Mathematics Placement Test Performance Predicts Subsequent Math Course Success at Four-Year Universities

Debbie E McGhee
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INTRODUCTION

This report describes the results of a study of the relationship between Mathematics Placement Test (MPT) scores and subsequent student performance in mathematics courses at four Washington universities. The research questions of main interest were: 1) How well do MPT scores predict subsequent mathematics course grades? and 2) How do the three tests compare to one another in terms of relative predictive power? These results may inform discussions among faculty as they review or set placement cut scores for the three mathematics placement tests.

METHOD

Math Placement Test (MPT) scores were obtained for all MPT exams administered during the Academic Placement Testing Program (APTP) 2008-2009 testing year (October 2008 – September 2009). Administrations included those conducted during an extensive pilot to validate the MPT-G[1], as well as regular statewide administrations in May and June, and on-campus testing throughout the year. In cases for which multiple test scores were found for a single student, the highest score (if the student took the same test type more than once) or placement (the student took different test types) was selected.

Subsequent mathematics course grades were collected for students attending four public universities: Eastern Washington University (EWU), University of Washington (UW), Washington State University (WSU), and Western Washington University (WWU). Grades were obtained for all academic terms within the 2009 calendar year (January – December). In cases for which multiple grades were obtained for a single student (whether for the same or different courses), only the first course grade was selected. For the purpose of analysis, courses were categorized as Level 1-4 (below college level, introductory college, precalculus, or calculus, respectively). Course grades and test scores were matched for individual students using uniquely assigned identifiers.

The average length of time between completion of the MPT and the first day of enrollment in the mathematics course was 58.8 days for takers of the Advanced test (MPT-A), 54.5 days for the Intermediate test (MPT-I), and 94.6 days for the General test (MPT-G). The longer span for MPT-G was due to the fact that most of the MPT-G administrations took place during the pilot.

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[1]   McGhee, D.E., Lowell, N., Gillmore, G.M., and Peterson, J.E. (2009). *General Mathematics Placement Test (MPT-G): 2009 Pilot Study*, **OEA Report 09-03**, http://www.washington.edu/oea/pdfs/reports/OEAReport0903.pdf

A majority of mathematics courses at EWU, UW, and WSU require a final grade of 2.0 to proceed to the next higher level course. For that reason, *course success* was defined as a numeric grade of 2.0 (letter grade 'C') for analyses described below.

Table 1 provides descriptive statistics by course level and success in the course. Average MPT score varied significantly as a function of test type and course level. Although the MPT-G and MPT-I initially were designed to be of equivalent difficulty, the average test score was lower for MPT-G than for MPT-I ($M = 18.3$ vs. $M = 21.2$, $t(2208) = 9.4$, $p < .001$). Unsurprisingly, average MPT score increased with increasing course level. This trend was observed for all three tests (MPT-G, $F(3,2195) = 146$, $p < .001$; MPT-I, $F(2,2195) = 498$, $p < .001$; MPT-A, $F(3,1066) = 177$, $p < .001$.

Students who achieved a course grade of at least 2.0 tended to have scored significantly higher on the MPT than those who did not, $F(1,2927) = 165$, $p < .001$. The majority (73%) of students completed their courses with a numeric grade of 2.0 or better; however, fewer students passed Level 1 courses (48%) than passed Level 2 (72%), Level 3 (75%), or Level 4 (91%).

Success rate also varied as a function of the interaction between course level and test type. At Level 1, students who had taken MPT-G were equally as likely to attain a grade of 2.0 as students who had taken MPT-I. At Level 2, the pass rate was much higher in the MPT-A group (87%) than in the MPT-I (69%) and MPT-G (76%) groups, $\chi^2(2, N=1119) = 16.9$, $p < .001$. In contrast, at Level 3, the pass rate was lower among the MPT-I group (72%) than both the MPT-A (79%) and MPT-G (80%) groups, $\chi^2(2, N=1246) = 8.4$, $p = .02$.

Table 1. MPT Total Score (Number Correct) by Success in Course, Course Level, and MPT Test Type

	Level 1 (below college)			Level 2 (introductory college)		
	MPT-G	MPT-I	MPT-A	MPT-G	MPT-I	MPT-A
Course Grade < 2.0						
Range	3 - 19	4 – 23		12 - 24	8 – 30	7 – 17
Mean	11.5	12.9		17.5	18.1	11.3
SD	3.2	3.0		2.7	3.5	3.2
n	72	128	0	54	245	15
Course Grade ≥ 2.0						
Range	5 - 19	4 – 29		9 - 33	8 - 33	6 – 30
Mean	11.5	13.8		19.8	21.0	17.8
SD	3.2	4.0		4.4	4.7	5.3
n	52	128	2	166	542	97
Total						
Range	3 - 19	4 – 29		9 - 33	8 - 33	6 – 30
Mean	11.5	13.3		19.3	20.1	16.9
SD	3.2	3.5		4.2	4.6	5.5
n	124	256	2	220	787	112

	Level 3 (precalculus)			Level 4 (calculus)		
	MPT-G	MPT-I	MPT-A	MPT-G	MPT-I	MPT-A
Course Grade < 2.0						
Range	12 – 28	14 – 33	10 – 23			14 – 29
Mean	22.5	23.7	14.8			22.0
SD	3.9	3.5	2.9			2.9
n	19	204	92	0	1	49
Course Grade ≥ 2.0						
Range	15 - 33	9 - 35	9 – 30			11 – 30
Mean	25.1	25.7	16.5			24.1
SD	3.9	4.0	3.7			3.5
n	77	517	337	1	4	481
Total						
Range	12 - 33	9 - 35	9 – 30			11 – 30
Mean	24.6	25.1	16.2			23.9
SD	4.0	4.0	3.6			3.5
n	96	721	429	1	5	530

Note. The maximum possible total scores are 35 for MPT-G and MPT-I and 30 for MPT-A.

Figure 1 displays the distributions of course grades by test type and course level.
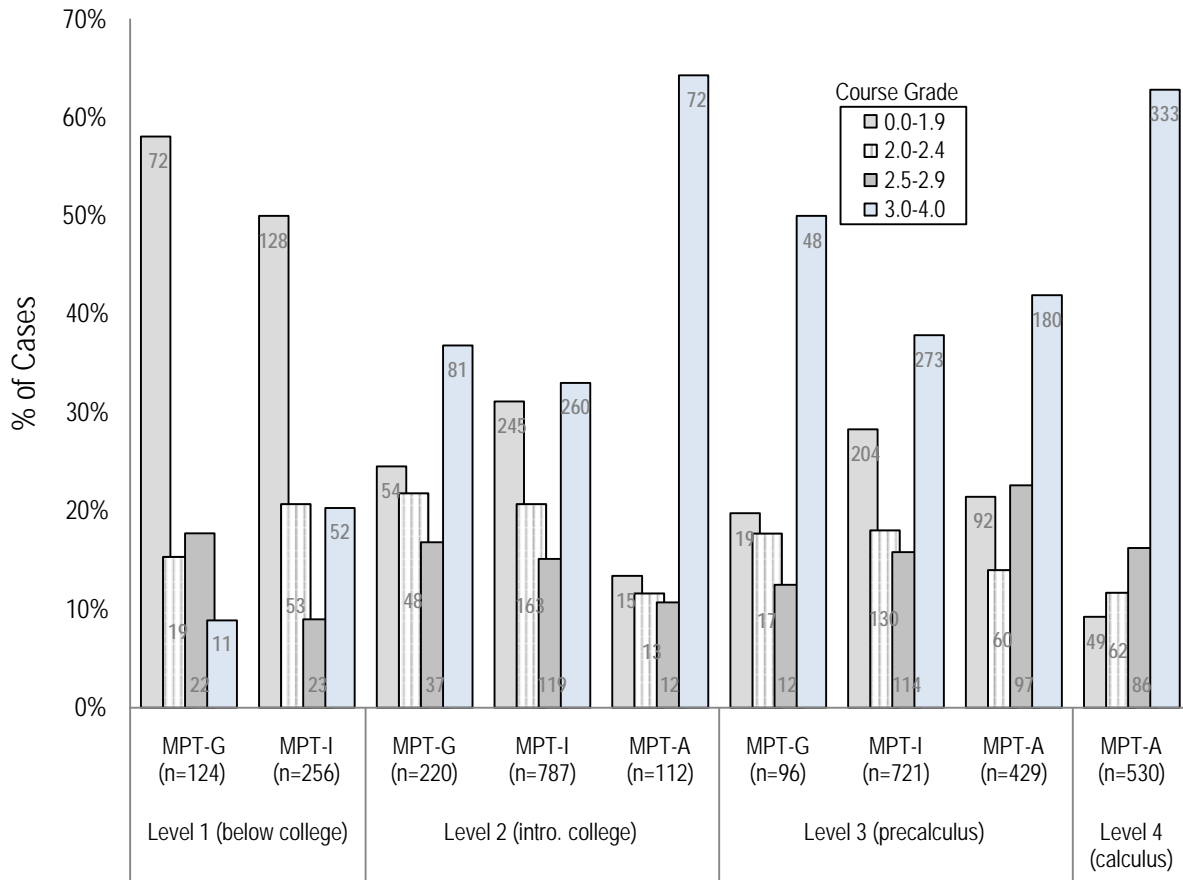
Figure 1. Course grade distributions by Test Type and Course Level. Bar labels are the number of cases in each group.

Table 2 shows the zero-order correlations between MPT total test score and course grade by course level and test type. MPT scores were moderately correlated with mathematics course grades. Across all institutions and course levels, the correlation between MPT-I total test score and numeric course grade was $r(1760) = .36$. The corresponding coefficient for MPT-G was $r(441) = .43$, and for MPT-A it was $r(1073) = .39$. Within course levels, the score-grade correlations were attenuated because MPT scores had been used for placement into those mathematics courses. Nevertheless, all coefficients for Levels 2 and 3, as well as the correlation between MPT-A score and grade at Level 4, were significantly different from zero.

Table 2. Correlations between MPT Total Score and Course Grade
         by Course Level and MPT Test Type

	Level 1 (below college)			Level 2 (introductory college)		
	MPT-G	MPT-I	MPT-A	MPT-G	MPT-I	MPT-A
r	-.001	.14*	--	.37**	.43**	.60**
n	124	256		220	787	112
	Level 3 (precalculus)			Level 4 (calculus)		
	MPT-G	MPT-I	MPT-A	MPT-G	MPT-I	MPT-A
r	.36**	.30**	.30**	--	--	.40**
n	96	721	429	1	5	530

Note.   *$p < .05$. **$p < .001$.

Table 3 displays the results of a set of exploratory logistic regression analyses which assessed the efficacies of the three placement tests in predicting success. The analyses indicated that predictive power varied with course level. At Level 1, MPT-G score did not predict outcome, and MPT-I score was a weak predictor. In contrast, at Levels 2 and 3, scores for all three tests were strong predictors, and at Level 4, MPT-A score significantly predicted outcome. The results of school-specific analyses may be found in Appendix B (which includes additional criteria for course success as used at each respective school).

Table 3. Results of logistic regression analyses predicting course grade ≥ 2.0 by test type and course level

Predictor by Test Type	Course Level 1						Course Level 2					
	B	SE B	χ^2	p	e^B	95% CI	B	SE B	χ^2	p	e^B	95% CI
MPT-G												
Total Test Score	.01	.06	.02	.89	1.01	[.90,1.13]	.17	.05	12.5	<.001	1.18	[1.08,1.30]
Intercept	-.42	.69	.37	.54	.66		-1.99	.87	5.2	.02	.14	
MPT-I												
Total Test Score	.07	.04	3.8	.05	1.07	[1.00,1.15]	.16	.02	58.6	<.001	1.17	[1.12,1.22]
Intercept	-.95	.50	3.5	.06	.39		-2.30	.40	32.9	<.001	.10	
MPT-A												
Total Test Score	--	--	--	--	--	--	.30	.08	14.3	<.001	1.35	[1.16,1.58]
Intercept	--	--	--	--	--	--	-2.42	1.03	5.5	.02	.09	
	Course Level 3						Course Level 4					
	B	SE B	χ^2	p	e^B	95% CI	B	SE B	χ^2	p	e^B	95% CI
MPT-G												
Total Test Score	.17	.07	5.8	.02	1.18	[1.03,1.35]	--	--	--	--	--	--
Intercept	-2.56	1.63	2.5	.12	.08		--	--	--	--	--	--
MPT-I												
Total Test Score	.13	.02	32.9	<.001	1.14	[1.09,1.19]	--	--	--	--	--	--
Intercept	-2.27	.56	16.6	<.001	.10		--	--	--	--	--	--
MPT-A												
Total Test Score	.16	.04	16.4	<.001	1.17	[1.08,1.26]	.16	.04	16.0	<.001	1.18	[1.09,1.28]
Intercept	-1.15	.60	3.7	.05	.32		-1.51	.93	2.6	.10	.22	

Note. Dashes indicate that estimates were not computed due to insufficient sample size. e^B is the odds ratio.

The results of the logistic regression analyses were used to create Table 4 and Figure 2. Table 4 lists the estimated test scores for given probability values (e.g., the MPT-A score associated with a .75 probability (*p*) of passing a Level 4 course is 15.9). Figure 2 plots the estimated probabilities of obtaining a course grade of 2.0 or better based on MPT-G and MPT-I scores.

Table 4. MPT Total Score estimates for obtaining course grade ≥ 2.0

Score assoc. with probability *p* of obtaining grade ≥ 2.0	Course Level 2			Course Level 3			Level 4
	MPT-G	MPT-I	MPT-A	MPT-G	MPT-I	MPT-A	MPT-A
p = .50	11.9	14.5	8.0	15.4	17.5	7.4	9.2
p = .67	16.1	18.9	10.4	19.7	22.9	11.9	13.5
p = .75	18.4	21.4	11.7	22.1	25.9	14.3	15.9

Note. The maximum possible total scores are 35 for MPT-G and MPT-I and 30 for MPT-A.
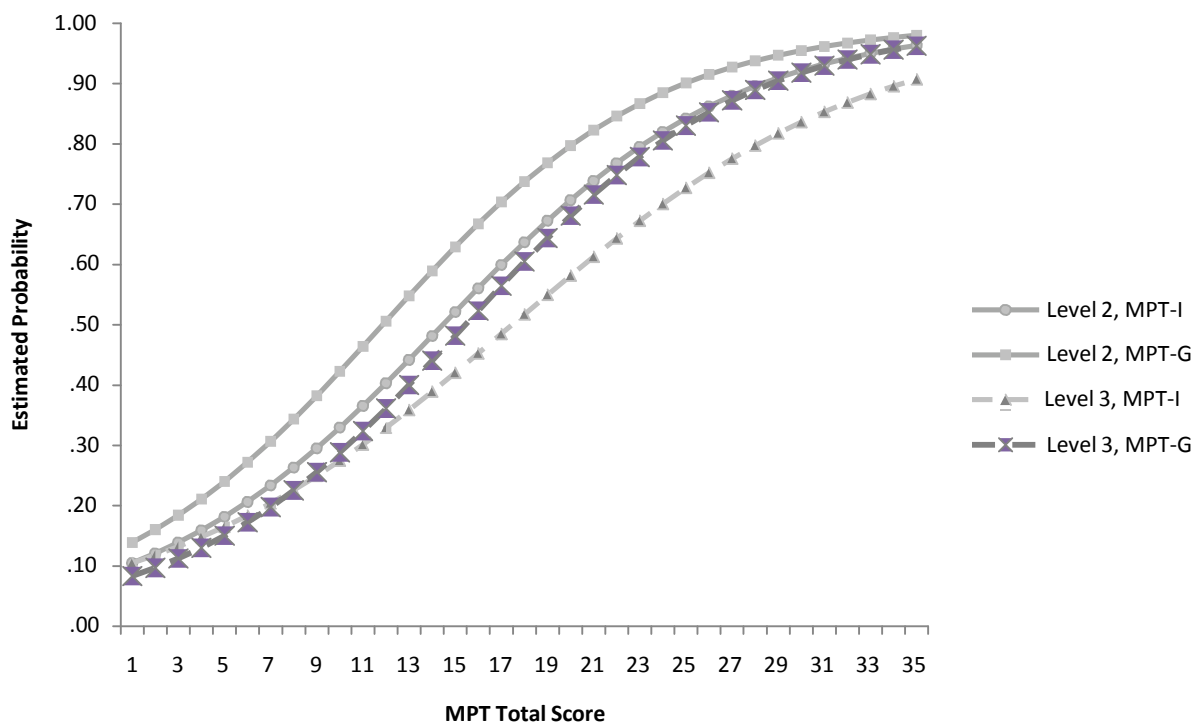
Figure 2. Estimated probability of obtaining course grade ≥ 2.0 based on MPT Total Score (by test type and course level).

CONCLUSION

The results of this study show that MPT total scores can be used to predict performance in college-level mathematics courses at the four participating Washington public universities. In entry- and precalculus-level courses, all three tests produced scores that were significantly correlated with numeric course grade. At the calculus level, MPT-A total score was moderately-to-strongly related to course grade.

The equations derived from logistic regression analyses can be used to estimate the MPT score likely to result in course success (for a given probability level). That information may be helpful to faculty going about the task of reviewing or setting placement cut scores.

The inability of the MPT-G and MPT-I to predict performance in below college level courses is consistent with the intended purpose of the tests to place students into college-level courses. It is also perhaps reflective of the greater heterogeneity of mathematics background and motivation to succeed among students in courses that are below college level.

The results of this study also underscore the need to use different cut scores for MPT-G and MPT-I if both are used to place students into common courses. Although scores from the two tests were similarly correlated with course grade, the mean scores associated with passing were significantly different by a magnitude of approximately three points. Ideally, this difference should be rectified through the use of scaled scores.

APPENDIX A. COURSE NAMES AND LEVELS

School	Course Number	Course Name	Course Level
EWU	100	Basic/Intermediate Algebra I	1
	101	Basic/Intermediate Algebra II	1
	102	Basic/Intermediate Algebra III	1
	103	Basic Algebra	1
	104	Intermediate Algebra	1
	105	Precalculus I	3
	106	Precalculus II	3
	114	Algebra Concepts	2
	115	Mathematical Reasoning	2
	161	Calculus I	4
	200	Finite Math	3
	211	Structure of Elementary Math I	3
	301	Discrete Mathematics	2
	380	Elementary Probability Statistics	3
UW	098	Intermediate Algebra	1
	103	Elementary Functions	2
	111	Algebra with Applications	2
	120	Precalculus	3
	124	Calculus	4
WSU	091	Beginning Algebra	1
	099	Intermediate Algebra	1
	105	Exploring Mathematics	2
	106	College Algebra	2
	107	Precalculus	3
	108	Trigonometry	3
	140	Calculus for Life Scientists	4
	171	Calculus I	4
	201	Finite Math for Business/Econ	3
	202	Calculus for Business/Econ	4
	205	Statistical Thinking	2
	206	Calculus for Architects	4
	212	Intro to Statistical Methods	2
	251	Math for Elementary School Teachers I	3
WWU	106	Quantitative Reasoning	1
	107	Mathematical Reasoning	2
	112	Functions and Algebraic	2
	114	Precalculus I	3
	115	Precalculus II	3
	118	Accelerated Precalculus	3
	124	Calculus	4
	156	Algebra with Applications	3
	157	Calculus with Applications	4
	240	Intro to Statistics	2
	381	Teaching K-8 Math	3

APPENDIX B. LOGISTIC REGRESSION RESULTS BY SCHOOL

Eastern Washington University.

Criterion: Course grade ≥ 2.0.

Predictor by Test Type	Course Level 2					
	B	SE B	χ^2	p	e^B	95% CI
MPT-G						
Total Test Score	.16	.07	5.2	.02	1.18	[1.02,1.35]
Intercept	-2.04	1.32	2.4	.12	.13	
MPT-I						
Total Test Score	.13	.05	7.5	.01	1.14	[1.04,1.25]
Intercept	-1.97	.92	4.6	.03	.14	

Notes. Estimates were not computed for Course Levels 1, 3-4 or for MPT-A due to insufficient sample size. e^B is the odds ratio.

Criterion: Course grade ≥ 3.0.

Predictor by Test Type	Course Level 2					
	B	SE B	χ^2	p	e^B	95% CI
MPT-G						
Total Test Score	.23	.07	11.9	.001	1.26	[1.11,1.44]
Intercept	-5.40	1.36	15.9	<.001	.004	
MPT-I						
Total Test Score	.35	.07	28.4	<.001	1.42	[1.25,1.62]
Intercept	-8.78	1.44	37.0	<.001	.00	

Notes. Estimates were not computed for Course Levels 3-4 or for MPT-A due to insufficient sample size. e^B is the odds ratio.

University of Washington

Criterion: Course grade ≥ 2.0.

Predictor by Test Type	B	SE B	Course Level 2 χ^2	p	e^B	95% CI	B	SE B	Course Level 3 χ^2	p	e^B	95% CI
MPT-I												
Total Test Score	.26	.07	15.4	<.001	1.30	[1,14,1.40]	.09	.05	3.0	.08	1.09	[.99,1.20]
Intercept	-4.10	1.44	8.2	.004	.02		-.68	1.28	.28	.60	.51	

Notes. Estimates were not computed for Course Level 1 or for MPT-G due to insufficient sample size. e^B is the odds ratio.

Predictor by Test Type	B	SE B	Course Level 3 χ^2	p	e^B	95% CI	B	SE B	Course Level 4 χ^2	p	e^B	95% CI
MPT-A												
Total Test Score	.11	.07	2.5	.12	1.12	[.97,1.28]	.20	.08	7.2	.007	1.23	[1.06,1.42]
Intercept	.05	1.16	.002	.96	1.05		-2.10	1.81	1.4	.24	.12	

Notes. Estimates were not computed for Course Level 2 due to insufficient sample size. e^B is the odds ratio.

Criterion: Course grade ≥ 2.5.

Predictor by Test Type	B	SE B	Course Level 2 χ^2	p	e^B	95% CI	B	SE B	Course Level 3 χ^2	p	e^B	95% CI
MPT-I												
Total Test Score	.23	.05	20.8	<.001	1.26	[1.14,1.39]	.10	.05	5.0	.02	1.11	[1.01,1.22]
Intercept	-4.38	1.15	14.5	<.001	.01		-1.63	1.19	1.9	.17	.20	

Notes. Estimates were not computed for Course Level 1 or for MPT-G due to insufficient sample size. e^B is the odds ratio.

Predictor by Test Type	B	SE B	Course Level 3 χ^2	p	e^B	95% CI	B	SE B	Course Level 4 χ^2	p	e^B	95% CI
MPT-A												
Total Test Score	.13	.06	4.4	.04	1.14	[1.01,1.30]	.30	.06	25.6	<.001	1.36	[1.20,1.52]
Intercept	-.68	1.04	.43	.51	.51		-5.66	1.43	15.6	<.001	.003	

Notes. Estimates were not computed for Course Level 2 due to insufficient sample size. e^B is the odds ratio.

Washington State University

Criterion: Course grade ≥ 2.0.

Predictor by Test Type			Course Level 2				Course Level 3					
	B	SE B	χ^2	p	e^B	95% CI	B	SE B	χ^2	p	e^B	95% CI
MPT-I												
Total Test Score	.13	.05	7.2	.007	1.14	[1.04,1.25]	.10	.04	6.8	.009	1.1	[1.02,1.18]
Intercept	-2.09	.96	4.7	.03	.12		-1.35	.89	2.3	.13	.26	

Notes. Estimates were not computed for Course Levels 1 or 4 or for MPT-G or MPT-A due to insufficient sample size. e^B is the odds ratio.

Western Washington University

Criterion: Course grade ≥ 1.7.

Predictor by Test Type	*B*	SE *B*	Course Level 2 χ^2	*p*	e^B	95% CI	*B*	SE *B*	Course Level 3 χ^2	*p*	e^B	95% CI
MPT-I												
Total Test Score	.14	.04	12.4	<.001	1.15	[1.05,1.24]	.16	.04	14.0	<.001	1.17	[1.08,1.27]
Intercept	-1.29	.70	3.4	.06	.28		-2.67	1.00	7.0	.008	.07	

Notes. Estimates were not computed for Course Levels 1 or 4 or for MPT-G or MPT-A due to insufficient sample size. e^B is the odds ratio.

Predictor by Test Type	*B*	SE *B*	Course Level 3 χ^2	*p*	e^B	95% CI	*B*	SE *B*	Course Level 4 χ^2	*p*	e^B	95% CI
MPT-A												
Total Test Score	.13	.06	4.91	.03	1.14	[1.02,1.28]	.03	.08	.19	.66	1.04	[.89,1.21]
Intercept	-.61	.86	.50	.48	.54		1.41	1.69	.70	.40	4.11	

Notes. Estimates were not computed for Course Levels 1-2 due to insufficient sample size. e^B is the odds ratio.

Criterion: Course grade ≥ 2.0.

Predictor by Test Type	*B*	SE *B*	Course Level 2 χ^2	*p*	e^B	95% CI	*B*	SE *B*	Course Level 3 χ^2	*p*	e^B	95% CI
MPT-I												
Total Test Score	.15	.04	16.6	<.001	1.16	[1.08,1.24]	.20	.04	22.7	<.001	1.22	[1.12,1.32]
Intercept	-1.90	.64	8.8	.003	.15		-3.98	.99	16.1	<.001	.02	

Notes. Estimates were not computed for Course Levels 1 or 4 or for MPT-G or MPT-A due to insufficient sample size. e^B is the odds ratio.

Predictor by Test Type	*B*	SE *B*	Course Level 3 χ^2	*p*	e^B	95% CI	*B*	SE *B*	Course Level 4 χ^2	*p*	e^B	95% CI
MPT-A												
Total Test Score	.11	.05	4.7	.03	1.12	[1.01,1.24]	.03	.07	.22	.64	1.03	[.90,1.18]
Intercept	-.78	.76	1.0	.31	.46		1.04	1.45	.52	.47	2.84	

Notes. Estimates were not computed for Course Levels 1-2 due to insufficient sample size. e^B is the odds ratio.