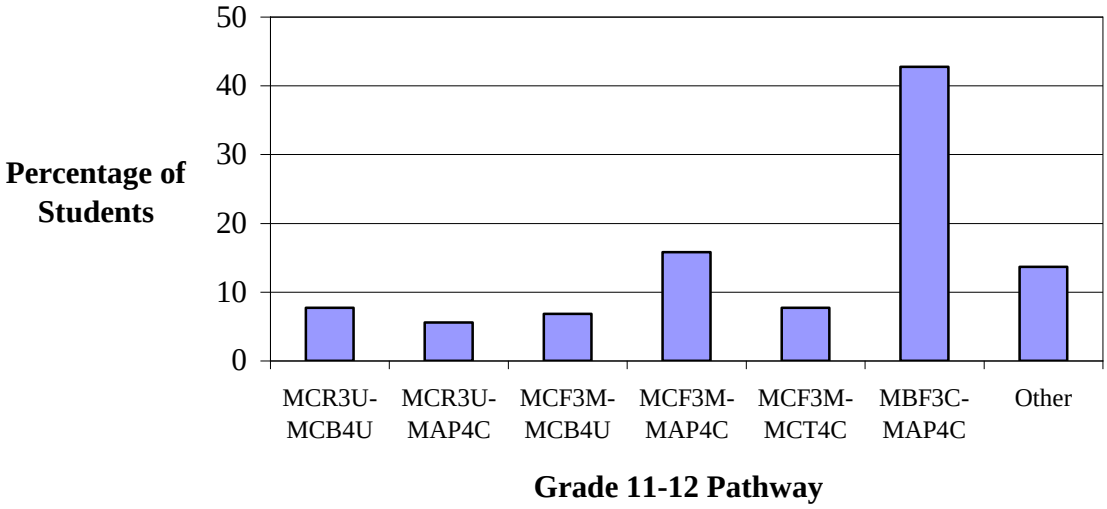
Figure 2.4 **Grade 11 Destination Math Course for Students Exiting Grade 10 Applied Math (n = 64)**



2.2.3 Common Pathways

In order to draw conclusions concerning grade 11-12 pathways in high school mathematics, it was decided to consider those pathways which represented sizeable groups of students. Any pathway taken by at least five percent or more students in the study group was chosen as a common pathway. As a result, six common pathways emerged, representing 202 (or 86.3%) of 234 students. Figure 2.5 exhibits the grade 11-12 pathways chosen by students in the study sample. By far the largest segment (42.7%) of these students opted for the 11C–12C pathway, namely MBF3C–MAP4C.

Figure 2.5 **Grade 11-12 New Curriculum Pathways Pursued by Study Sample (n=234) Students**



2.2.4 Grade 11-12 Pathways

Table 2.3 provides the average marks in grades 11 and 12 mathematics by pathway. The last column in this table also provides the failure rates in first semester college mathematics for students emerging from these pathways. The pathways which indicate the best chances for a passing grade in first semester college mathematics were MCR3U-MCB4U and MCF3M-MCT4C. Both groups exhibited a zero failure rate. By far, students who took the

pathway MBF3C- MAP4C exhibited the highest failure rate in college mathematics (43.0%). Students who chose other pathways culminating in the grade 12C mathematics course MAP4C fared much better in college mathematics with significantly lower failure rates. Students who opted to take either MCR3U (11U) or MCF3M (11U/C) as a preparation for MAP4C, scored extremely well in their grade 12 course (84.5% and 81.5% respectively) and experienced lower failure rates in first semester college mathematics (15.4% and 16.2% respectively).

Table 2.3 Achievement of Students in Grade 11 and 12 Mathematics

Pathway	Grade 11 Average Mark (%)	Grade 12 Average Mark (%)	Frequency of F Grades in First Semester College Mathematics (%)
MCR3U-MCB4U (n = 18)	75.2	74.3	0
MCR3U-MAP4C (n = 13)	64.1	84.5	15.4
MCF3M-MCB4U (n = 16)	70.6	65.5	12.5
MCF3M-MAP4C (n = 37)	62.4	81.5	16.2
MCF3M-MCT4C (n = 18)	64.6	71	0
MBF3C-MAP4C (n = 100)	69.9	68.7	43.0

Clearly, the choice of grade 11 mathematics as preparation for college mathematics has a significant impact on first semester college mathematics outcomes. The CMP 2007 report's findings are similar to those of the current study: "over 40% of students who took MAP4C were '"at risk"' after first semester, and this number rose to 60% in the case of technology students" (YSIMSTE, 2007, p.40).

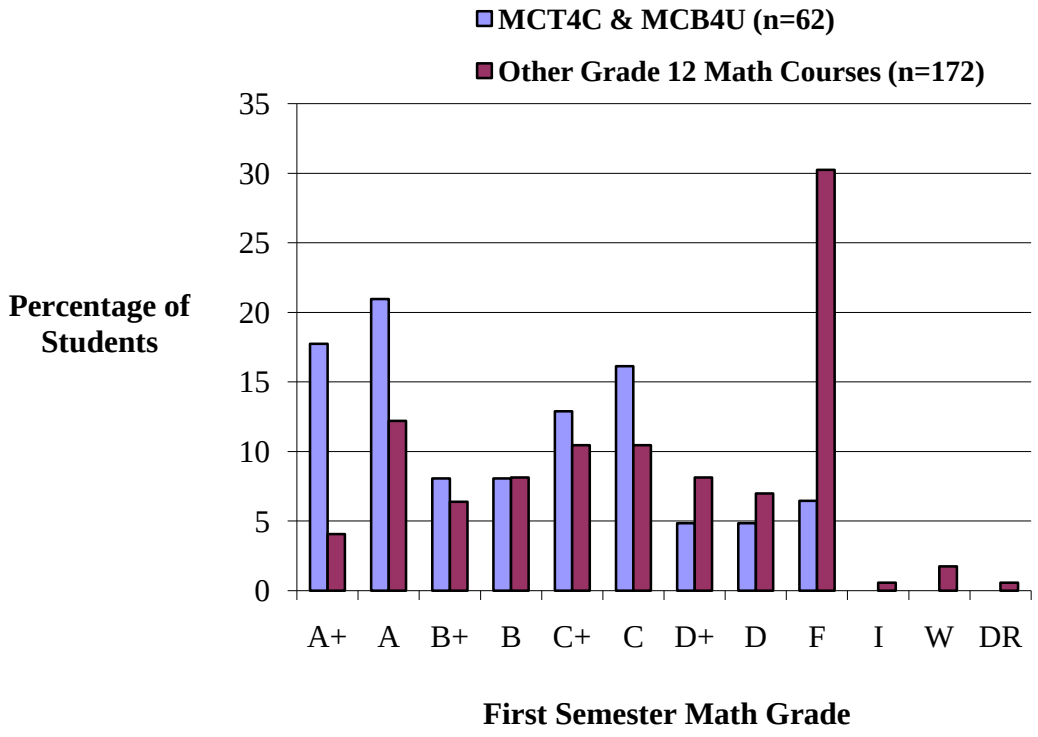
The report goes on to conclude that "the specific choice of Grade 11 courses makes a substantial difference" in first semester college mathematics success, indicating that "many more students who took MCF3M or MCR3U rather than MBF3C in Grade 11 achieved

good grades: 68% compared to 51% for those with MAP4C, and 71% compared to 52% for those with MCT4C" (YSIMSTE, 2007, p.42-43).

Only 3 students (1.28%) of the study sample group took the MBF3C-MCT4C pathway (see Figure 2.5). However, all students who took MCT4C (Grade 12 Mathematics for College Technology), regardless of pathway, passed first semester college math. Likewise, the group of 32 students in the study sample whose high school pathway included MCB4U (Grade 12 Calculus) also exhibited a low failure rate in first semester college math. This finding resonates with those of the CMP 2007 report which finds a "dramatic" difference in success rates between groups who had taken MCT4C in grade 12 and those who took MAP4C. In fact, the CMP report observes that 70% of students who had taken MCT4C achieved good grades (YSIMSTE, 2007, p.41).

Similarly, where U-stream mathematics prerequisites are concerned, it appears that within the CMP study sample, fewer students opted to take 12U courses. Again, achievement among those that did "was uniformly high" (YSIMSTE, 2007, p.41). The current study indicates that only 2 out of 34 (5.9%) students in this group failed college math. Therefore, a pathway leading to either the grade 12 mathematics course MCT4C or MCB4U is desirable for achieving a passing grade in first semester college math. Figure 2.6 shows the grade distribution for groups whose pathways culminated with the courses MCB4U and MCT4C. The relative frequencies of students scoring in the upper grade ranges are higher for students emerging from these two courses compared to the frequencies of grades achieved by students whose pathway included other grade 12 mathematics courses.

Figure 2.6 **Grade Distribution Comparison for Students with MCT4C or MCB4U (n = 62) and other Grade 12 New Curriculum Prerequisites (n = 172)**



2.2.5 College Mathematics Grade Distribution for Students by Grade 11-12 Pathway

The students in the study sample were categorized by grade 11 and 12 pathway in mathematics and their corresponding grade distributions plotted. These results are presented in Figures 2.7a–d. The distributions of students from the six major pathways are shown along with an additional distribution of grades from students whose pathway represented less than 5% of students (Figure 2.7e). The first semester college mathematics grade distributions of students who took the pathways MCR3U-MCB4U (11U-12U), MCF3M–MCB4U (11U/C – 12U) and MCF3M-MCT4C (11U/C–12CT) are right skewed with many students scoring in the upper grade ranges, as expected. These distributions show failure rates of 0% , 12.5% and 0% respectively.

While pathways culminating in MCB4U are highly desirable, data for the Fall 2005 intake reinforces the desirability of MCT4C as a minimum preparation for college math: of the 56

students who took MCT4C in grade 12, none failed first semester college mathematics in the School of Manufacturing Sciences post-secondary programs (Henning, 2007).
The grade distributions for grade 11-12 pathways culminating with the grade 12C mathematics course MAP4C are presented in Figure 2.7d. The grade distributions for the MCR3U – MAP4C (11U – 12C) and MCF3M – MAP4C (11 U/C – 12 C) pathways exhibit mixed results with college mathematics failure rates for these groups of 15.4 % and 16.2 % respectively. The pathway MBF3C–MAP4C (11C – 12C) was by far the most popular pathway taken by students from the study group (100 out of 234 students). Of the group that chose this pathway, 43.0% of students experienced failure in first semester college technology mathematics. This was by far the greatest proportion of failures of any of the six common pathways studied. Henning (2007) documents the effect of grade 12 mathematics courses on first semester college mathematics achievement. The number of students who had taken the grade 12 mathematics MAP4C was the largest proportion of the total intake in the Fall of 2005 (140 of 386 students or 36.3%). Likewise, the failure rate of students who had taken that course prior to entering college was 20.7%, the highest of any grouping from a grade 12 or OAC mathematics course (Henning, 2007).

Figure 2.7a **Grade Distribution for Students (n = 18) who Pursued MCR3U-MCB4U Pathway (11U - 12U)**

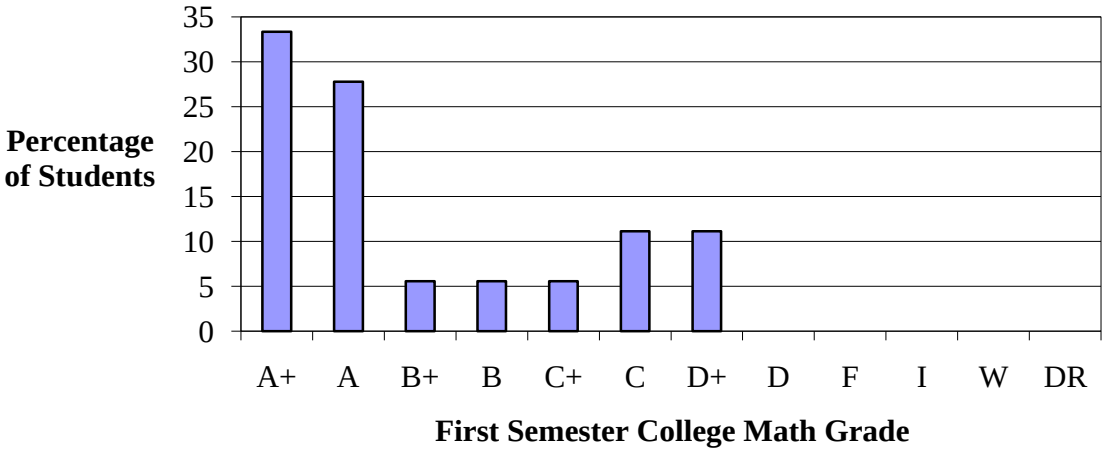


Figure 2.7b **Grade Distribution for Students (n = 16) who Pursued MCF3M - MCB4U Pathway (11U/C - 12U)**

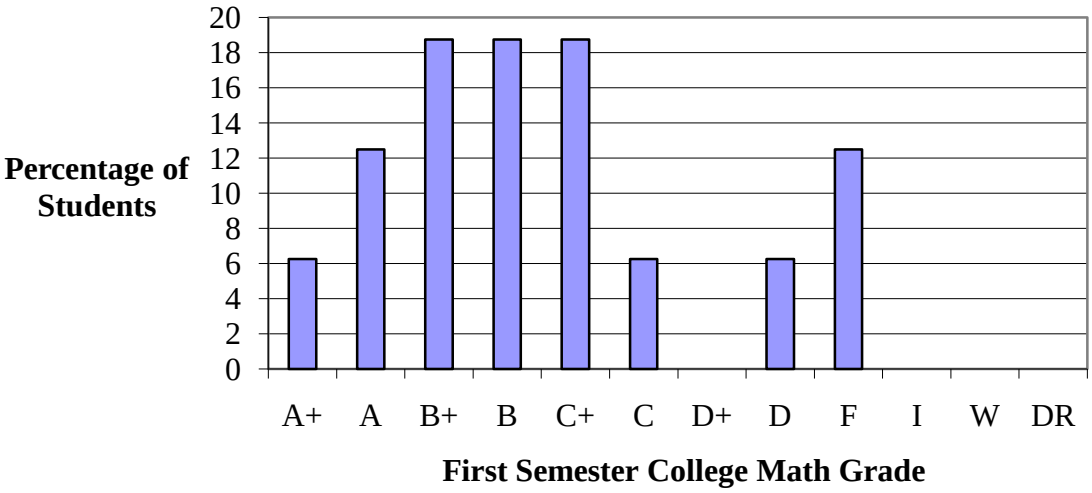


Figure 2.7c **Grade Distribution for Students (n=18) who Pursued MCF3M - MCT4C Pathway (11U/C - 12CT)**

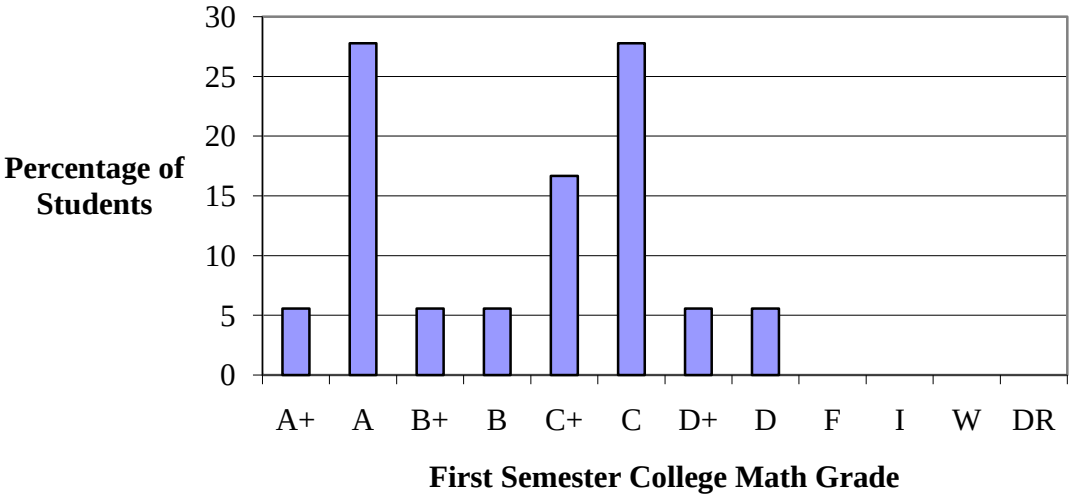
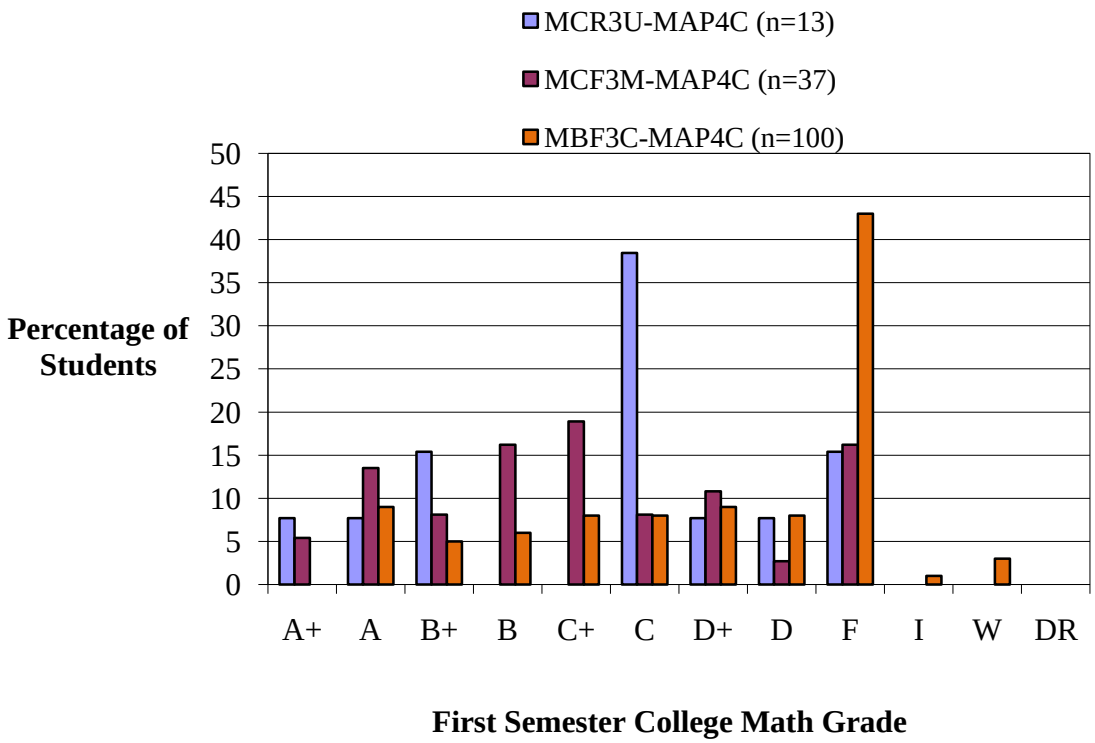


Figure 2.7d

Grade Distribution for Students whose Grade 11-12 Pathway included MAP4C (n=150)



2.2.6 Progress of Students from Other New Curriculum Grade 11-12 Pathways

The distribution in Figure 2.7e shows the number of students who took less popular pathways through grade 11 and 12 high school mathematics. These samples represent groups of less than 5% of the students in the study sample (n= 234). Combined, this group represents a total of 13.7% of all students included in the study sample. From Figure 2.7f, it is evident that most of these students fared well in their first college mathematics with almost half (15 of 32 or 46.9%) of the students scoring a B+ or better in their first semester college mathematics course.

Figure 2.7e **Grade 11-12 Pathways Taken by Less than 5% of Students (n=32 or 13.7 % of Study Sample)**

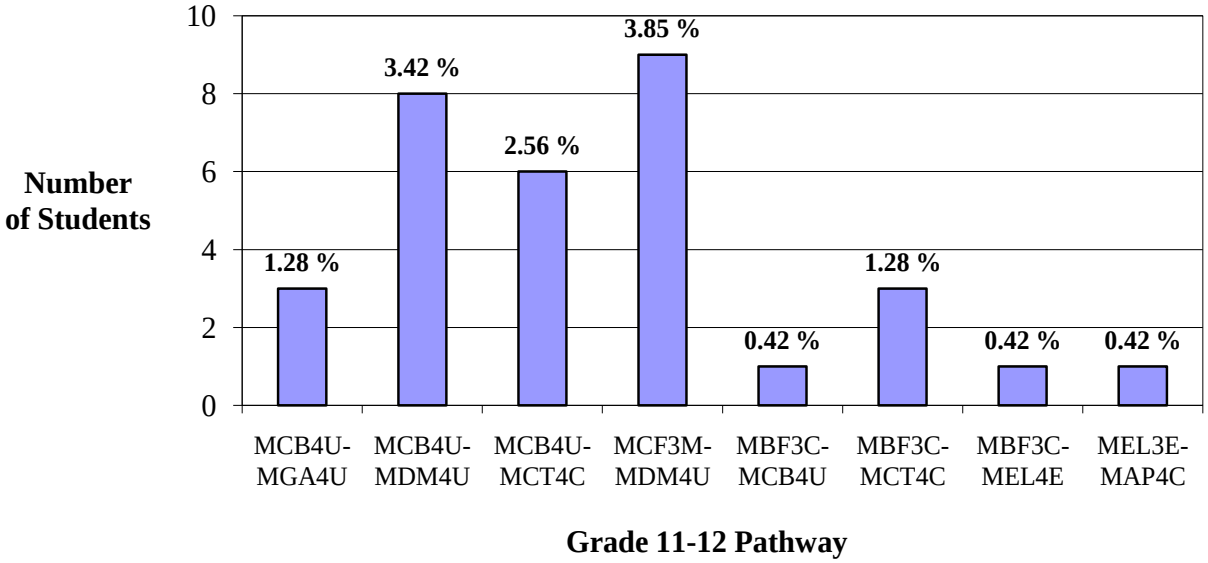
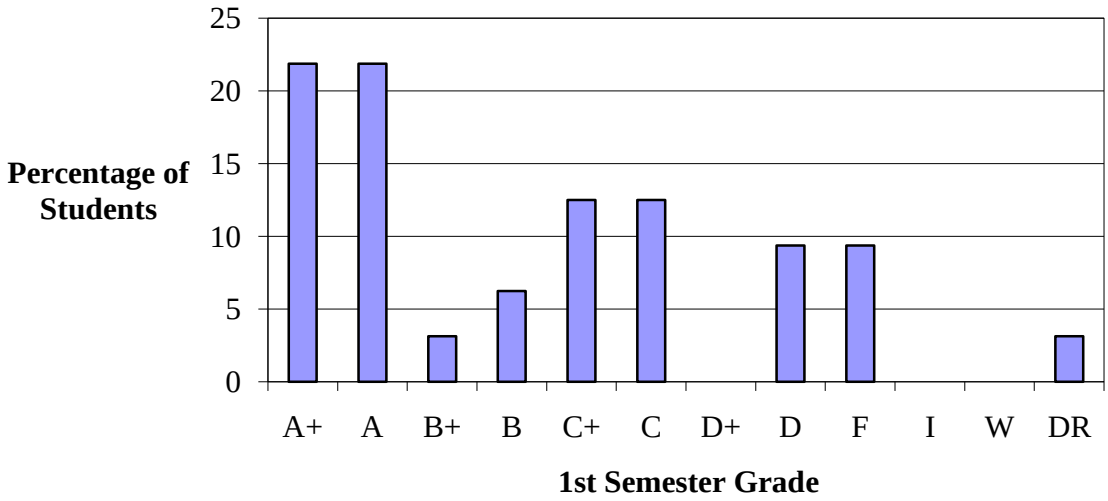


Figure 2.7f **Grade Distribution for Students (n = 32) who Took Other Grade 11-12 New Curriculum Pathways**



2.3 Diagnostic Test Score Distributions

The following discussion begins with the analysis of the results of all students who wrote one or both diagnostic tests. This is followed by an analysis of the results attained by the students in the study sample (n = 234) in relation to their first semester college mathematics course final grades.

2.3.1 Comparison of the Score Distributions of Diagnostic Tests 1 and 2

A total of 356 and 368 students wrote the first and second diagnostic tests, respectively. The score distributions for each test are presented in Figure 2.8a and 2.8b below.
The distribution for test 1 scores is fairly normal with a mean score of 14.7 out of 30 and a skewness of +0.080. The distribution of test scores for the second diagnostic test exhibits a mean score of 20.9 marks out of 30 and is left skewed (-0.733). The higher mean score on the second test is expected since the students were given a review of the test topics in the intervening period between the first and second tests.

Figure 2.8a

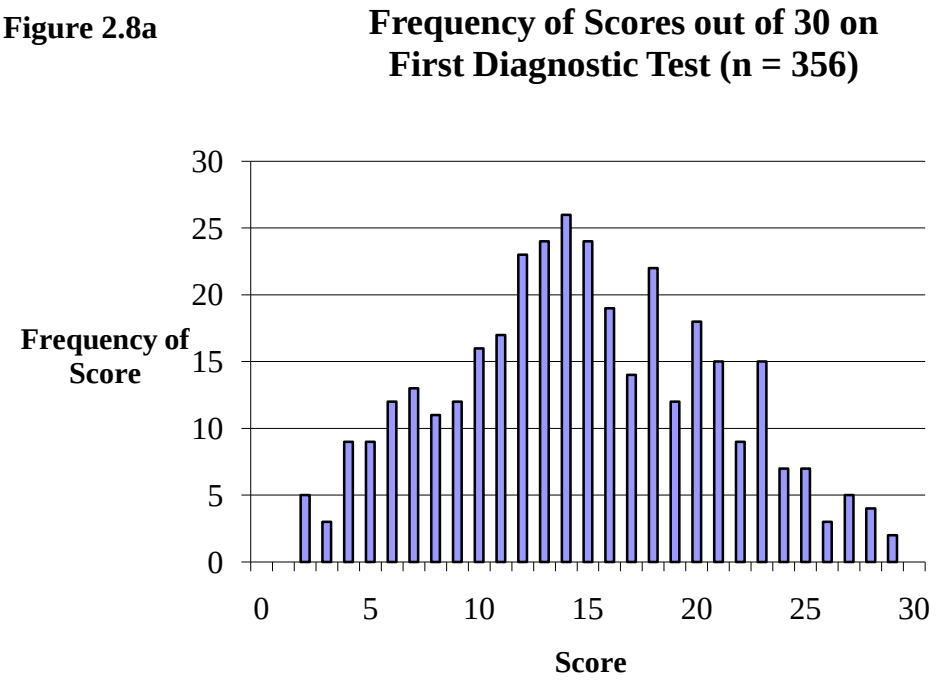


Figure 2.8b **Frequency of Scores out of 30 on Second Diagnostic Test (n = 368)**

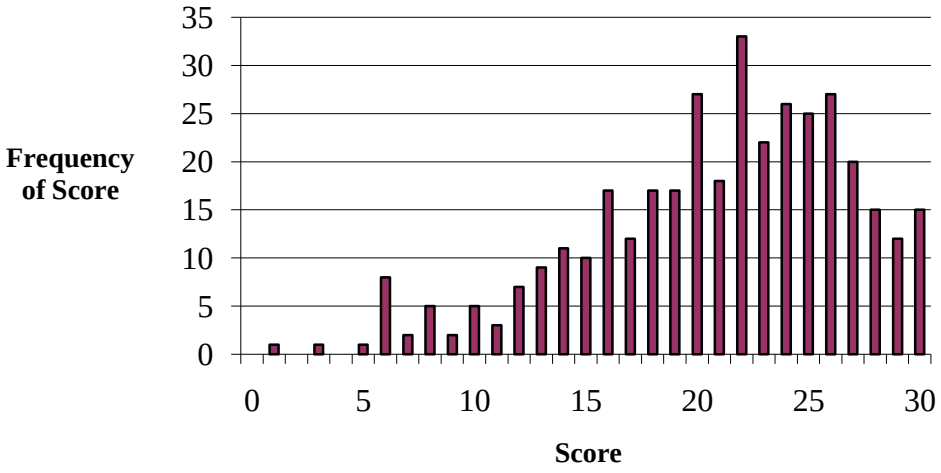


Table 2.4 below provides a list of topic sections covered on each of the diagnostic tests while Table 2.5 provides a breakdown of student performance on each section of the two tests.

Table 2.4 Description of Topic Sections on the Diagnostic Tests

Section	Description
i	operations with signed numbers
ii	addition and subtraction of numeric fractions
iii	multiplication and division of numeric fractions
iv	operations with percentages
v	solution/rearrangement of simple equations

Table 2.5 Average Scores on Diagnostic Tests 1 and 2

	Possible Marks per Section					Total
	(i) 4	(ii) 6	(iii) 4	(iv) 6	(v) 10	30
Average Score Test 1	2.17 (54.2%)	3.97 (66.2%)	1.09 (27.2%)	3.09 (51.5%)	3.99 (39.9%)	14.3 (47.7%)
Average Score Test 2	2.82 (70.6%)	4.79 (79.8%)	2.64 (65.9%)	4.26 (70.9%)	5.80 (58.0%)	20.3 (67.7%)
Δ%	16.5%	13.6%	38.7%	19.4%	18.1%	20.0%

Table 2.6 below gives a comparison of average marks achieved by the study sample and the larger groups which wrote either or both diagnostic tests.

Table 2.6 A Comparison of Results from Diagnostic Tests 1 and 2 for the Groups Who Wrote Each Test and the Study Sample

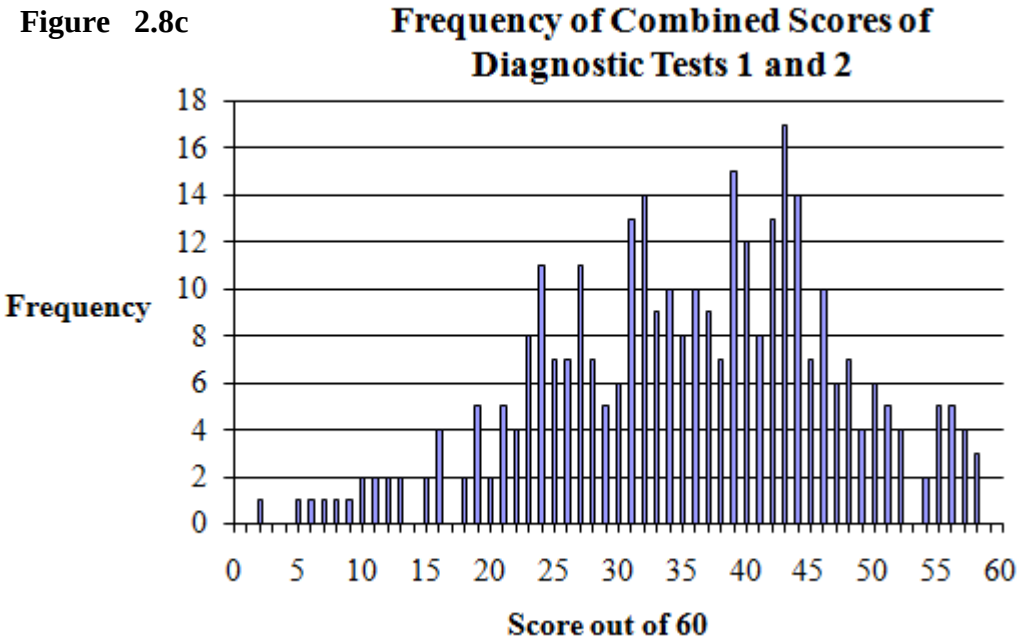
Sample		Mean Mark (out of 30)	Mean Mark %	Standard Deviation
Diagnostic Test 1	**n = 356**	14.7	49.0	6.1
	Study Sample (n = 234)	14.3	47.7	5.9
Diagnostic Test 2	**n = 368**	20.9	67.7	5.9
	Study Sample (n = 234)	20.3	67.8	5.8

Totals of 356 and 368 students wrote diagnostic tests one and two respectively. It is clearly evident that the mean marks and standard deviations of the score distributions of the group of students who wrote both tests and the study sample are very close. As a result, inferences drawn from the study sample data would likely hold for samples outside of that group.

2.3.2 Distribution of the Combined Scores of Diagnostic Tests 1 and 2

A total of 327 students wrote both diagnostic tests 1 and 2. The frequency of combined scores of tests 1 and 2 (out of 60 possible marks) is given in Figure 2.8c. This distribution exhibits a mean score of 35.6 out of a possible 60 marks (59.3%) with a standard deviation of 11.3 and skewness of -0.332. The study sample has a mean of 34.6 marks (57.7%) for the combined diagnostic test score distribution with a standard deviation of 11.0 marks and skewness of -0.318.

Figure 2.8c



2.4 Analysis of Diagnostic Test Scores

The following discussion analyzes diagnostic test scores, grade 11-12 high school new curriculum pathways and first semester college mathematics grade outcomes for the study sample group (n=234).

2.4.1 Analysis of Diagnostic Test Results by Combined Score

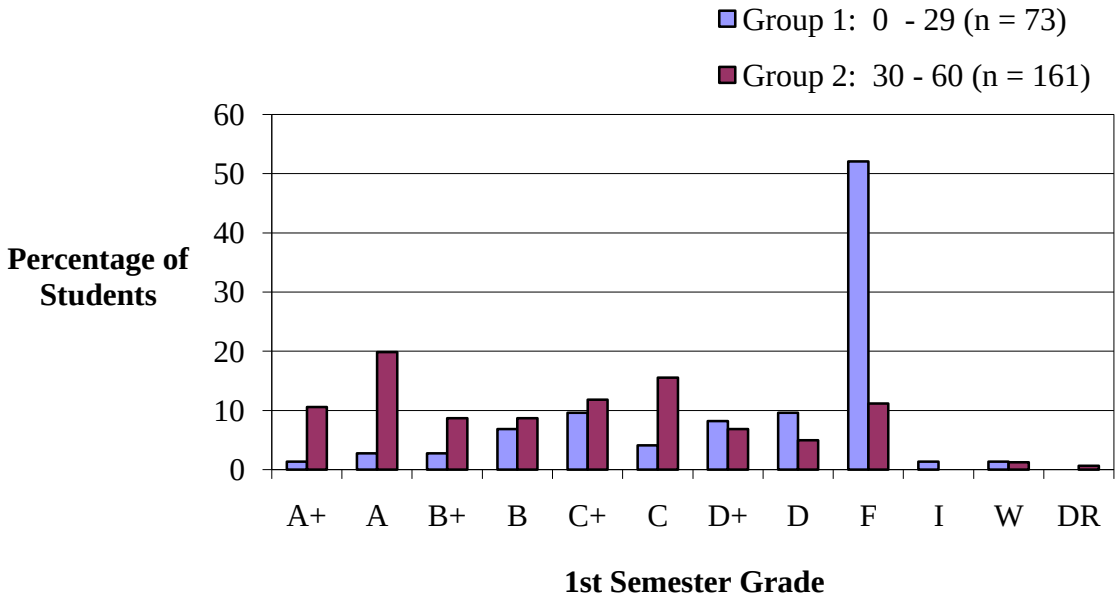
After studying the marks on diagnostic tests 1 and 2, it was apparent that the simplest method of assessing their impact on various outcomes in first semester mathematics was to combine these test scores.

2.4.2 College Mathematics Grade Outcomes for Students with Combined Diagnostic Test Scores of Less Than 50%

This analysis examines the outcomes of the study sample group in first semester college mathematics based on a passing grade of 30 out of a possible 60 marks for the combined diagnostic test scores. Of the study sample, 73 students out of 234 (31.2 %) scored less than 30 out of 60 while 161 students (68.8%) scored 30 or greater. The first semester mathematics grade distribution for the study sample having combined scores in the ranges 0 to 29 and 30 to 60 are shown in Figure 2.9. The group (n=73) with combined scores in the lower range (0-29) exhibit a large number of failing and "at risk" grade outcomes after first semester, as expected. Specifically, this group (n=73) exhibited a failure rate of 52.1% while 83.6% of this group had grade outcomes in the lower end of the grade range (F to C+).

Within this group (n=73), the students were also ranked by their improvement between tests 1 and 2. Those students (n = 13) who improved their mark between tests by 10 marks or greater, but still scored less than 30 marks overall, showed a slight decrease in failure rate (38.5%) versus the remainder (n = 60) whose failure rate was 55.0%. As expected, the group exhibiting combined scores in the 30 to 60 range typically performed well in first semester college math. Only 11.2% of the group scoring in the range 30 to 60 finished with F grades in mathematics.

Figure 2.9 **Grade Distribution for Study Sample Students with a Combined Diagnostic Test Score of 0 - 29 and 30 - 60**



2.4.3 Further Analysis of Results

The results of the combined diagnostic test scores were further broken down by decades so that trends within the larger groups described above might be evident. Since it is clear that the pathway taken in grade 11 and 12 high school mathematics has a significant bearing on student final grades in first semester mathematics, the frequency of students in various pathways is presented along with the grade distributions for each decade of test scores in Figures 2.10a–2.15a. The frequency of students from each high school grade 11-12 pathway is further subdivided by categories of technician and technology streams.

2.4.4 Score Ranges 0 - 9, 10 – 19 and 20 - 29

Figures 2.10a, 2.11a and 2.12a illustrate remarkably high failure rates for these groups in the range of 40-60%. Further the majority (82.2%) of these students is from the technician stream. Figures 2.10b, 2.11b and 2.12b show that the pathway MBF3C-MAP4C is taken by a majority of students in grades 11 and 12 mathematics.

2.4.5 Score Ranges 30 - 39

Figure 2.13a illustrates grade outcomes for the group of students with combined scores in the first decade of results in the passing range, 30-39. For this group of students, a significant drop in first semester college mathematics failure rates is evident (13.3% for the technician stream and 19.4% for the technology stream students in this group). Even though the MBF3C-MAP4C pathway still represents the single most popular pathway, it now represents only 42.6% of technician stream and 29.9% of technology stream students, in this group.

2.4.6 Score Ranges 40 - 49

The grade distribution corresponding to the group in the score range 40-49 (Figure 2.14a) shows a continuing downward trend in the frequency of F grades in college mathematics (5.4% and 12.9% for technician and technology streams respectively). The pathways representing these students are evenly mixed as is evident in Figure 2.14b. The proportion of students who emerged from the MBF3C–MAP4C pathway dropped further to 16.2% of the total number of students in this group. Interestingly, the proportion of students from pathways other than the six common pathways is quite high. In fact, the proportion of technology stream students from this pathway grouping is the largest for this score range.

2.4.7 Score Ranges 50 - 59

The grade distribution for the group of students with a combined score in the range of 50-60 is skewed heavily to the right, as expected. The lowest final mathematics grade achieved by students who finished first semester mathematics in this group is C+. A large proportion of students in this test score range had taken the grade 11 U or U/C mathematics courses. No students in this group took the MBF3C – MAP4C pathway.

Figure 2.10a **Grade Distribution for Technician (n = 5) and Technology (n = 0) Students with a Combined Diagnostic Test Score of 0 - 9**

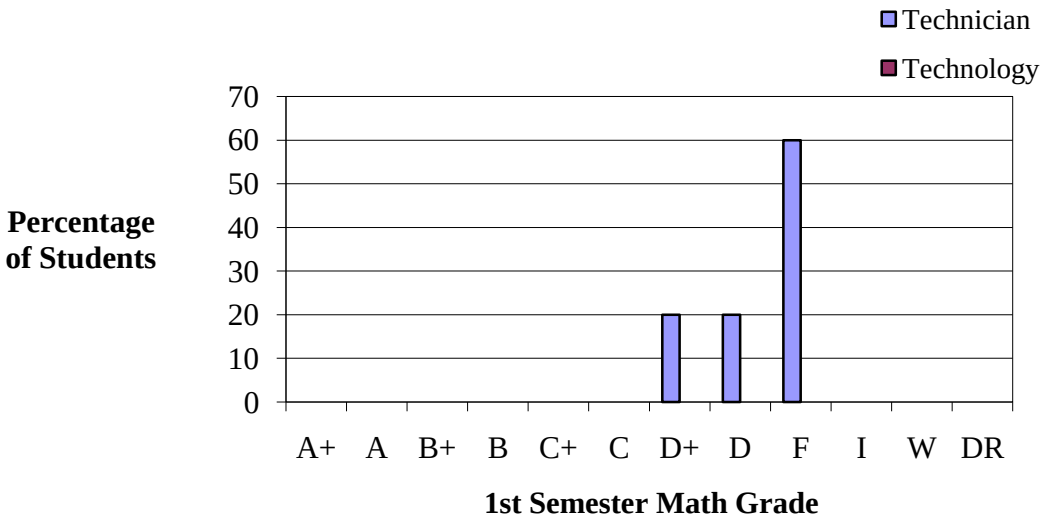


Figure 2.10b **Grade 11-12 Pathways of Technician (n=5) and Technology (n=0) Students with a Combined Diagnostic Test Score of 0 - 9**

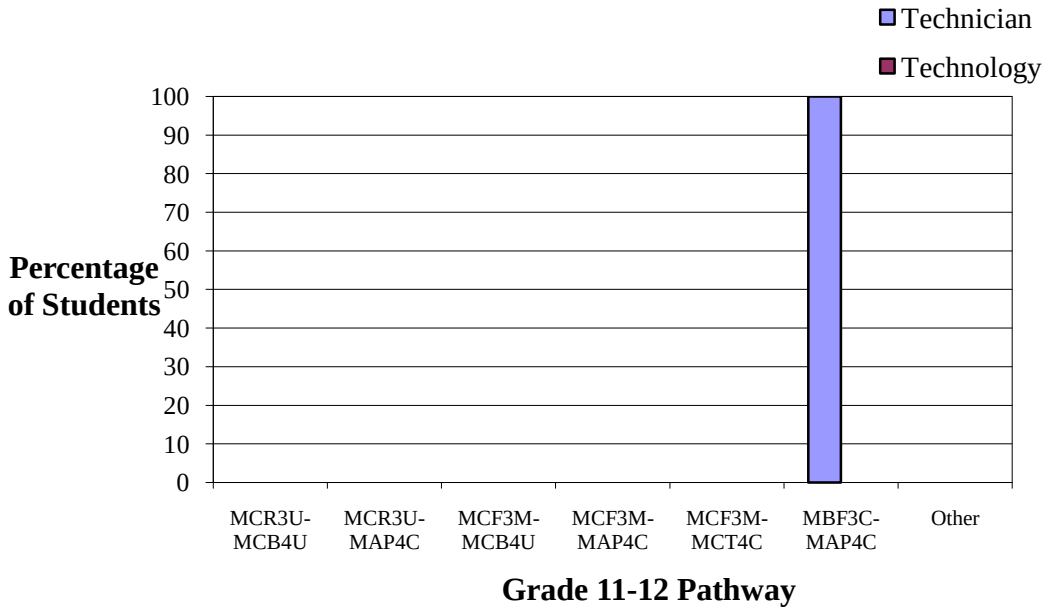


Figure 2.11a **Grade Distribution for Technician(n=14) and Technology (n=1) Students with a Combined Diagnostic Test Score of 10-19**

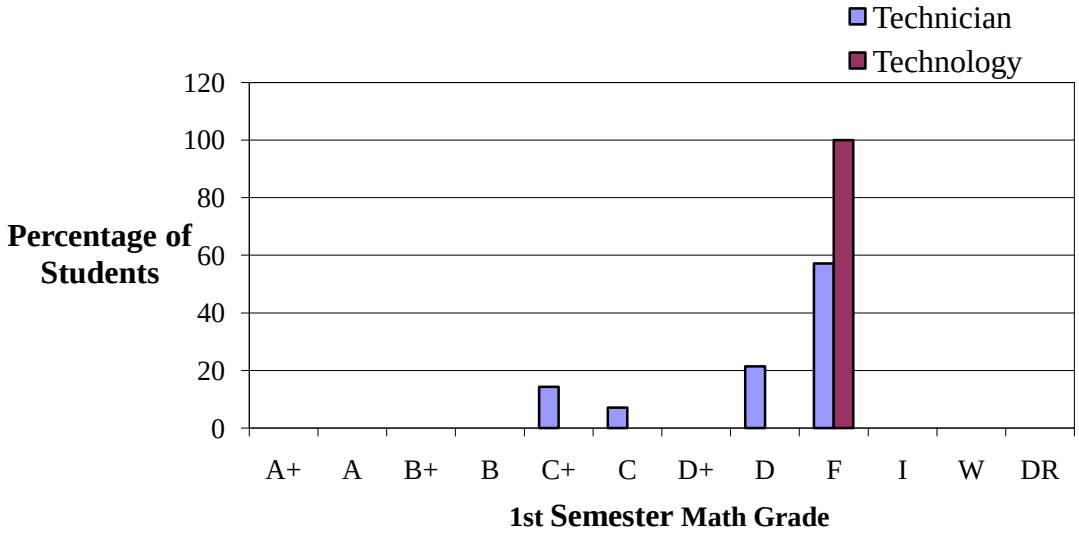


Figure 2.11b **Grade 11-12 Pathways of Technician (n=14) and Technology (n=1) Students with a Combined Diagnostic Test Score of 10-19**

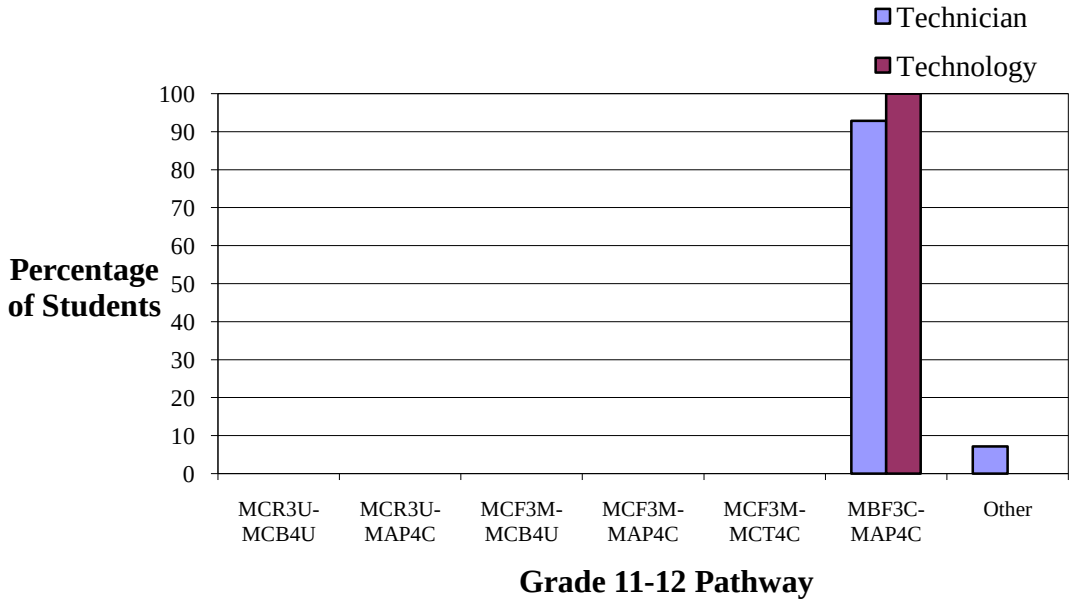


Figure 2.12a **Grade Distribution for Technician (n=41) and Technology (n=12) Stream Students with a Combined Diagnostic Test Score of 20-29**

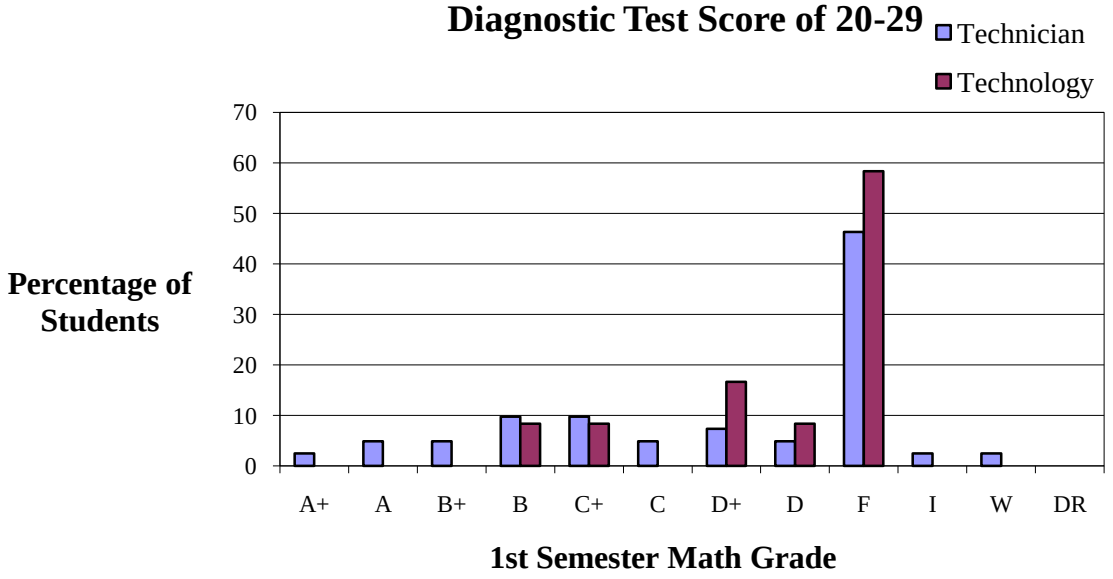


Figure 2.12b **Grade 11-12 Pathways of Technician (n=41) and Technology (n=12) Stream Students with a Combined Diagnostic Test Score of 20-29**

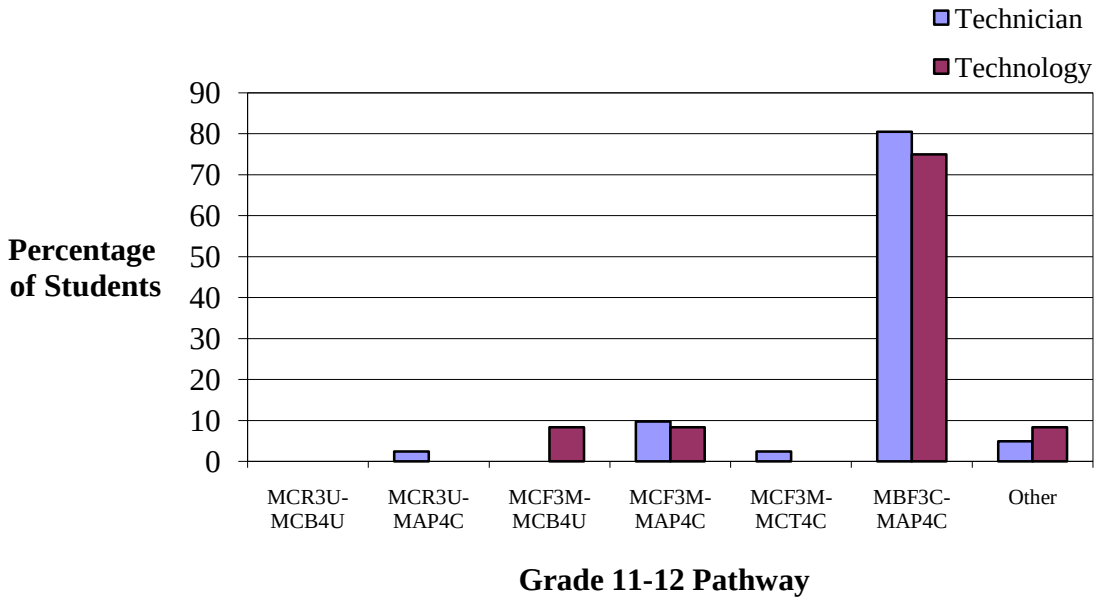


Figure 2.13a **Grade Distribution for Technician (n=45) and Technology (n=31) Stream Students with a Combined Diagnostic Test Score of 30-39**

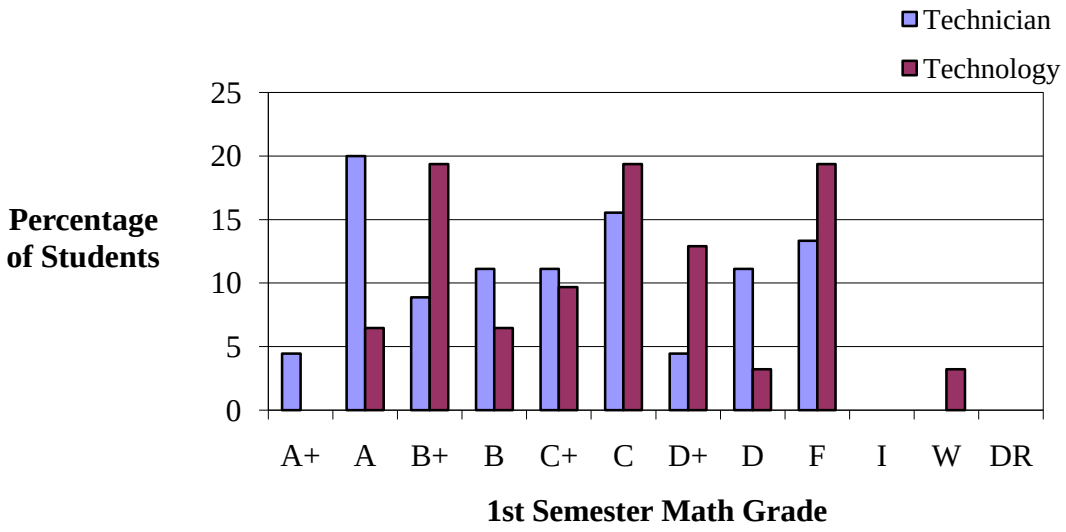


Figure 2.13b **Grade 11-12 Pathways of Technician (n=45) and Technology (n=31) Stream Students with a Combined Diagnostic Test Score of 30-39**

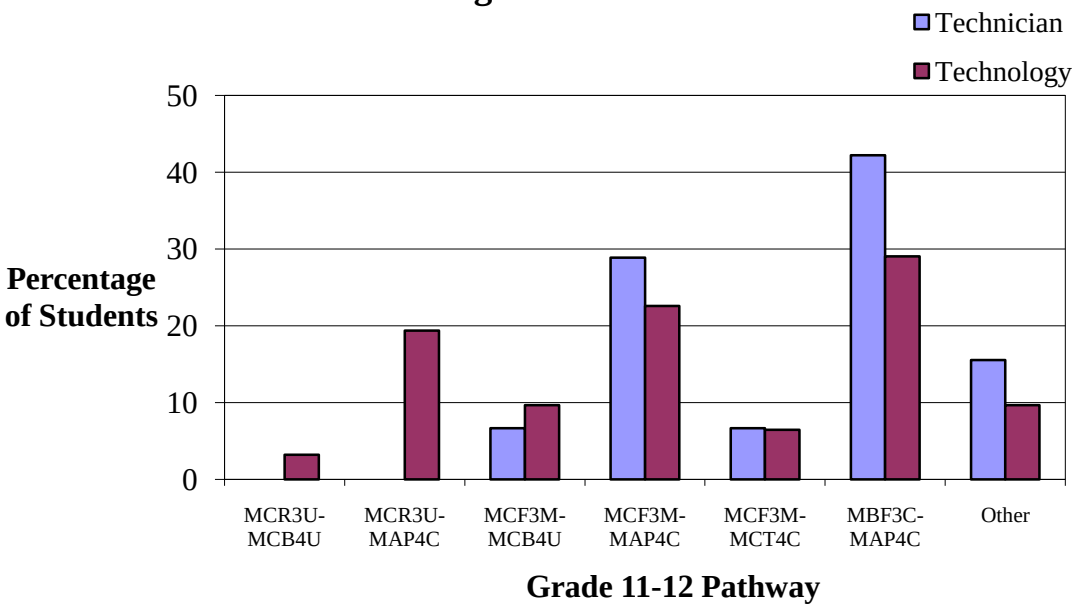


Figure 2.14a **Grade Distributiuon for Technician (n=37) and Technology (n=31) Stream Students with a Combined Diagnostic Test Score of 40-49**

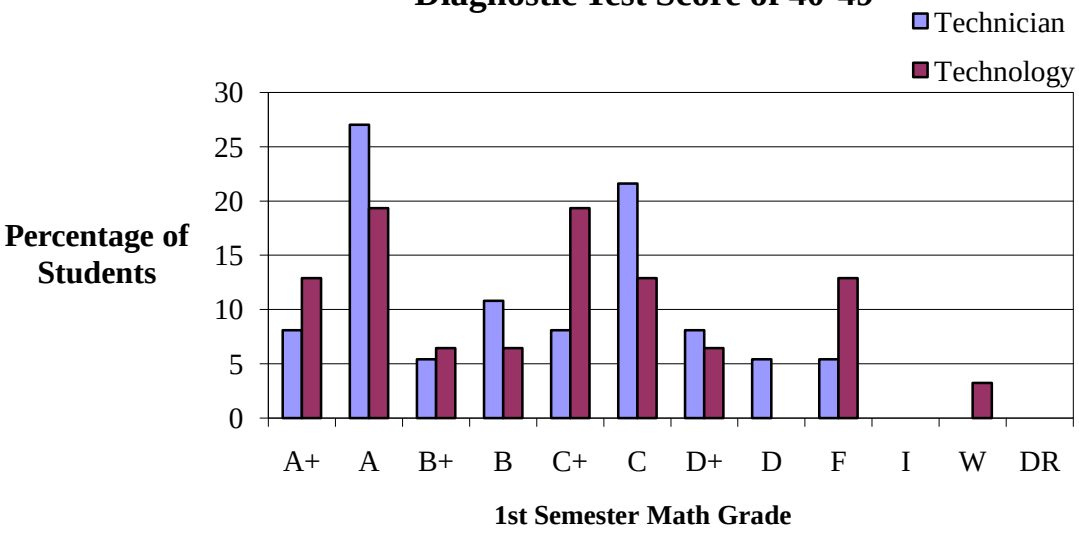


Figure 2.14b **Grade 11-12 Pathway for Technician (n=37) and Technology (n=31) Stream Students with a Combined Diagnostic Test Score of 40-49**

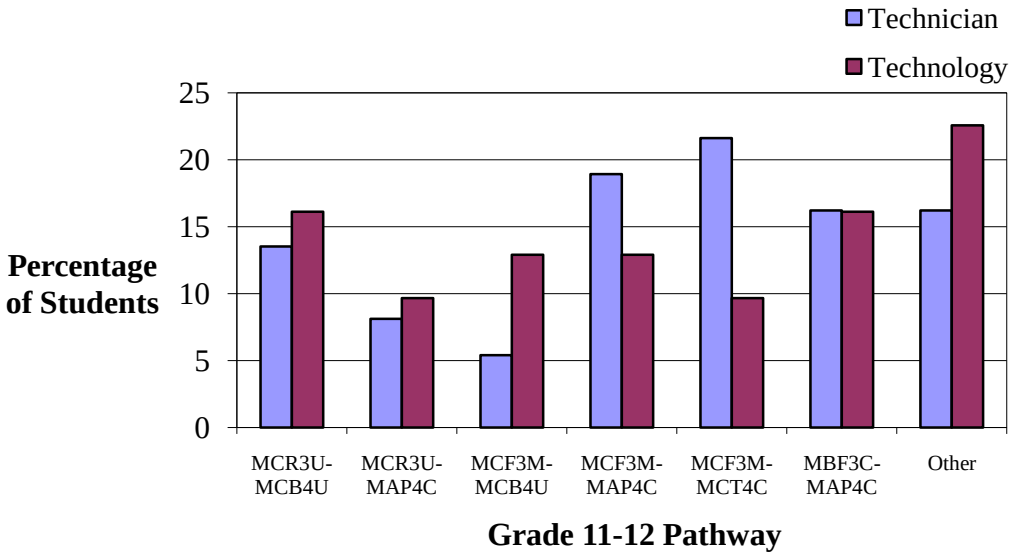


Figure 2.15a **Grade Distribution for Technician (n=8) and Technology (n=9) Stream Students with a Combined Diagnostic Test Score of 50-60**

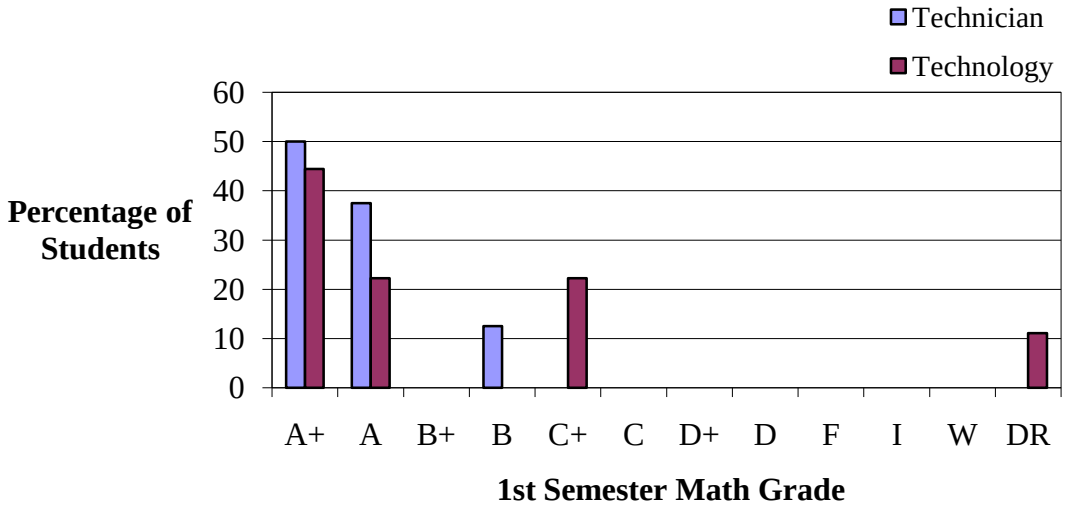
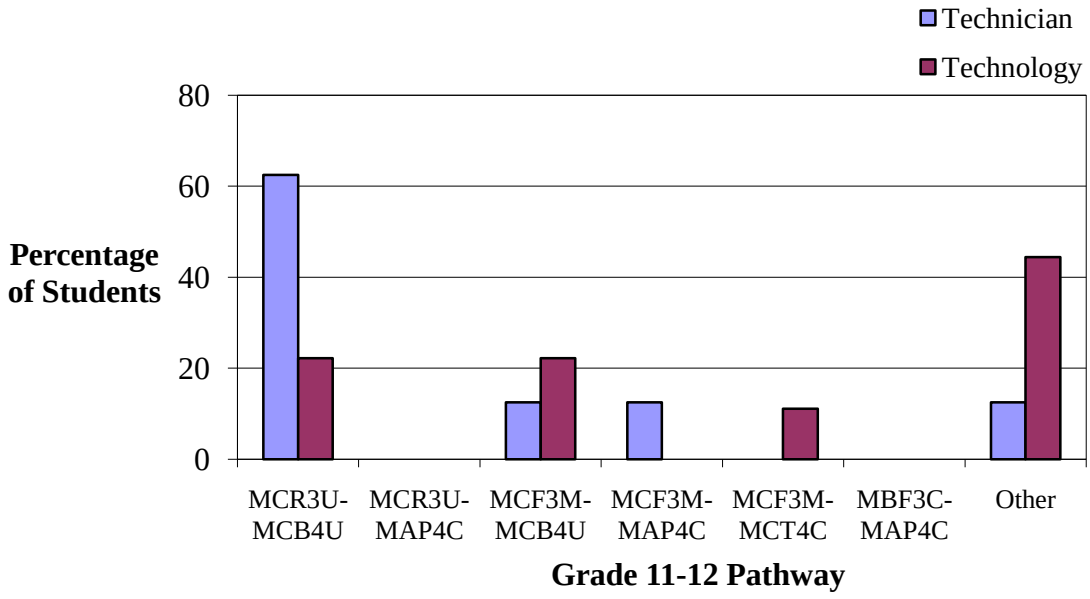


Figure 2.15b **Grade 11-12 Pathway of Technician (n=8) and Technology (n=9) Stream Students with a Combined Diagnostic Test Score of 50-60**



2.5 Diagnostic Test Scores and Pathway for "At Risk" Students

Table 2.7 provides the grade outcomes in the lower end of the grade range for the group of students who scored less than 30 out of 60 marks on the combined diagnostic tests. Of the group (n=56) who failed first semester college technology mathematics, 38 or 67.9% of these students scored less than 30 out of 60 on the combined diagnostic tests. From the study group (n = 234), a sample of all students who achieved first semester mathematics grades in the range F, D, D+, C, C+ was chosen to investigate the effect of high school pathways in mathematics. First semester mathematics grades in this range indicate "at risk" tendencies. The previous analyses highlight the unsuitability of the MBF3C–MAP4C pathway as a preparation for students entering post-secondary programs in the School of Manufacturing Sciences.

Table 2.7 also allows a comparison of student achievement in first semester mathematics at the lower end of the college grade scheme with the numbers of students who emerged from the MBF3C–MAP4C pathway. An unacceptably large number of students who failed first semester college technology mathematics progressed from the MBF3C–MAP4C pathway (43 out of 100 or 43%). Further, 53.1% of students who achieved college mathematics grades of D or D+ took this same pathway.

Table 2.7 MBF3C–MAP4C Pathway, Failing Diagnostic Test Scores and "At Risk" Tendencies in Mathematics

	C/C+ (n = 54)	**D/D+ (n = 32)**	**F (n = 56)**
Number of Students in Pathway MBF3C-MAP4C (n=100)	16 (29.6%)	17 (53.1%)	43 (76.8%)
Number of Students who Scored < 30 out of 60 (n=73)	10 (18.5%)	13 (40. 6%)	38 (67.9%)

2.6 Trends in Failure Rates

Data collected for three consecutive Fall student intakes (2005-2007) of the School of Manufacturing Sciences post-secondary programs shows a steady increase in failure rates in first semester college math. Table 2.8 provides a breakdown of failure rates over three Fall terms for the intake group of the technician and technology streams. Within the School of Manufacturing Sciences a partial transition from 14 to 18 week semesters commenced in the Fall of 2007. Currently, the School offers a mixture of 14 and 18 week semester programs. As a result, the data concerning failure rates has been further analyzed by semester duration.

Table 2.8 Failure Rates for Three Intake Years: Fall 2005, Fall 2006, Fall 2007

	Fall 2005	**Fall 2006**	**Fall 2007**		
Stream			**14 Week Group**	**18 Week Group**	**Combined (14 +18 wk)**
Technician	15.2 % (n = 250)	12.6 % (n = 215)	18.7 % (n = 91)	33.1 % (n = 124)	27.0 % (n = 215)
Technology	6.6 % (n = 136)	15.6 % (n = 154)	16.1 % (n = 56)	25.0 % (n = 64)	20.8 % (n = 120)
Overall	12.7 % (n = 386)	13.8 % (n = 369)	17.4 % (n = 147)	30.3 % (n = 188)	24.8 % (n = 335)

Although failure rates in first semester mathematics for the technician stream dipped slightly between 2005 and 2006, the trend of a gradual increase in failure rates is evident over the three intake years 2005, 2006 and 2007. Students enrolled in 18 week semester programs exhibited higher failure rates than their counterparts in 14 week semesters for the Fall 2007 term.

3.0 Conclusions

3.1 Diagnostic Testing

Whereas both Cluett et al. (2009) and Henning (2007) suggest that results of a single diagnostic test prove to be inconclusive in predicting grade outcomes in first semester college mathematics, the results of the two-step approach to diagnostic testing provide a highly effective predictive tool for this purpose. Of the group of students in the current study who failed first semester technology mathematics, 67.9% scored less than 30 out of 60 on the combined diagnostic tests.

3.2 High School Grade 11-12 Pathways

Regarding student preparedness, the high school grade 11-12 pathway through the new curriculum mathematics program is the most significant factor that affects success of the intake group as a whole. Students who take pathways which culminate in grade 12U or 12CT mathematics are typically well-prepared for first semester college technology mathematics. Both this study and YSIMSTE (2007) similarly show that students who chose the MBF3C–MAP4C pathway were the least well-prepared of all common pathway groups for first semester college mathematics and experienced the highest failure rates in both technician and technology streams at college. In particular, 43% of the students in the study group who took the pathway MBF3C-MAP4C failed first semester college technology mathematics. Therefore, of the number of students in this sample who failed first semester technology mathematics (n=56), 76.8% had taken this pathway.

Conversely, students who took a grade 11-12 pathway culminating in 12U (MCB4U) or 12CT (MCT4C) mathematics were the best prepared for success in college technology mathematics.

The CMP report offers a detailed look at the implications of academic versus applied stream grade 9/10 course selection for college mathematics grades and finds that: "Most students (71.7%) who followed the academic pathway through grades 9 and 10 received good grades in college; that number dropped to 48.7% when corresponding applied courses were selected" (YSIMSTE, 2007, p.38). Further, both the current study

and the YSIMSTE (2007) report share similar conclusions concerning the implications surrounding pathways chosen in grades 9 and 10. Based on the trajectory of grade 9 and 10 students, the current study finds that students who take the grade 10 applied stream mathematics course typically transition to grade 11C (MBF3C) and in turn, invariably opt for the grade 12C (MAP4C) mathematics course. Therefore, the foundations for students taking the undesirable pathway MBF3C-MAP4C are established in grade 9 or earlier.

3.3 Mathematics for College Technology

Too few high school students who are aiming for entry into post-secondary technology programs at the college level are taking the college mathematics designed for this purpose, namely Mathematics for College Technology (MCT4C).

3.4 Stream

A disproportionate number of students in technician stream programs experience failing grade outcomes in first semester technology mathematics in the School of Manufacturing Sciences post-secondary programs

3.5 Semester Length

Students who were enrolled in programs with 14 week semesters failed mathematics at a lower rate than their counterparts in 18 week semesters during the Fall semester of 2007 in both technician and technology streams. Data was analyzed for a single intake and, therefore, a study of these outcomes should be tracked further.

4.0 Recommendations

4.1 Diagnostic Testing

High school mathematics marks alone have been found to be an inconclusive indicator of success in first semester college mathematics (Henning, 2007), (Geyser & Santelices, 2007). A University of California, Berkeley study published in 2007 found that: "The most fully-specified prediction model presented in this study… indicates that HSGPA, SAT scores and other factors known at admissions together account for only about 30% of the total variance in cumulative college grades–leaving 70% unaccounted for and unexplained (Geyser & Santelices, 2007, p.25).

As a result, it is recommended that Fanshawe College's Faculty of Technology implements a system to deliver two-step diagnostic testing as part of its Fall term operations. The results of these tests would provide the basis for decisions concerning intervention strategies for helping "at risk" first semester students in all college post-secondary programs containing significant mathematics components.

Based upon similar experience at other colleges in Ontario, the results of this study and YSIMSTE (2007) findings, the Ontario college system would benefit by adopting "a common and appropriate assessment tool, based on systematic analysis of the new secondary school courses and first semester college courses, to enable early diagnosis and appropriate remediation of students' mathematical skills" (YSIMSTE,2007, p.61).

The results of the diagnostic test would form the basis of interventionist strategies formulated by the colleges to ensure student success in first semester mathematics courses. Although many colleges in the Ontario system offer academic support to students in several disciplines including mathematics, only a small percentage of students utilize these offerings. The *Pan-Canadian Study of First Year College Students Report 1* finds that "few first-term students make use of these services with any regularity" (Association of Canadian Community Colleges & Human Resources and Social Development Canada , 2007, p.50). In assessing student tendency to voluntarily access college academic support services in mathematics, the study found that "85% of respondents confirmed they never used mathematics skills services offered by their

college or institute" (Association of Canadian Community Colleges & Human Resources and Social Development Canada, 2007, p.50).

Therefore, it is recommended that the College explore ways to encourage students who are struggling in mathematics to access existing academic help services.

4.2 High School Mathematics Programs

It is recommended that high school guidance counsellors and mathematics teachers apprise students that their chances for success in post-secondary studies in college first semester technology mathematics programs are enhanced by taking a pathway which includes grade 11U (MCR3U) or 11U/C (MCF3M) mathematics courses. Students who are bound for technology level programs should be encouraged to take pathways culminating in grade 12CT (MCT4C) mathematics. Minimally, students entering technician level programs should be counselled to take one of the two aforementioned grade 11 mathematics courses as preparation for grade 12 mathematics. Further, it is recommended that the Heads of Technology in the Ontario college system revise minimum entrance standards for technology programs based on these suggestions.

4.3 Program and Career Counselling

Fanshawe College should expand its role in communicating proven strategies for success in college technology programs to the high schools. This study, along with Cluett et al. (2009), Henning (2007) and YSIMSTE(2007) provide a body of evidence for suggesting that certain pathways through high school mathematics programs are preferable, from a success standpoint.

Although, Fanshawe College has engaged regional school board mathematics teachers and counsellors using informal forums to discuss problem areas in mathematics education and preparation for college, the sharing of key elements of this research with these school boards using formalized communication links and appropriate literature is advisable.

The *Pan-Canadian Study of First Year College Students Report 1* (Association of Canadian Community Colleges & Human Resources and Social Development Canada , 2007)

questions whether college applicants are aware of the career path afforded by chosen programs. With regard to career counseling, it found that 65% of respondents (first year students enrolled in college programs) reported that they could benefit from support in selecting a career: "A substantial percentage of respondents confirmed that they did not have intensive exposure to career guidance and information prior to beginning their college/institute programs, nor did they spend much time exploring the type of work they would likely be doing upon graduation" (Association of Canadian Community Colleges & Human Resources and Social Development Canada, 2007, p.60).

With relation to high school mathematics course pathways, both the current study and the *College Mathematics Project 2007 Final Report* speculate that many students opt for high school mathematics courses in which they expect high grades in preference to courses which, while often more challenging, provide a better preparation for first semester college mathematics (YSIMSTE, 2007, p.60).

4.4 Failure Rates

While the failure rates for both the technician and technology streams is unacceptably high, it is apparent that technician program students fail first semester college mathematics in larger proportions than the technology stream students. The current study and Henning (2007) detail this trend, indicating that further investigation of this problem should be carried out.

This study also found that students enrolled in programs delivered in a 14 week semester format fare better in first semester college mathematics than their counterparts in 18 week semester programs. Further study of this observation is required in order to determine whether the trend continues.

4.5 Looking Forward

In general, a disconnect exists between the level of preparation in mathematics of high school graduates applying to college and the expectations of first semester technology mathematics programs. Although discussion surrounding the modification of program

mathematics prerequisites has begun for faculties of technology in the Ontario college system, a voluntary bridging opportunity for students who have taken MAP4C should be offered by the college to allow candidates to upgrade themselves. The problem of insufficient preparation in mathematics is not unique to School of Manufacturing Sciences program applicants. A remedial program would likely run during the summer prior to entry into Fall semester programs and should be available to all college entrants taking first semester college mathematics.

Appendix 1

Course Code , Level and Description of Grade 12/OAC Mathematics Courses from the Ontario High School Curriculum Pre-2002

Course Code	Level	Description
MAT4A	Grade 12	Advanced Math
MTT4G	Grade 12	General level Math
MAGOA	OAC	Algebra and Geometry
MCAOA	OAC	Calculus
MFNOA	OAC	Finite Mathematics

References

Henning, Mark C. (2007). A study of the level of mathematics preparedness of manufacturing sciences students in the Fall semester of 2005. *College Quarterly*, 10, (1). Retrieved June 2, 2007 from http://www.senecac.on.ca/quarterly/2007-vol10-num01- winter/henning.html

Cluett, S., Jarosh, J. and Roscoe, W. (2009). Correlating student mathematics diagnostic testing and high school mathematics performance in the Fanshawe College pre-health science program. Retrieved June 1, 2009 from Fanshawe College's Applied Research and Innovation web site: http://www.fanshawec.ca/EN/research/research/13038.html

York-Seneca Institute for Mathematics, Science and Technology Education. (2007). College mathematics project 2007 final report. Retrieved October 8, 2008 from York/Seneca Institute for Mathematics, Science and Technology Education web site: http://www.ysimste.ca/projects/CMP2007.pdf

Association of Canadian Community Colleges & Human Resources and Social Development Canada. (2007). Pan-Canadian study of first year college students report 1. Retrieved June 15, 2008 from Government of Canada's HRSDC web site: http://www.hrsdc.gc.ca/eng/publications_resources/learning_policy/sp_787_08_07e/sp_787_08_07e.pdf

Geyser, S. and Santelices, M.V. (2007). Validity of high school grades in predicting student success beyond the freshman year: high-school record vs. standardized tests as indicators of four-year college outcomes. *Research and Occasional Paper Series: CSHE.6.07*. University of California, Berkeley. http://cshe.berkeley.edu/publications/publications.php?id=265