



2-1-2002

Ability, Interest and Effort: Understanding Outcomes of Math Coursework for Western Washington University Freshmen

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Recommended Citation

Jull, Pamela and McKinney, Gary (Gary Russell), "Ability, Interest and Effort: Understanding Outcomes of Math Coursework for Western Washington University Freshmen" (2002). *Office of Survey Research*. 359.

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ABILITY, INTEREST AND EFFORT: UNDERSTANDING
OUTCOMES OF MATH COURSEWORK FOR WESTERN
WASHINGTON UNIVERSITY FRESHMEN

(REPORT 2002-01)

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February, 2002

INTRODUCTION

In the winter of 2001, the Office of Survey Research conducted surveys of freshmen and transfer students who entered Western in the fall of 2000. Because the surveys tapped detailed student information during the course of their academic career rather than after it, the research was deemed the “Close-in Survey” project. The purpose of the surveys was to inform several offices at the university—including those committed to reviewing registration, academic advising, and the General University Requirements (GURs)—on retention issues and the use of online materials in the classroom.

Prior analysis of administrative records suggested that certain characteristics of math courses taken in the first quarter of the freshman year were tied to retention outcomes. To follow up, a substantial section of the Close-in Survey was devoted to asking students about their experiences in math courses prior to attending Western, and their experience, if any, in Western math courses during their first quarter.

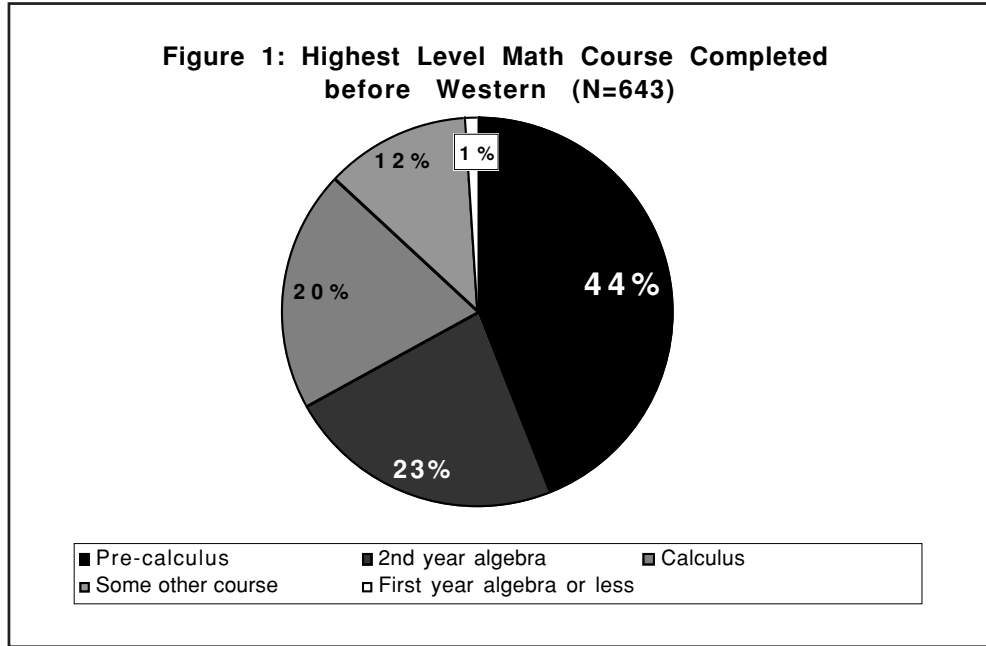
In particular, analysis focused on the following questions:

- How do the Math Placement Test (MPT), Math SAT scores and other measures correspond to students’ prior math experiences, student satisfaction with the math courses they took, and students’ grades in their fall math course?
- Are there certain markers for students who are apt to do poorly in a fall math course that might be ascertained before they enroll? Do those markers suggest any changes in the way freshman advising or the math program functions that might improve student outcomes?

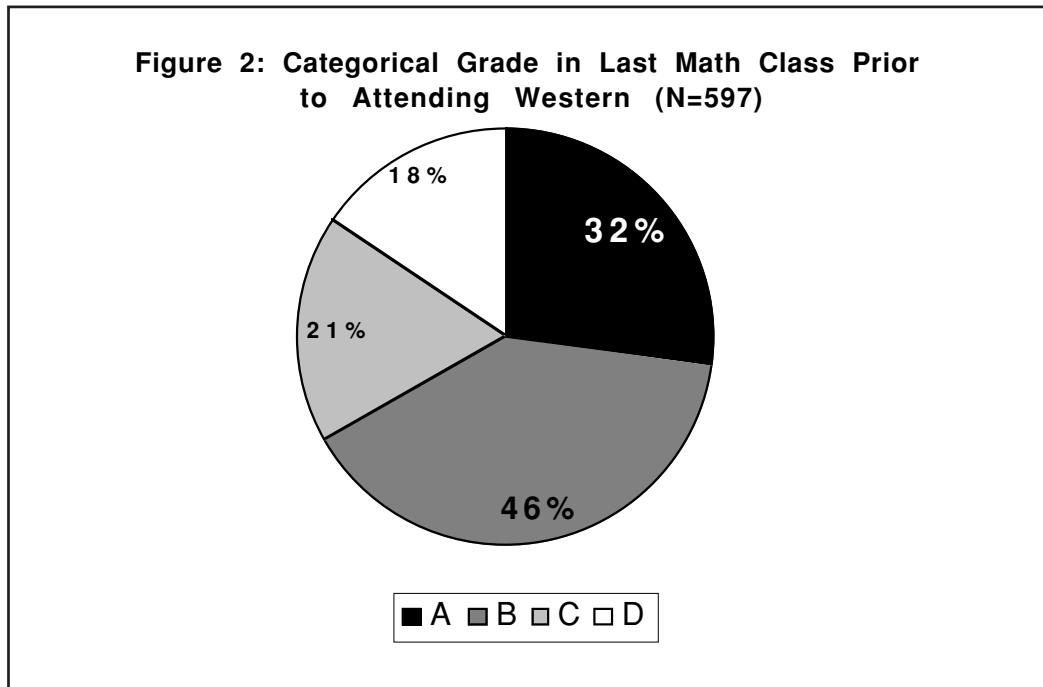
Only a small proportion of transfer students took math courses in the fall; therefore, this report focuses on findings from the freshman survey. This report summarizes the findings of the analysis and makes some limited recommendations regarding how key administrators at Western may want to respond. (Descriptive findings and the survey items are included in Appendix B of this report.)

ANALYSIS OF FINDINGS

Overwhelmingly, in-coming freshmen completed their most recent math courses in their high schools, with the majority having taken pre-calculus (44%) or second-year algebra (23%). (See Figure 1.) Among the 12% reporting “other” courses, more than half (56%) said the course was Math Analysis, Geometry, Trigonometry, or some combination of the three (See Appendix A.)



Taking math courses in close succession may result in better performance for some students if they are better able to remember the material from their prior class or classes. Although 55% of freshmen took a math course in the last half of their senior year, another 34% took their last course in the prior calendar year. The remaining 11% had not taken a math course in two years or more. Generally, those who had taken math more recently had also completed higher division math courses. The distribution of their grades from those courses is shown in Figure 2.



Nearly all (96%) freshmen entering Western in the fall of 2000 had taken the Math SAT test, with an average score of 537 points. Moreover, most (83%) took the Math Placement Test (MPT)—a standardized test administered throughout Washington State designed to help students choose appropriate math courses. All students who want to take a course at a level higher than math 102 (Functions and algebraic methods) are required to take the math placement test. Students who want to take math 102 may have the MPT waived if: 1) they have scored three or higher on ETS' Advanced Placement Calculus Exam; 2) they receive approval from the Western Mathematics Department Chair; 3) they have scored at least 480 on the Math SAT, 51 on the Quantitative Composite of the WPCT, or 18 on the Math ACT; or 4) they have credit for having taken calculus. Any student may take Math 99, *Review of Algebra*, without taking the MPT, though the course does not count toward college credits, GURs or graduation.

Of the 1809 freshmen that took the MPT, 73% took the intermediate exam while 27% took the advanced exam. For this analysis, scores were standardized into a seven-point scale indicating the highest course level recommended by the Mathematics Department for the score. Table 1 shows the MPT scores students needed in order to enroll in the course, and the distribution of scores according to this scale.

Table 1: Math Placement Test—Highest Recommended Course (according to test score) for Freshmen Entering in the Fall of 2000*

Course Description	Course #	Level	Intermediate Test score	Advanced Test score	N	%
Review of algebra (uncredited)	99	1	0-9	-	100	6%
Functions and algebraic methods	102	2	10-16	3-7	565	31%
Statistics/Pre-calculus	240/114	3	17-19	8-11	344	19%
Teaching K-8 mathematics	381	4	20-23	12-14	310	17%
Accelerated precalculus	118	5	24-35	15-17	294	16%
Algebra applications to business	157	6	-	18	23	1%
Calculus I	124	7	-	19-30	170	9%
Total w/ MPT					1806	100%
No MPT					373	
Grand Total					2179	

*These freshmen were the first to try a new version of the MPT and are unique in that regard. After this cohort enrolled in math courses, the scoring criteria for each level of course work were determined to be too high, placing students in courses that were too difficult for their ability level. As a result, the math department chose a new scoring criterion based on the probability of a 66% success rate—success being anything other than receiving an F, dropping out of the class or dropping out of school. The new scoring criterion has been enacted for this academic year. Some analysis of administrative data should indicate how well it works.

Based on their MPT scores, Western provides students with a description of the range of courses they can choose from. A majority of in-coming freshmen (64%) took a math course in their first quarter. Most were in five-credit courses that met daily. Table 2 shows their distribution among the courses they took, along with the average class size for the course and the average grade freshmen achieved in the course.

Table 2: Fall Math Course Taken by Respondents

Course Description	Course #	N	%	Average Class Size	Average Frosh Grade
Review of algebra (uncredited)	99	30	2%	38	n/a
Functions and algebraic methods	102	673	48%	55	1.98
Precalculus	114	304	22%	40	2.15
Accelerated precalculus	118	98	7%	37	2.25
Calculus I	124	105	7%	34	2.80
Calculus II	125	19	1%	26	2.92
Accelerated calculus	128	21	1%	26	2.96
Algebra w/applications to business and economics	156	126	9%	57	2.15
Calculus w/applications to business and economics (156 prerequisite)	157	15	1%	58	2.98
Elementary linear algebra	204	1	0%	16	n/a
Introduction to statistics	240	9	1%	32	2.12
	Total	1401	100%		

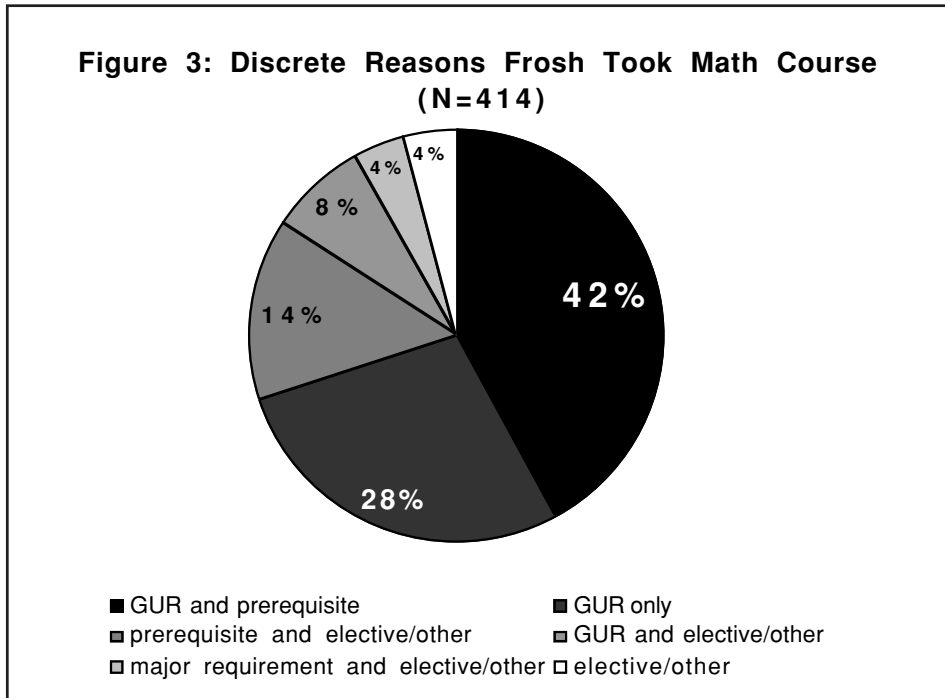
Patterns vary regarding how students respond to the MPT course recommendations. Among those who took math courses in the fall, 99% who tested at the Math 102 level enrolled in Math 102. But so did half of the students who tested at the Math 99 level (presumably due to a petition challenging the MPT results). In addition, 20% of students testing *above* the Math 102 level also enrolled in Math 102. Students may be taking lower level courses for a variety of reasons, including:

- they only intend to take math courses to fulfill the minimum university requirements;
- they want to be assured of doing well enough to protect their GPA;
- they want to fulfill a specific prerequisite for other courses; or
- they don't receive proper advising about the course material contained in the upper division classes.

Students were asked to describe all the reasons they were enrolled in their fall quarter Math class. Table 3 shows the frequency of responses for all students (with most giving two or more reasons), while Figure 3 shows discrete categories in combination. The most common reasons student gave for taking their fall math course were both to fulfill a GUR requirement *and* to fulfill a course prerequisite (42%). Another 28% took math only to fulfill the GUR requirement. If they were planning to take the course only to fulfill a GUR, students were most likely to enroll in Math 102. Controlling for their performance on the MPT, students who were taking their math course only to fulfill GUR requirements were more than twice as likely to enroll in Math 102 than any other course.

Table 3: Reasons Student Took Math Course (multiple responses possible; N=414)

Reason	N	%
Prerequisite	226	55%
Fullfill GUR	312	75%
Major requirement	164	40%
Elective	27	7%
Other	44	11%



Most students who took the MPT enrolled for a math course in their first quarter: 79% of those taking the advanced MPT and 69% of those taking the intermediate MPT. On the other hand, only 30% of those *not* taking the MPT (for example, who had the MPT waived) enrolled in a fall math class.

In the fall of 2000, math class offerings varied throughout the day and by course level. For example, Math 99 was offered once: at 8 a.m. Math 102 was also offered at 8 a.m.—with 199 students enrolled—but was not offered again until noon—with 228 enrolled—and then at each hour of the afternoon. By contrast, Math 124 was offered every hour from 8 a.m. until 2 p.m.—with 105 students enrolled. Of possible interest here is that Math 102, the most in-demand course, was not offered during the peak-demand course times of 9 a.m. to 11 a.m. This finding was explicated somewhat in an earlier report (Data Memo to Math Department and Provost, Simpson & Schmitz, Institutional Research and Resource Planning, September 17, 2001.) and the Math Department has responded promptly. In Fall 2001, six sections of Math 102 accommodating more than 200 students were offered first at 9 a.m. and another five sections were offered at 11 a.m.

The demands these courses place on the Math Department are substantial. All together, the Mathematics Department supported the education of over 1400 freshmen in one quarter—not including sophomores, juniors or seniors. When all students are accounted for, fall 2000 math course enrollment totaled 2,909. By contrast, the Mathematics Department taught nearly 500 fewer students in the winter quarter of that academic year (2,435), and about 1,100 fewer in the spring term (1,799). More than 900 total students enrolled in Math 102 in the fall, with another 547 in the winter and 234 in the spring. (Note that the demand for Math 102 courses in the fall is nearly fourfold the demand in the spring.)

To cope with the need for so many courses in the fall quarter, the Mathematics Department supplements its faculty with additional lecturers and teaching assistants. The level of the math class determines, in part, the level of the instructor. In the fall of 2000, teaching assistants (T.A.s) taught the Math 99 course. They also were the instructors of record for about one-third of all the Math 102 course students and taught 449 of the 1401 (32%) freshman math students. Lecturers were the instructors of record for the remaining Math 102 students, and taught 724 of the 1401 (52%) freshmen math students. Professors taught the remaining 16% of freshmen math students, with the bulk of their effort given to Math 114, Math 124 and Math 156 courses.

Survey data showed that the type of instructor, though related to course level, was unrelated to satisfaction with the course. There was some relationship between type of instructor and students' grades: students who took courses with lecturers for instructors had lower grades than others—even after course level, math SAT scores, high school GPA and MPT results were controlled. This finding is especially odd since lecturers often teach a larger section of students, accompanied at the same hour by a set of graduate TAs teaching smaller section. These teachers work as a team, administering the same tests to all their sections and grading those tests jointly.

FACTORS INFLUENCING FALL MATH COURSE PERFORMANCE

Fall Math course performance appears to be closely tied to problems of retention one year later. (Frye, R., Simpson, C., and Clark, L (June, 2001). *Survey of Non-returning Students*. Office of Insitutional Assessment and Testing. Bellingham, WA.) What factors might influence how well or

poorly freshman do in their fall math courses? Using the bulleted variables below, student ability, experience, effort, maturity, interest or motivation, and course placement were explored:

- MPT scores
- Math SAT scores
- Overall high school grade point average (hsgpa)
- Reasons for taking the course (to fulfill a GUR, prerequisite, elective, etc.)
- Interest in mathematics
- How well prepared students felt for the course
- Prior math course work beyond pre-calculus
- How difficult students found the course
- How much effort students put into the course (attendance, use of tutorial center, etc.)
- How long it had been since their last math course
- How well they made the transition to WWU.

Analysis showed that there is some relationship between the MPT score and student math performance, with 40% of the students who scored in the lower strata of the MPT earning C grades or less in their fall math courses. One would hope that the MPT would prevent students from signing up for courses in which they would perform poorly; however, in addition to being an indicator of experience and ability, lower MPT scores may also reflect a student’s level of interest and motivation.

Analysis found that students’ grades in their fall math courses were moderately correlated to high school GPA, Math SAT scores, and fall MPT scores. However, only 10-12% of the variance in grades was explained by any one of the variables. Combined in a regression analysis, the explained variance climbed somewhat to 16%. The most powerful variables were Math SAT scores followed by the MPT results (see Table 4).

Table 4: OLS Regression of Fall Math Course Grade on Prior Math and School Performance (N=534)

	Standardized Coefficients
(Constant)	
High school GPA	0.11
Math Placement Test score	0.21
Math SAT score	0.27

Also included in the analysis: last math course grade, and level of math course taken prior to attending Western

INTEREST IN MATH

In the survey, students were asked to report their level of interest in the six GUR areas, of which mathematics was one. A low level of interest in mathematics was highly predictive of several other characteristics, including:

- taking a fall math course only to fulfill a GUR requirement;
- not having taken an upper-division math course prior to attending WWU (calculus or above);
- lower scores on the Math SAT test;
- poorer student reports of how well prepared they were for their fall math course;
- dropping their fall math course;
- relatively lower ratings given to a variety of aspects of their fall math course; and/or
- fall math course grades.

Taking math only to fulfill a GUR is extremely indicative of overall low interest in math and, *visa versa*: a low interest in math is extremely indicative of taking a math course solely to fulfill a GUR. Adding both to the model in Table 4, the latter becomes the strongest indicator of fall math course grades, with high school gpa a close second.

More advanced math students tend to feel better prepared for their first college math course than those who finished high school in lower division courses (pre-calculus, algebra and pre-algebra). In turn, those who felt better prepared also performed better in their fall math course.

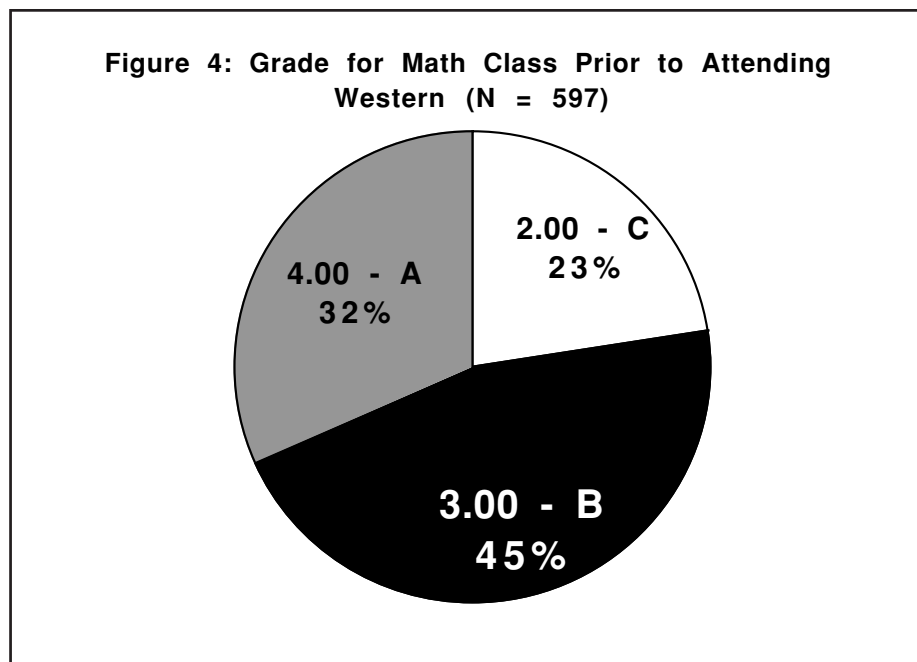
LAST HIGH SCHOOL MATH COURSE

Respondents were asked to report the last math course they took prior to attending WWU, how recently they took it, and what grade they attained in it. (See Figure 4, next page.) Analysis showed that grades in prior math courses were poor predictors of grades in current math courses. In particular, B-level students tended to have wide ranges of ability according to Math SAT scores and math course grades at WWU. Those who attained As or Cs in their high school math courses performed more consistently.

The sample was split fairly evenly between those who took math courses just before attending Western—defined as having completed the course in 2000—and those who took math courses earlier than 2000 (55% and 45% respectively).

Correlations show that those who took more recent math courses scored slightly higher on the Math SAT ($r=.106$) and reported being better prepared for their fall math course than those who had a 1-3 year lag between courses. MPT scores were also affected, though the relationship was similarly weak ($r=.10$). There was, however, no relationship between how recently students took their last high school math course and grades in their fall math courses. It may be that their poorer performance on the MPT and SAT put them in lower division classes, which helped mitigate the effects of the delays.

The extreme upper and lower ends of the MPT score distribution showed the strong effect of how recently students took their last math course. Students who took their last math course prior to 2000 were almost twice as likely to score at the Math 99 level on the MPT as their counterparts (8% vs. 4%). Similarly, 38% of those who took their last math class prior to 2000 scored at the Math 102 level on the MPT, compared to 23% of those who took math more recently.



STUDENT EFFORT

Students were asked how often they were absent from their math class during the quarter, how often they used the tutorial center (either in Old Main, or the Math Center in Bond Hall), and how difficult they found the material. People who used the tutorial centers were more likely to be taking the course as a prerequisite, to have had good attendance, to have found the material difficult, and to report poorer prior preparation. They also gave poorer ratings to both the quality of the teaching and the enthusiasm of the instructor. Additionally, they were more likely to report that the material covered on exams was not matched well to that covered in class.

It may be that these students are good indicators of those who are motivated and responsible, but who cannot overcome either their own inability or certain characteristics of the class. In a limited sense, this may be tied to the level of the instructor: While 26% of students in courses taught by professors used the tutorial centers, almost 50% of students in courses taught by teaching assistants and lecturers used them. Students taking Math 102 used the tutorial center at about the same rate, regardless of whether they were taught by TAs and Lecturers (no professors teach Math 102). Students in courses *other* than Math 102 used the tutorial centers almost twice as often if they had a TA or Lecturer than if they had a professor.

This limited association between instructor type and how their teaching ability is evaluated by survey respondents suggests that rather than an overall effect of instructor type, there may instead be an interaction between instructor type and a particular type of student, especially those taking courses more advanced than Math 102. Less experienced lecturers and TAs may be unsatisfactory for more demanding students, while less demanding students—especially those with a low interest in math (taking it as a GUR only, not as a prerequisite)—may be better matched to less experienced instructors.

MULTIVARIATE MODEL

The final regression model included measures of student-reported course difficulty, frequency of absences, and use of the tutorial center, along with the other variables discussed above. Table 5 shows the significant items from this model, which explained 47% of the variance in student grades (adjusted r-square). Ranked according to strength of the association, it is clear that Math SAT scores and high school gpa are excellent indicators of fall math course performance. In addition, students who take Math 102 tend to do better than their peers in higher division math courses, when controlling for these other factors. MPT results continue to predict fall math course grades, though difficulty of the material and interest in mathematics are somewhat stronger predictors. Students' efforts also have an impact, with better attendance and frequent use of the tutorial center contributing to better fall math course grades.

Math 102 students are of particular interest since they make up the bulk of freshmen taking fall math courses. The pattern of findings for the multivariate model is the same when examining only Math 102 students, though the explained variance climbs to 51.3%. Unlike prior findings noted by the Office of Institutional Research & Resource Planning, there is no clear effect of taking a math course at 8:00 a.m.

Table 5. Significant Indicators of Fall Math Grade Outcomes, Ranked (N=319)

	Standardized Coefficients
(Constant)	
Math SAT scores	0.56
Took Math 102	0.36
High school GPA	0.29
Difficulty of math course material (1=extremely)	-0.27
Interest in mathematics (1=extremely)	0.21
MPT results	0.18
How many times absent	-0.16
How well prior math prepared you (1=extremely)	0.12
Number of times visited Tutorial Center	0.11

Also in the model, but insignificant: type of instructor, level of math course taken, level of math course prior to attending WWU, how recently prior math course was taken, reason for taking fall math course (GUR only). Adding controls for the section of the math course taken did not substantively change the results.

For students taking courses above 102, only the difficulty of the course, preparation, high school gpa and interest in mathematics are significant predictors. Math SAT scores and MPT results are not predictive of math course performance above the Math 102 level once these other factors have been taken into account.

MATH’S ROLE IN MAKING THE TRANSITION TO WWU

In addition to asking students to rate their transition to Western overall, six items in the Close-in Survey measured a variety of aspects that define making a successful college transition. They were:

- 1 Making friends and feeling comfortable socially.
- 2 Getting access to the courses you needed.
- 3 Coping with the academic demands of courses.
- 4 Learning what your professors expect.
- 5 Learning about required courses, prerequisites, etc.
- 6 Getting the advising you needed.

In terms of making a successful transition to college, “coping with academic demands” was significantly correlated with fall math course grades. Also important were high school gpa and getting a failing grade (C- or lower) in other courses. By contrast, students who didn’t take a fall math class were more likely to report an “excellent” ability to cope with academic demands than those who did. (See Table 6.)

Table 6. How Well Frosh Coped with the Academic Demands of Courses with Math, and Course Performance Indicators

	Standardized Coefficients
(Constant)	
Took a math course fall 2000	0.10
High school GPA	-0.10
C- or less in a fall course	0.17

Also in the model but insignificant: Math SAT score, MPT, Interest in math

CONCLUSION

Taken together, these findings seem to point to some recommendations for advising. If students took relatively low level math courses in high school, feel they aren’t well prepared, and are not highly motivated to learn math (low levels of interest), they may do better if they are advised to take lower level courses among the range of classes recommended by the MPT. Many students who were dissatisfied with the results of the MPT

reported that the MPT recommended too many courses, making it hard to know what to choose. In addition, many students reported that the MPT placed them in too high a course, while others said the MPT placed them in courses that were too easy (about a 2:1 ratio). The MPT needs to be described to students as just one tool for placing students; indeed, students may do better if the MPT is consciously augmented with other advice and recommendations.

In addition:

- Student experiences with math courses tend to vary a great deal depending on their interest, aptitude and experience in math.
- Compared to other GUR areas, math is an area in which many freshman are not interested.
- Many freshmen take math in their first quarter—during a time of intense adjustment to college. Most freshmen do so to fulfill prerequisites for courses offered in the second quarter.
- Some freshmen are constrained to take classes with limited availability and lower-level instructors. For example, at the time of this study, there were a limited number of Math 102 courses offered during key course taking times of 9 to 12. (Currently, the Mathematics Department is giving special attention to making more Math 102 sections available during peak demand hours.)

There does not seem to be a key culprit in producing problems for freshmen who take math courses. The causes of problems for students based on the multivariate analysis seem to fall out in the following order:

- Student interest/motivation
- Student ability/experience in math
- MPT recommendations and a lack of advising about how to use them
- Math course offerings/times of day courses are offered

If each of these issues is addressed in part, students should do better and make a smoother transition to Western.

APPENDIX A:

Other Math Courses Specified

Math Analysis/Trigonometry/Geometry	43
Integrated Math 3	8
Logistics	1
Discrete Math	2
Statistics	7
Algebra and Calculus	1
Applied Math	1
Advanced Algebra	1
Integrated Algebra 3	3
IB Math Studies	1
Integrated Math	1
Like Math 102 (Intro to College Math)	1
Functions, Statistics and Trigonometry	4
1/2 year of pre-calculus, probabilities, statistics	1
AP Calculus	1
Pre Calculus	1
Total	77

APPENDIX B:

DESCRIPTIVE FINDINGS AND THE SURVEY ITEMS