PREDICTIVE VALIDITY OF PLACEMENT TEST SCORES FOR COURSE PLACEMENT AT IUPUI: SUMMER AND FALL 2000

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Executive Summary

Renewed interest in placement testing has emerged on the IUPUI Campus with the adoption of two tests from the commercial COMPASS series produced by ACT. The move to COMPASS Math was predicated on an expressed dissatisfaction with math placements at the upper end of the ability spectrum by the web-based computerized adaptive math test (Hsu & Shermis, 1989). Moreover there was the additional attraction in aligning placement testing practices with those adopted by Ivy Tech State College since there are a number of students who move between Ivy Tech and IUPUI through the Passport Program. The math faculty examined two commercial systems and concluded that the COMPASS system provided the best overall package in terms of its predictive validity and compatibility with other schools that might refer students to IUPUI. Additional advantages of the COMPASS Math test include a larger item bank and national norms. As was true with the web-based computerized adaptive test, COMPASS Math consists of multiple-choice items and administers approximately 25 items before making a placement recommendation. It incorporates computerized adaptive testing technology across four content domains including pre-algebra, algebra, college algebra, and trigonometry.

The change in the reading assessment arose, in part, because of the discontinuance of remedial reading courses through the School of Education. Since University College assumed responsibility for remedial efforts in reading, a subcommittee of UC Faculty engaged in a process similar to that undertaken with math. The faculty adopted the COMPASS Reading Test as a way to improve the testing and advising procedures associated with reading. The COMPASS Reading is a multiple-choice, computerized adaptive test that incorporates both comprehension from reading passages and tests of vocabulary in an assessment that is about 45 items in length. Both COMPASS Reading and Math tests are network-based which restricts their

administration to those entities that are part of the IU NT domain. As such, they cannot be used as components of the high school placement testing program described in previous reports.

With the exception of a change in prompts, the format for the writing test remained unchanged. The English placement exam is a one-hour exam that asks students to write an essay that explains and supports their opinion on a current social issue. The test provides a brief explanation of the issue or the context in which the issue is posed. Students are also asked to evaluate their answer and explain what changes they might make, had they the time to do so. When readers assess the English placement tests, they look for presence or absence of organization, support, development, and the student's position on the issue presented. Students who need extra help focusing their essays around a major theme, or students who need extra help understanding the relationship between assertion and support, are placed into an appropriate developmental course.

Beginning in January of 2000, the Testing Center began administering placement tests in math and reading using ACT's COMPASS tests (ACT's ASSET tests are used for paper-and-pencil administrations, e.g., students administered tests through Adaptive Education Services). The evaluation of all three tests involved samples drawn from Spring and Summer 2000 who subsequently enrolled in a course during Summer and Fall 2000 for which a placement was made. In math, since some students enroll in courses other than those recommended by the test, the sample (n = 2,961) was divided into two groups, "compliant" and "non-compliant". The compliance rate for math was 65% (down from 84% from last year). The samples for the compliant and combined groups were analyzed separately. The results of logistic regression analyses based on combined groups might be helpful in determining the optimum placement cutoffs for the respective courses. The outcome measures used in the assessment of the math test consisted of the

common final test score administered at the end of the term (primary outcome) and course grade (secondary outcome).

The English Department rarely makes placements outside of those recommended through placement testing. The sample used for this study (n = 1903) had a compliance rate of 97% (similar to last year). Because the "non-compliant" pool was so small, only the "compliant" data were analyzed. The outcome variable used in this study was course grade.

As mentioned previously, IUPUI no longer offers remedial reading courses. As a consequence, there is no formal criterion against which to evaluate the placement test. In anticipation that there may be some interest in using the COMPASS Reading test as a way to predict student retention, end-of-semester GPA was used as a proxy criterion. A sample of n = 2,523 students was extracted to evaluate the performance of the COMPASS Reading test for this role.

As in the past, the data were analyzed using two complementary processes. In applying logistic regression, the probability of obtaining a particular grade was graphed as a function of what score one obtained on the placement test. In both the case of math and written English, there was a positive monotonic relationship between the predictor and the criterion for each of the courses defined by the cutoff criteria. This means that the higher the score within the placement range defined for a particular course, the greater the probability of success. Counselors can use this information to convey how likely it is that a student would get an "A", "B", "C", etc. for a particular course based on the placement test score. Also, faculty could use results of the logistic regression analyses to determine the optimum placement cutoffs for the respective courses in math and writing.

The second approach employed the traditional predictive validity coefficient as a way to evaluate the effectiveness for each of the tests.

The placement validity coefficients for the COMPASS mathematics tests, calculated on the relationship between the placement test scores and scores on a common final mathematics exam, averaged .16. The average correlation coefficient between COMPASS mathematics test scores and mathematics course grades was approximately .11. The relationship with both outcomes was significantly lower than that obtained last year with the web-based placement exam.

For reading, the obtained correlation coefficient between the COMPASS Reading Skills Test scores and semester GPA was approximately .10 (n = 2115, $p < .001$) for the Fall 2000 cohort. This result is comparable to the overall correlation of approximately .07 between the previous IUPUI computerized Reading Placement Test (RD100) and semester GPAs for the 1999 cohort (n = 2755, $p < .001$). The difference between the two tests in terms of predictive validity is negligible and non-significant.

The average correlation coefficient between the English Placement Test (EN100) scores and course grades was .17. This was comparable to the results obtained in last year's study. In addition, the potential application of Project Essay Grade computer technology (PEG) for supplemental use in making placement recommendations was also evaluated. The correlation between PEG predictions and course grades in English W131 was r = .14, a negligible and non-significant difference from the averages of human raters.

The report concludes with several recommendations. The Department of Mathematical Sciences has already anticipated improving the utility of the test by implementing adjustments to the placement cutoff scores. Their initial set of changes was put into effect in early October. Additional monitoring of the cutoff scores is recommended throughout 2001.

As suggested in the previous Placement Validity Reports, the English Department faculty are encouraged to seek or adopt alternative methods of

assessment (e.g., portfolios), in conjunction with traditional forms of assessment, to obtain a wider range of scores. Some thought might also be given to using a graded writing assignment as an outcome measure instead of relying solely on course grades, since these sometimes include non-ability factors in their composition. This would help to strengthen the relationship between the test score and end-of-course outcomes.

As reading test scores are no longer used for course placement, it is recommended that the use of the COMPASS/ASSET Reading Skills Test be discontinued as a part of the regular requirement for beginning freshmen at IUPUI. If the reading test scores are perceived as being useful as general reading assessment indicators and/or for conducting research on student retention, then some reconsideration might be given to employing the locally-developed web-based Reading Placement Test (RD100), as the exploratory correlations between reading test scores and semester GPAs suggest that the previous test is psychometrically as sound as the COMPASS Reading Skills Test (RD200). In either case, the additional costs associated with the commercial test no longer seem to be justified.

Overview

As part of ongoing efforts to monitor and improve the placement testing program, the present study was designed to assess the validity of placement test scores in making course placement decisions at Indiana University Purdue University Indianapolis (IUPUI) for the Fall 2000 cohort. As IUPUI adopted use of the ACT's COMPASS Placement Tests in Mathematics and Reading in Spring 2000, this is the first formal study of the predictive validity of COMPASS Mathematics placement test scores for course placement at IUPUI. Because the COMPASS Reading Skills Test scores are currently not used for course placement at IUPUI, only a general exploratory validity study will be conducted for the reading test scores, using semester Grade Point Averages (GPAs) as the criterion measure.

Introduction

A cursory review of related literature suggests that placing new students into appropriate first year courses has become an increasingly challenging task for colleges and universities. Sawyer (1996, 1999) indicates that the percentage of postsecondary institutions with some form of placement and developmental instruction has steadily increased in the past decade and is now about 90%.

In placement decisions, the concern of the institution is to create learning environments in which <u>all</u> students will learn. Hills, Hirsch, and Subhiyah (1990) define placement as a process by which students are assigned to courses commensurate with their past achievements in order to facilitate expeditious further learning. "The underlying idea is that students differ. They may differ in their level of preparation, in their adeptness at learning, in their interests, in their ability to organize for themselves, and so on. As a result, for efficient instruction, one arranges for different approaches for the different students or groups of

students. Ideally, a student is placed in the learning situation which is best for him" (Hills, Hirsch, & Subhiyah, 1990, p.5). Accordingly, IUPUI has implemented a placement testing program for new undergraduate students in order to facilitate the academic success of students at the University.

The IUPUI placement test in English and the COMPASS Mathematics tests serve the course placement function at IUPUI (i.e., matching students with instruction appropriate to their academic preparation) in English (writing) and mathematics. Thus, like most other higher education institutions (NCES, October 1996), IUPUI provides developmental courses in writing and mathematics. Generally speaking, developmental courses are provided to those college students lacking in academic skills necessary to perform college-level work at the level required by the institution (NCES, October 1996). Although what constitutes developmental courses varies from institution to institution, often developmental courses do not carry credit toward satisfying degree requirements.

In general, the rationale for placement testing is threefold: First, students who enroll in appropriate university courses should have a more positive experience than those who enroll in courses that are either too difficult or too easy. They should be more satisfied with their university experience, and thus more likely to be retained. Second, because students are more likely to be retained in classes that are appropriate to their ability level, departmental administrators can more carefully plan how best to allocate faculty resources to respective class sections. Finally, the placement tests might serve as a basis for assessing the contributions of the University to the development of general educational skills. If placement tests perform the three vital functions well, then University funds spent on these assessments are wisely expended.

As is the case with most placement testing systems, COMPASS scores are intended for placing students into college courses. The elements of the validity argument supporting this use include the following:

- The COMPASS tests measure the skills and knowledge students need to succeed in specific courses
- Students who have the skills and knowledge necessary to succeed in a given course are likely to perform satisfactorily, and students without those skills are not.
- Greater levels of proficiency are related to higher levels of satisfactory performance in the course. If course placement is a valid use of these tests, then one would expect a significant, positive statistical relationship between COMPASS test scores and course grades. (ACT's COMPASS *Technical Manual*, 1999, 3-48)

In addition to the use of correlation coefficients and related indices, the present study employs logistic regression procedures as an alternative methodology (developed by ACT) to provide more informative and useful validity evidence (cf. Sawyer, 1989). As outlined in the ACT's COMPASS *Technical Manual*, the correlation approach has three main limitations: (1) Correlation coefficients provide little direct information about the effectiveness of test scores for placing students into courses, and are easily misinterpreted; (2) Correlations indicate the direction and strength of the relationship between test scores and course grades, but the procedure makes several statistical assumptions (particularly the assumptions of normality of course grades, equal variance, and linear relationship between predictor and outcome measures) that may not be warranted; (3) Correlations do not take into account the costs of incorrect placement decisions; and (4) Correlation coefficients are unduly influenced by restriction of test score range. In contrast to using simple correlation coefficients, logistic regression enables one to estimate the probability of success (e.g., a grade of B or better or a grade of C or better) in the standard courses for all tested students and, in particular, allows the calculation of the percentage of students correctly placed (i.e., the *accuracy rate*). For a detailed discussion on the advantages and

disadvantages of the two methodologies for making placement decisions, see the COMPASS *Technical Manual* (ACT, 1999).

A brief overview of the three standard placement tests employed at IUPUI is as follows.

COMPASS Mathematics. The computerized adaptive COMPASS Mathematics Placement Tests administered at IUPUI include four content domains: Pre-Algebra, Algebra, College Algebra, and Trigonometry. Multiple-choice items in each area test the following: *basic skills* (performing a sequence of basic operations), *application* (applying sequences of basic operations to novel settings or in complex ways), and *analysis* (demonstrating conceptual understanding of principles and relationships for mathematical operations). Students are permitted to use a calculator when completing the mathematics placement tests. An online calculator is available for students who wish to access it via Microsoft Windows®; or students may use their own calculators as long as they meet the requirements specified by ACT. Table 1 shows the COMPASS Mathematics cutoff scores that were used for MATH placements for students who tested between January 4 and October 3, 2000, at IUPUI. Consequently, the present validity study (in mathematics) is based on placement cutoff scores presented in Table 1. Note that students' mathematics test scores are valid for one year from the test date.

TABLE 1. COMPASS Mathematics Placement Cutoff Scores (as of March 10, 2000)

	Pre-Algebra Test (MA401)	**Algebra Test** (MA402)	**College Algebra Test** (MA403)	**Trig. Test** (MA404)
MATH 044: Basic Math/Arithmetic course (Refer to Ivy Tech State College)	1-18			
MATH M010: Pre-Algebra (7^{th} & 8^{th} Grade Math)	19-44			
MATH 001: Introduction to Algebra (1^{st} Year High School Algebra)	45-100 and (see MA402)	1-35		
MATH 110: Algebra for Non-Science Majors (2^{nd} Year High School Algebra)	45-100 and (see MA402)	36-45		
MATH 111: Algebra for SCI/ENGR/TECH Majors (2^{nd} Year High School Algebra for Science)	45-100 and (see MA402)	46-70		
MATH M118: Finite Mathematics (or a Pre-requisite MATH 111 or 110)		71-100		
MATH M119: Brief Survey of Calculus (or a Prerequisite MATH 111 or 110)		71-100		
MATH 130: Math for Elementary Educ Majors (or a Pre-requisite MATH 111 or 110)		71-100		
MATH 153: College Algebra (or a Pre-requisite MATH 111 with C or better)		71-100 and (see MA403)	1-35	
MATH 151: College Algebra and Trigonometry (or a Pre-requisite MATH 111 with B or better)		71-100 and (see MA403)	36-55	
MATH 163: Calculus for SCI/ENGR Students (or a Pre-requisite MATH 153 and 154, or 151)			56-100	1-100

COMPASS Reading. According to the ACT *Technical Manual* and other publications on the COMPASS/ESL system, the COMPASS Reading Placement Test was designed to help determine if students have the skills to succeed in standard entry-level college courses of if they need developmental reading courses or other instructional support options. Types of reading comprehension passages included are humanities, social sciences, and natural sciences. The COMPASS Reading Test employs a computerized adaptive testing procedure, with items that have multiple-choice response options. The COMPASS for Windows format makes it possible for students to see and read a passage on one side of the screen while the test questions and answer choices are displayed on the other half of the screen. (Note: Currently, the COMPASS Reading Test is not used for course placement at

IUPUI. Thus, at the present time, there are no course placements associated with the COMPASS Reading Test scores. Also, the COMPASS Reading Diagnostic section is not administered at IUPUI.)

English Placement Test. The English placement exam is a one-hour exam that asks students to write an essay that explains and supports their opinion on a current social issue. The test provides a brief explanation of the issue or the context in which the issue is posed. Students are also asked to evaluate their answer and explain what changes they might make, had they the time to do so. When readers assess the English placement tests, they look for presence or absence of organization, support, development, and the student's position on the issue presented. Students who need extra help focusing their essays around a major theme, or students who need extra help understanding the relationship between assertion and support, are placed into an appropriate developmental course.

The purpose of the English placement exam is to assess students' ability to write an essay that explains and supports one's viewpoint or opinion on a given issue. Examinees have a choice of two questions, each of which allows the students to use their personal experiences and/or observations in writing the essay. It is important that the test conveys not only the examinee's viewpoint on the selected topic, but also the reasons for taking a particular position. The test, however, does not require any specialized knowledge or research, only an ability to discuss an individual's opinion and reasons. Within the one hour time allotted to the English placement test, students are expected to (a) think seriously about the topic selected, (b) state an opinion clearly, (c) present examples or details that support an opinion, and (d) organize the essay clearly. The English test score is valid for two years from the test date. Students are required to register for the respective courses into which

they are placed [i.e., W001 - Fundamentals of English; W131 - Elementary Composition; or W140 - an honors version of W131].

Major Changes Made in 2000

As noted earlier, during the spring of 2000 the Department of Mathematical Sciences adopted the use of COMPASS Mathematics Placement Tests to be administered to “beginning freshmen” for summer and fall 2000 semesters. The decision to replace the Web-based IUPUI Mathematics Placement Tests with the COMPASS placement tests followed a series of deliberations aimed at addressing concerns regarding the alleged “under-placement” of students in higher-level mathematics courses at IUPUI (i.e., courses above MATH 111, College Algebra). As part of the deliberations, the mathematics faculty reviewed two of the most popular commercial and nationally-normed placement tests (namely, The College Board's Accuplacer and ACT's COMPASS) in an effort to find a suitable mathematics placement test to address the concerns about student "under-placement" in higher-level MATH courses at IUPUI. The deliberations culminated in a decision (by the Department of Mathematical Sciences, University College, and endorsed by the Student Placement Testing Advisory Committee) to adopt the COMPASS tests to replace the in-house developed Web-based mathematics and reading placement tests. However, no changes were made to the IUPUI English Placement Test. (The new procedural changes pertaining to the COMPASS placement tests are reported in the Testing Center’s annual report, which will soon be available on-line at the Testing Center’s Web site: http://assessment.iupui.edu/report/report.html).

Method

Sample

The target population comprised all students who took the IUPUI English, COMPASS Mathematics, or COMPASS Reading placement tests from January to August 2000, and enrolled in an English writing or mathematics course during the summer or fall of 2000 at the IUPUI campus. Note that the present study excluded students who were tested but did not enroll in any mathematics or writing course in summer or fall of 2000. Also, students with incomplete and/or missing course grades were excluded from subsequent data analysis.

Procedure for Obtaining the Data

Students' raw data were obtained through a FOCUS query from the Fall 2000 cohort of students who took the IUPUI English or the COMPASS Mathematics or Reading placement tests and then enrolled in a writing or mathematics course during the Summer or Fall 2000 semesters. Because the IUPUI placement tests are seen as advisory[1] rather than prescriptive, in some cases (particularly with reference to mathematics) a student enrolled in a course that was not recommended by the placement test score. Consequently, for the purpose of statistical analyses, students were divided into two categories referred to as "compliant" and "non-compliant" groups. The compliant group comprised students who took the recommended courses based on the placement test scores. The non-compliant group consisted of students who chose (sometimes in consultation with their advisors) not to take the recommended course. Since IUPUI has a system of pre-requisite check, a student in the "non-compliant" group had the explicit waiver of a representative from the Department of Mathematical

[1]The English Department views the placement test results as prescriptive rather than advisory, although it does offer an appeal process for students who wish to challenge their course placements.

Sciences to take the math course in which s/he was enrolled. The relevant extract resulted in a pool of 1,477 students for the English (written) Placement Test, 2,617 students for mathematics (based on combined data for summer and fall of 2000), and 2,523 students for reading[2].

With respect to compliance, there were 1157 students who took the COMPASS Mathematics Placement Tests (based on the cutoff scores for MA401-MA404) during the spring semester of 2000, and then enrolled in a recommended mathematics course (i.e., MATH M010, MATH 001, MATH 110, MATH 111 or a higher-level MATH class) during summer or fall of 2000. With respect to English, there were 1387 students who took the English placement test and then enrolled in one of the following recommended courses: W001, W131, or W140 in fall of 2000. Overall, the total compliance rates (based on the available data) were approximately 65% for mathematics (which is considerably lower than last year's 84% compliant rate) and 97% for English, which is identical to the one reported in the 1999 Placement Validity Report.

Research Design and Data Analysis

Like the previous placement validity reports, the present study employed some aspects of decision theory models (Sawyer, 1996; Noble & Sawyer, 1997) and logistic regression techniques (Grimm & Yarnold, 1995; Hosmer & Lemeshow; 1989; Norusis/SPSS Inc., 1992; ACT's COMPASS/ESL *Technical Manual*) to provide validity evidence for course placement criteria. These statistical procedures supplemented the simple correlation approach that was used to demonstrate the relationship between predictor scores and outcome measures. It is noteworthy that most college placement exams have correlations that run between .20 and .40 (Hills, Hirsch, &

[2]Note: COMPASS Reading Skills Test scores are currently not used for course placement at IUPUI.

Subhiyah, 1990). This offers an arbitrary benchmark to assess the results of the present study.

The predictor variables consisted of students' placement test scores on mathematics, reading, and English, respectively. The outcome measures were the corresponding exam scores and/or course grades in the respective content areas. The rationale for the validation/research design was as follows. To the extent that the usefulness of a placement test depends on the existence of statistical relationships, such evidence is clearly essential to validation. Thus, by measuring the strength of this statistical relationship, we obtained evidence on the validity of the placement test scores for making course placement recommendations. However, to address limitations of using correlation coefficients as evidence of predictive validity, the present study employed the logistic regression model in validating the IUPUI course placement tests.

The primary criterion measure for mathematics comprised final examination scores and/or grades based on a common departmental final math exam. The secondary outcome variable for mathematics consisted of the course grade obtained by the student at the end of Summer and Fall 2000. The mathematics grades ranged from "A+" to "F". For purposes of correlation analyses, the letter grades were converted to a numeric scale ranging from 4.33 for an "A+" to 0.33 for an "F".

For the correlation procedure, the primary outcome variable for reading consisted of the student's end-of-fall semester Grade Point Average (also known as Freshman GPA in short). For the logistic regression analyses, however, the criterion measures were based on the course grades and not the post-test (RD004) reading scores. The predictor variable for reading comprised students' placement test scores based on the computerized adaptive COMPASS Reading Test (RD200). As noted earlier, IUPUI no longer offers the two reading courses (namely, EDUC X150 and EDUC X152); hence,

there are no outcome measures for reading. For purposes of conducting exploratory correlation analyses, however, the freshman GPA was used as a criterion measure. (Note that students who withdrew from the University College were excluded from the correlation analyses.)

The outcome variable for English was the course grade obtained at the end of the fall semester. English grades ranged from “A+” to “F”. For purposes of calculating correlation coefficients, the letter grades were converted to a numeric scale ranging from 4.33 for “A+” to 0.33 for “F”. Students who withdrew from courses of interest were excluded only from the correlation analyses.

The present study was aimed at providing two major types of validity information. First, probabilities of success were estimated from logistic regression and frequency distributions of scores on the placement measures to determine the effectiveness of the course placement criteria. Probability graphs were then developed to provide graphical illustrations of the relationship between placement test scores and predicted first-year college performance in English, mathematics, and reading, respectively. Second, simple correlation analyses were conducted to obtain coefficients among all the variables studied (i.e., predictor and outcome measures). The intercorrelations (validity coefficients) between the predictors and each outcome measure indicated how the predictors were working, but did not provide a means of making specific predictions for individuals. This was accomplished with the prediction equations, which were essentially the product of logistic regression analyses. In essence, the prediction equations used one variable (i.e., the respective placement test scores) to predict an outcome. This information, however, did not indicate how effective the predictions were. Thus, estimates of measurement error in prediction (i.e., standard errors of estimate) were computed. The results

of fitting logistic regression models to the respective data are reported in subsequent tables (see Tables B.1 – B.10 in Appendix B).

Probability of Success

The statistical relationship between students' outcomes (i.e., a course grade of, say, "C" or higher) and their placement test scores was estimated using logistic regression. (Details regarding logistic regression are presented in Appendix A.) The relationship was estimated from the data of students who actually took a placement test and subsequently enrolled and completed the respective course(s) during fall of 2000. For each placement test score, a corresponding probability of success was estimated for the respective courses. The dependent variable used a 0/1 (unsuccessful/successful) criterion measure. (Note that for logistic regression analyses, "FX" or incomplete ("I") grades and withdrawals ("W"), were simply excluded from the analyses, without necessarily converting them to "F" grades and/or treating that data as unsuccessful outcomes). For purposes of this study, the criterion variable was generally defined as a grade of "C-" or higher. However, probabilities of success were also estimated for grades of "B-" or higher and "A-" or higher, respectively.

Results

The basic course placement procedure applied at IUPUI is mostly dependent upon students' academic achievement, as measured by the placement tests in English, mathematics, and reading, respectively. The manner in which placement decisions are made has been described in the Introduction section. Thus, it is imperative that the effectiveness of the existing placement procedures be known. To provide some information, the

probability of success estimated what would happen if a specific cutoff on a particular criterion measure was applied to a particular reference group. (In the context of course placement, the reference group may be thought to as the student pool that took placement tests.) Note that using correlations as the basis of comparing potential placement measures can be misleading, as the "compliant" group of students may differ substantially from the reference group. Also, the restriction of range problem in the outcome measures lowers the utility of correlation coefficients in validating placement criteria. Alternative methods for validating course placement criteria were warranted as correlation evidence *per se* has severe limitations (e.g., see ACT COMPASS *Technical Manual*; Mzumara, Shermis, & Wimer, 1996; Noble & Sawyer, 1997).

Table 2 provides a summary of the descriptive statistics for the compliant and non-compliant groups based on the respective placement test scores. Table 3 shows the overall descriptive statistics for Summer and Fall 2000 cohorts. The detailed results of logistic regression analyses for the respective courses are provided as Tables B.1 - B.10 in Appendix B. Based on the tables and graphs, a summary of the results per course is presented in turn.

Mathematics

The following is a summary of the descriptive statistics based on "compliant" and "non-compliant" groups for mathematics (see Table 2). The mathematics compliant and non-compliant groups were determined on the basis of placement cutoffs that were used for the Summer and Fall 2000 cohorts (see Table 1). For instance, the compliant group for MATH M010 consisted of students who obtained Pre-Algebra domain scores of between 19 and 44 and enrolled in the recommended course (MATH M010) during the summer or fall of 2000. In contrast, the non-compliant group consisted of students who

enrolled in a different math course other than the recommended course based on placement cutoffs. Note that for purposes of calculating descriptive statistics reported in Table 2 and/or estimating the overall compliance rate for mathematics, courses that had overlapping placement cutoffs were grouped in one category (e.g., MATH 001, 110 or 111, which have the same Pre-Algebra placement cutoffs (45-100)), as reported in Table 1.

The compliant group for MATH M010 (n = 533) had a mean Pre-Algebra Placement Test score of 34.35 with a standard deviation of 6.68. Students in the non-compliant group for MATH M010 (n = 333) obtained a mean Pre-Algebra Placement Test score of 36.95, with a standard deviation of 5.37. With Pre-Algebra Test (MA401) as the predictor measure, the compliant group for MATH 001/110/111 (n = 450) obtained a mean COMPASS Pre-Algebra Test score of 57.27, with a standard deviation of 12.92. The corresponding non-compliant group for MATH 001/110/111 (n = 38) had a mean Pre-Algebra Test score of 53.97 and a standard deviation of 12.17. Table 2 shows similar breakdowns for the other COMPASS Mathematics Placement Tests (MA402-MA404) and Math courses, respectively.

Table 2.

Descriptive Statistics for the Compliant and Non-Compliant Groups Based on Placement Test Scores for Summer and Fall 2000 Cohorts

				Placement Test Scores[3]		
Test Area	**Placement Test-ID**	**Course Placement**	**Group**	**Mean**	***SD***	***N***
English	EN100	W001	Compliant	9.87	0.78	269
			Non-compliant	8.75	1.89	4
	EN100	W131	Compliant	14.26	1.20	1079
			Non-compliant	14.35	1.06	17
	EN100	W140	Compliant	19.77	0.90	39

[3]The current descriptive statistics are based on students who tested between January and August 2000, and enrolled in Math and Writing courses during summer or fall of 2000. Also, the reported COMPASS Math data are based on the initial placement cutoffs implemented in Spring 2000 (labeled as MA401-MA404, respectively), and exclude students who took the ASSET Math Tests or the previous computerized adaptive Math placement test (MA305).

			Non-compliant	19.40	0.83	15
Mathematics	MA401	M010	Compliant	34.35	6.68	533
			Non-compliant	36.95	5.37	333
	MA401	001/110/111	Compliant	57.27	12.92	450
			Non-compliant	53.97	12.17	38
	MA402	001	Compliant	30.23	3.45	213
			Non-compliant	30.78	3.65	67
	MA402	110	Compliant	40.53	2.84	135
			Non-compliant	40.99	3.04	102
	MA402	111	Compliant	55.41	5.65	218
			Non-compliant	54.46	5.33	168
	MA402	M118/M119/130	Compliant	83.50	17.68	2
			Non-compliant	79.00	7.31	8
	MA403	153	Compliant	32.25	2.38	8
			Non-compliant	33.50	1.29	4
	MA403	151	Compliant	43.10	3.21	10
			Non-compliant	44.23	3.85	62
	MA403	163	Compliant	67.67	6.43	3
			Non-compliant	68.00	14.14	2
	MA404	163/221	Compliant	52.64	18.30	103
			Non-compliant	45.81	18.57	100
Reading	RD200	Not Applicable	Not Applicable	83.98	12.30	2523

Table 3.

Overall Descriptive Statistics for Summer and Fall 2000 Cohorts

PREDICTOR/OUTCOME MEASURE	N	MINIMUM SCORE	MAXIMUM SCORE	MEAN	STD. DEVIATION
English Placement Test (EN100)	1477	6	22	13.63	2.37
COMPASS Pre-Algebra Test (MA401)	1414	17	99	42.05	14.60
COMPASS Algebra Test (MA402)	911	8	91	43.90	11.83
COMPASS College Algebra	89	28	78	43.87	8.06

Test (MA403)					
COMPASS Trigonometry Test (MA404)	203	16	96	49.28	18.70
COMPASS Reading Test (RD200)	2523	1	99	83.98	12.30
Math Common Final Score	2872	0	47	24.39	7.83

*The current data exclude ESL students and/or students with “FX”, “W”, or “I” grades.

Figures 1 to 8 present probability estimates based on placement cutoffs and the outcome measures when applied to particular mathematics courses (with combined groups of students regardless of compliance). (Note: Tables B.1 - B.8 in Appendix B show the results of logistic regression analyses for mathematics data, based on all students who enrolled in the respective courses regardless of compliance. The probability graphs presented in the present report might be helpful in determining the optimum placement cutoffs in the respective courses. The vertical reference lines in the graphs indicate the placement cutoffs that were in use at IUPUI before October 4, 2000.) For instance, as Figure 1 shows, a student who enrolls in MATH M010 with a COMPASS Pre-Algebra (MA401) placement test score of 34 is associated with an estimated probability of a B- or higher grade of about .50. The corresponding C- or higher cutoff score is 11 (probability of success is about .50). Note, however, when a grade of A- or higher is employed, scores between 19 and 44 are associated with estimated probabilities of success of between .11 and .33. For MATH 111 (see Figure 5), a student with a COMPASS Algebra (MA402) placement score of 56 has an estimated probability of .50 for a grade of B- or higher. In contrast, Algebra (MA402) placement scores between 46 and 70 are associated with probabilities of success of approximately .78 or

greater for a grade of C- or higher. The rest of the figures could be interpreted in a similar manner. In general, the overall results for mathematics show that the estimated probability of success increases as placement test scores increase. In other words, the higher the COMPASS mathematics placement scores, the greater the probability of success in the respective mathematics courses. (Note, however, an exception was observed for MATH 110 and MATH 111 courses given COMPASS Pre-Algebra (MA401) scores, which showed an inverse relationship in the logistic regression curves. This is an anomaly that requires further investigation.)

It is worthwhile to mention that the advantages of using a logistic regression approach, rather than traditional correlation methods, are that we can observe curvilinear relationships and the approach does not require strong distributional assumptions. “When the outcome measure is considered as a dichotomy (pass/fail), rather than as a continuous variable, the focus is placed on addressing the appropriate question, that being whether a student will be successful or unsuccessful, and less so whether a student will receive an A average vs. a B average” (Noble & Sawyer, 1997, p. 3). Thus, the logistic regression approach helps to reduce the problem of restriction of range in course grades.

The placement validity coefficients for the COMPASS mathematics tests, calculated on the relationship between the placement test scores and scores on a common final mathematics exam, averaged .16 for the compliant groups (MA401 and MATH M010: $\underline{r}_{xy}$ = .24, $\underline{n}$ = 344, $\underline{p}$ < .001; MA401 and MATH 001/110/111: $\underline{r}_{xy}$ = .23, $\underline{n}$ = 282, $\underline{p}$ < .001; MA402 and MATH 001: $\underline{r}_{xy}$ = -.09, $\underline{n}$ = 157, not significant (ns)); MA402 and MATH 110: $\underline{r}_{xy}$ = .08, $\underline{n}$ = 102, ns; MA402 and MATH 111: $\underline{r}_{xy}$ = .16, $\underline{n}$ = 174, $\underline{p}$ < .05). Using mathematics course grades as outcome measures, the validity coefficient between COMPASS Pre-Algebra Test (MA401) scores and MATH M010 course grades was .21 ($\underline{n}$ = 476, $\underline{p}$ < .001), and the highest obtained correlation coefficient for compliant

students was approximately .40 between COMPASS Trigonometry Test (MA404) scores and MATH 163 (n = 72, p < .001) and negligible for courses below MATH 111 (except for the negative and statistically significant correlation coefficient between MA401 and MATH 110/111 (r_{xy} = -.25, n = 80, p < .05)). Overall, the average correlation coefficient between COMPASS mathematics test scores and mathematics course grades was approximately .11. In contrast with the correlation coefficients for the Math common final scores, a slight drop in the validity coefficients for course grades was expected because of the adverse effect of range restriction. Note that the observed correlation coefficients, based on compliant groups, were not corrected for attenuation. Also, it is possible that the negative correlation coefficient for MATH 110/111 is artificially inflated due to the relatively small sample size (n = 80); hence, caution must be taken when interpreting the observed validity coefficients. Nonetheless, the present average validity coefficients are lower than those obtained for the previous version of the computerized adaptive mathematics placement test (MA305), which averaged in the mid-.40s, as reported in the 1999 Placement Test Validity Report.

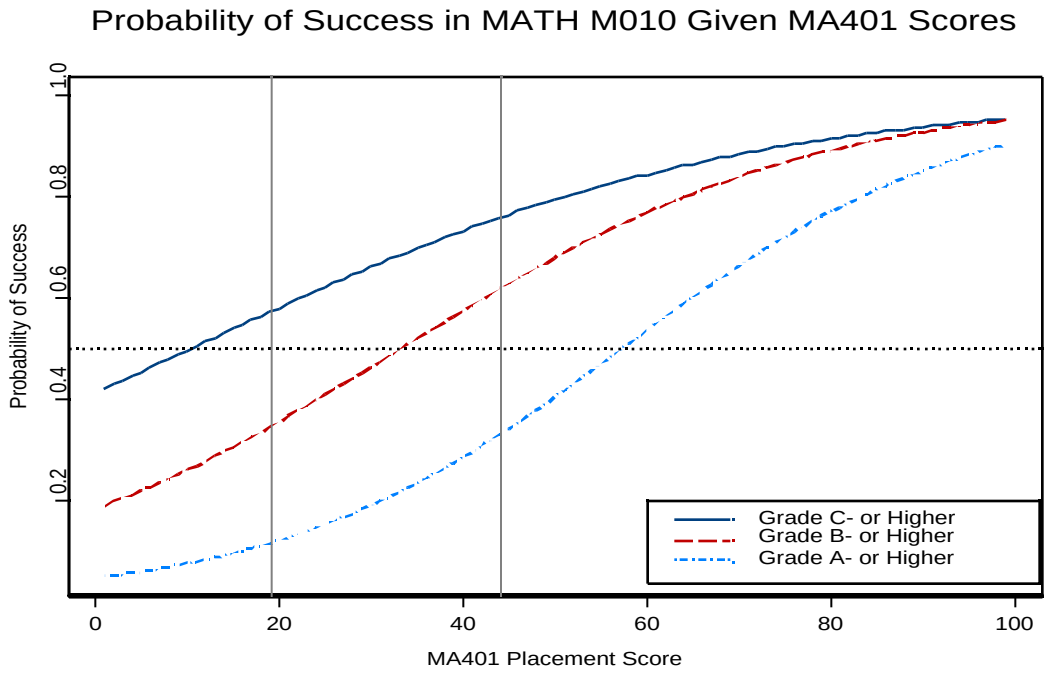

Figure 1. Probability of Success in MATH M010 for MA401 Placement Scores (A- or Higher, B- or Higher, and C- or Higher)

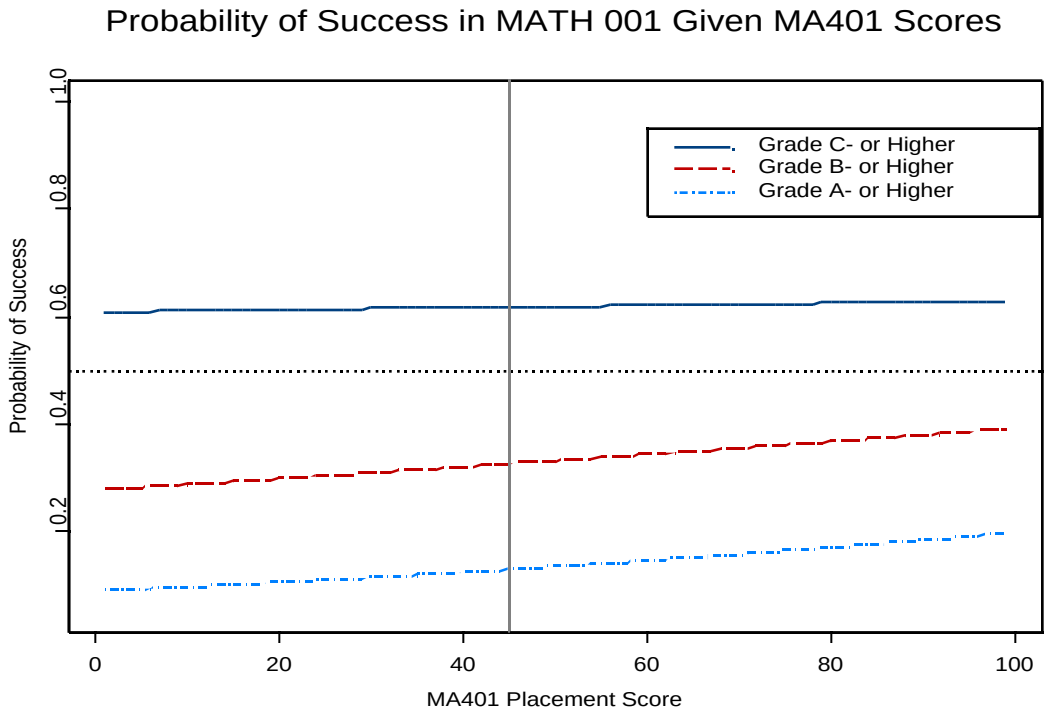

Figure 2. Probability of Success in MATH 001 for MA401 Placement Scores (A- or Higher, B- or Higher, and C- or Higher)

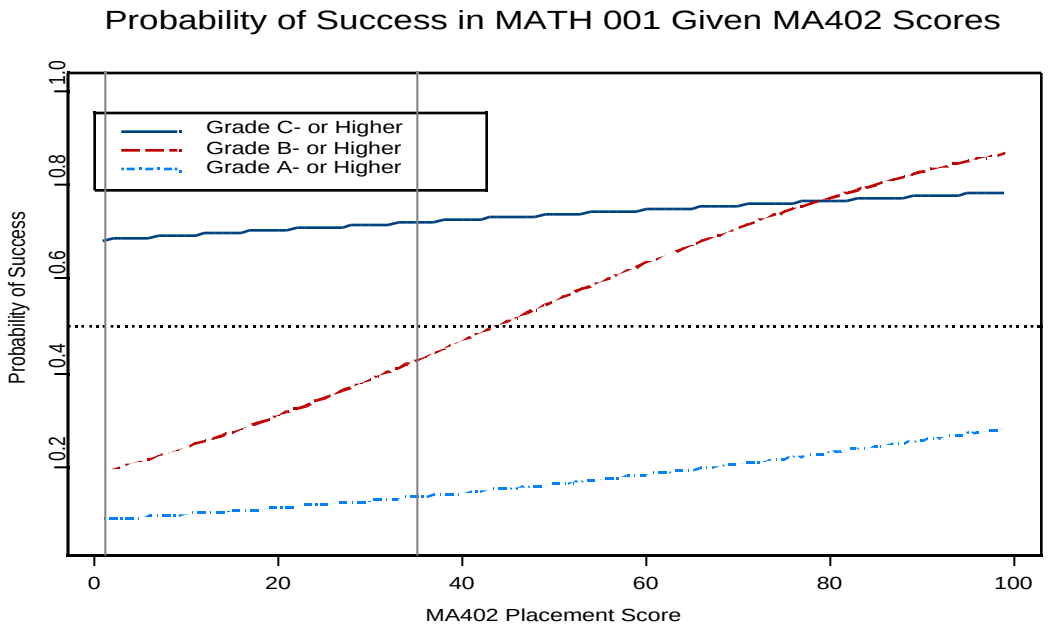

Figure 3. Probability of Success in MATH 001 for MA402 Placement Scores (A- or Higher, B- or Higher, and C- or Higher)

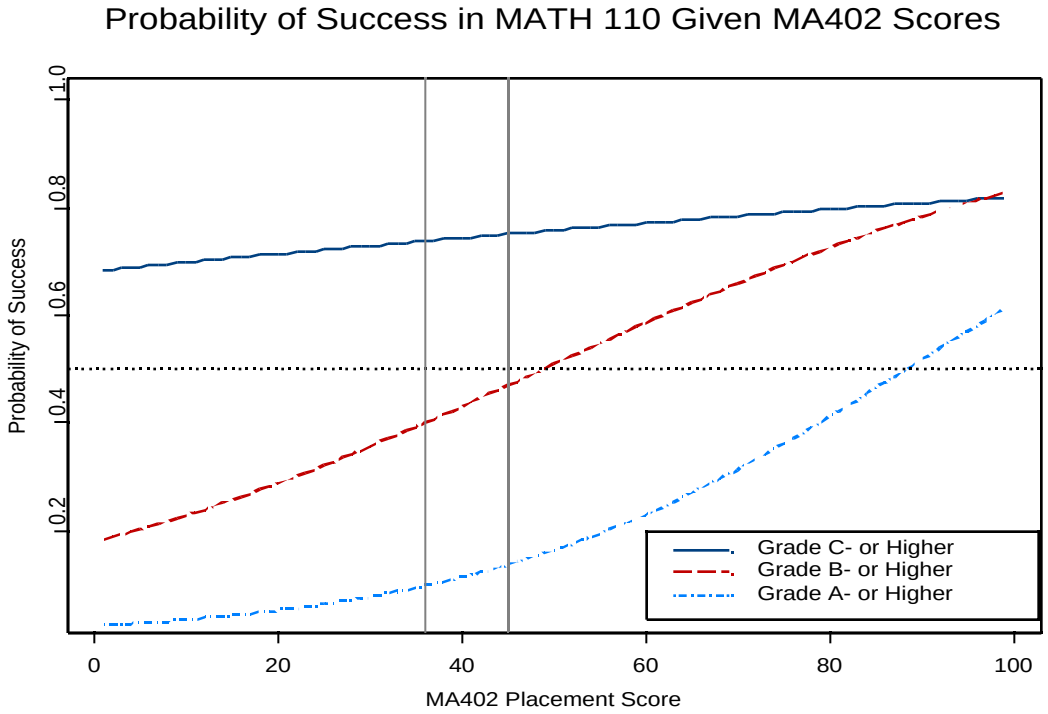

Figure 4. Probability of Success in MATH 110 for MA402 Placement Scores (A- or Higher, B- or Higher, and C- or Higher)

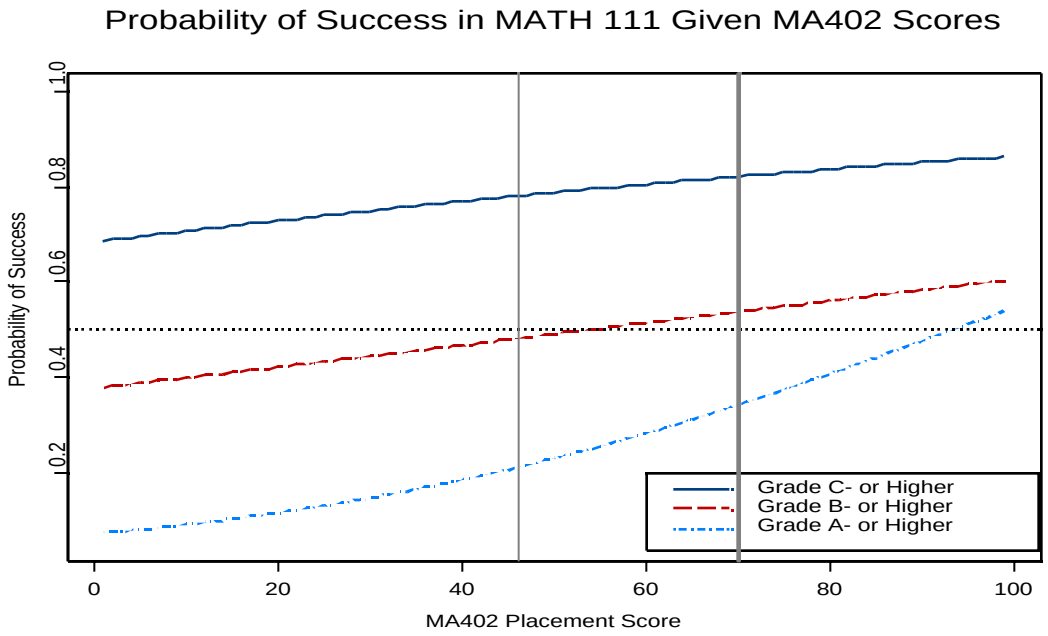

Figure 5. Estimated Probability of Success in MATH 111 for MA402 Scores (A- or Higher, B- or Higher, and C- or Higher)

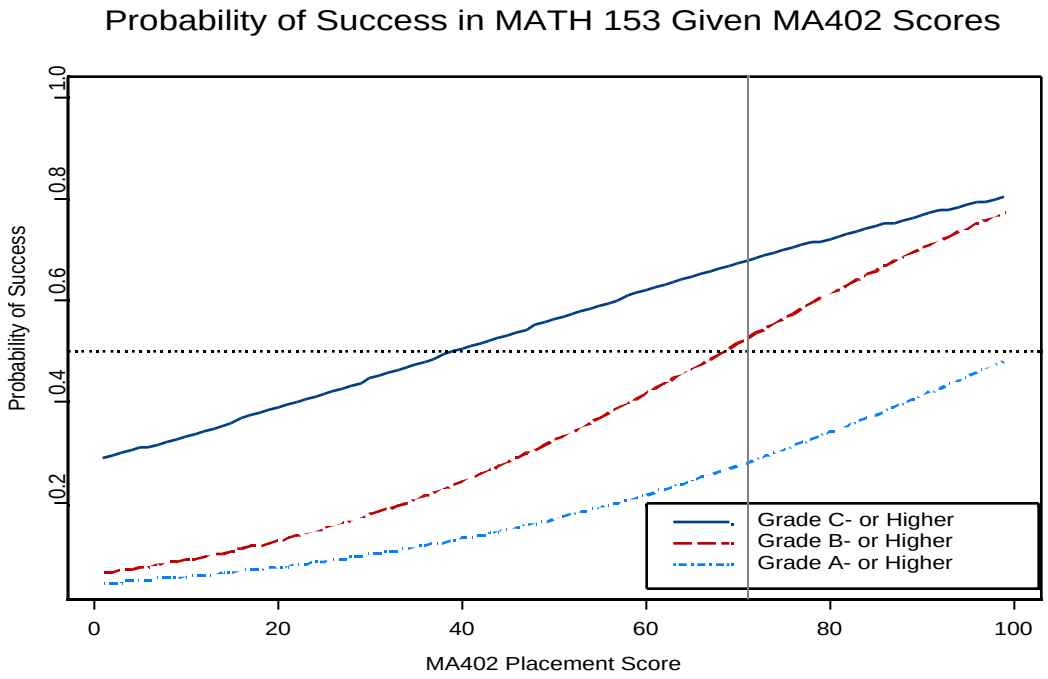

Figure 6. Estimated Probability of Success in MATH 153 for MA403 Scores (A- or Higher, B- or Higher, and C- or Higher)

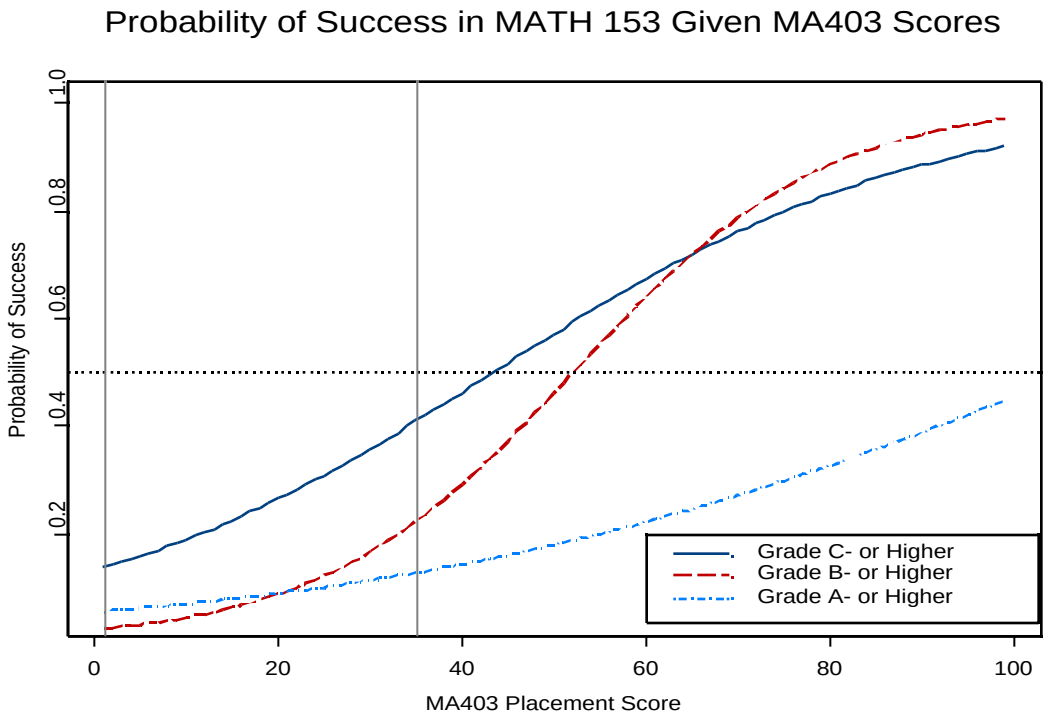

Figure 7. Estimated Probability of Success in MATH 153 for MA403 Scores or Higher, B- or Higher, and C- or Higher)

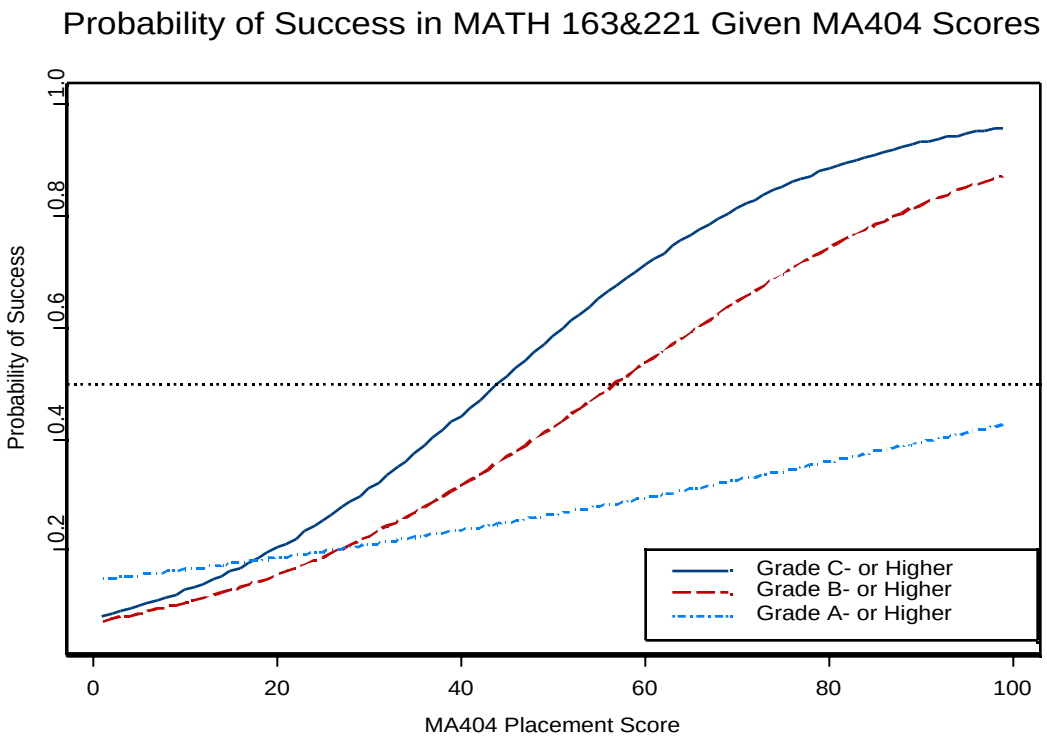

Figure 8. Estimated Probability of Success in MATH 163&221 for MA404 Scores (A- or Higher, B- or Higher, and C- or Higher)

Reading

The overall descriptive statistics for reading are shown in Tables 2 and 3. As there are no course placements associated with the COMPASS Reading Skills Test (RD200) scores, an appropriate outcome measure to compute the validity coefficients for reading was unavailable. However, based on an exploratory correlation analysis using the Fall 2000 semester GPAs as the outcome measure, the obtained correlation coefficient between the COMPASS Reading Skills Test scores and semester GPA was approximately .10 ($\underline{n}$ = 2115, $\underline{p} < .001$) for the Fall 2000 cohort. This result is comparable to the overall correlation of approximately .07 between the previous IUPUI computerized Reading Placement Test (RD100) and semester GPAs for the 1999 cohort ($\underline{n}$ = 2755, $\underline{p} < .001$). The difference between the two tests in predictive validity is negligible.

English

The descriptive statistics for English are summarized in Table 2. The compliant students for W001 writing course ($\underline{n}$ = 269) obtained a mean English placement test score of 9.87 and a standard deviation of .78. The compliant group for W131 course comprised 1079 students who had a mean English placement score of 14.26 with a standard deviation of 1.20. For the W140 compliant group ($\underline{n}$ = 39), the mean English placement test score was 19.77 with a standard deviation of .90. In most cases, there were too few non-compliant students for writing courses to warrant separate statistical analyses. These results are similar to those reported for last year. Note that the average correlation coefficient between the English Placement Test (EN100) scores and course grades was .17. The correlations for the respective writing courses (based on compliant groups) were as follows: ENG W001: $\underline{r}_{xy}$ = .14, $\underline{n}$ = 241, $\underline{p} < .001$; ENG W131: $\underline{r}_{xy}$ = .18, $\underline{n}$ = 950, $\underline{p} < .001$; and ENG W140: $\underline{r}_{xy}$ = .004, $\underline{n}$ = 35, $\underline{p} > .05$)).

Figures 9 and 10 show graphs with estimates of probability of success in the respective writing courses. (Note: The present probability graphs are based on combined groups of students enrolled in ENG W001 and ENG W131,

respectively, and regardless of compliance.) As Figure 9 indicates, an English placement score of 9 is associated with a probability of a B- or higher grade of about .50 in ENG W001. A placement score of 1 is associated with an estimated probability of success of .53 for a grade of C- or higher in ENG W001. Figure 9, which shows probability estimates for success in ENG W131, suggests that students with placement scores of 8, 13, and 18 have a probability of success of approximately .50 with grades of C- or higher, B- or higher, and A- or higher, respectively. Overall, Figures 9 and 10 show that the estimated probability of success in writing courses increases as placement scores increase. However, as observed in Table B.11 (see Appendix B), the negative results and/or lack of statistical significance of the estimated logistic regression coefficients and the corresponding Wald (W) statistics for ENG W140 data could most likely be due to sampling error, as the honors writing course had relatively few students enrolled (n = 39). The present probability graphs may be helpful in determining the optimum placement cutoffs for the two writing courses. The vertical reference lines in the graphs indicate the placement cutoffs currently in use at IUPUI.

For exploratory purposes, a correlation analysis was conducted between PEG scores and English course grades for IUPUI students. As observed in the previous studies, the overall results are quite promising. In particular, it is noteworthy that a statistically significant correlation coefficient was obtained between PEG final ratings and Fall 2000 final course grades in ENG W001 and W131 (r_{xy} = .15, n = 222, p < .05; r_{xy} = .16, n = 884, p < .001, respectively), which are comparable to the validity coefficients obtained for the conventional English Placement Test (EN100) scores. Thus, PEG did reasonably well for predicting ENG W001 and W131 course grades; but did not do as well for ENG W140, primarily due to

the relatively small sample size (n = 39) associated with the honors course.

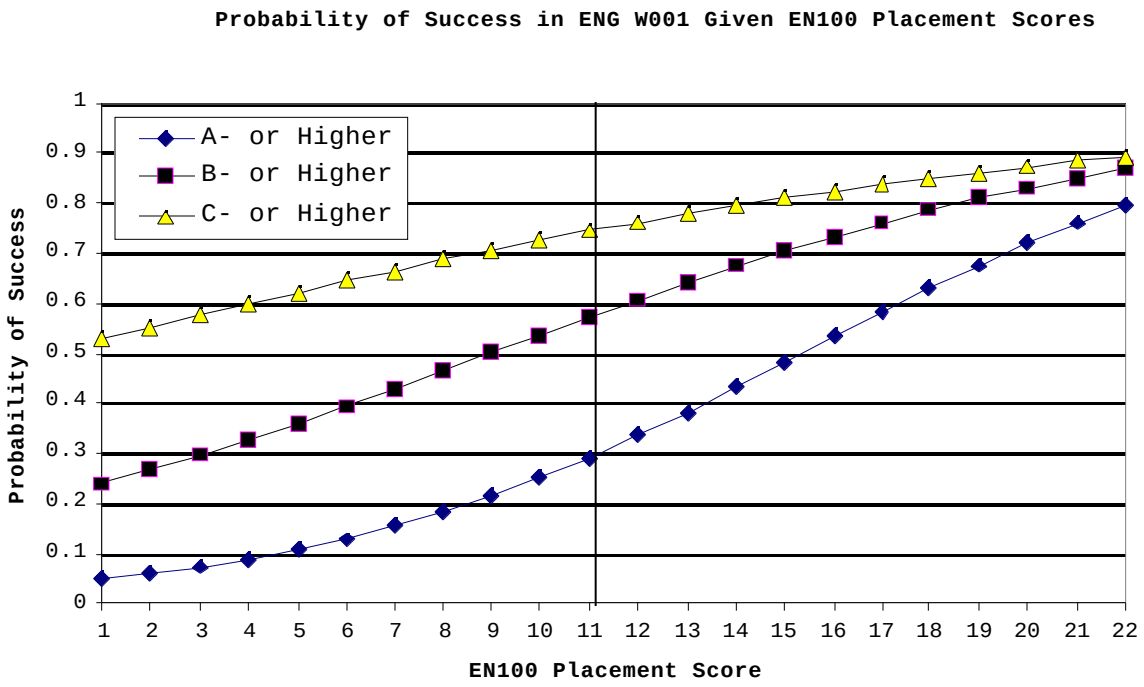

Figure 9. Estimated Probability of Success in ENG W001 Given EN100 Placement Scores (A- or Higher, B- or Higher, and C- or Higher)

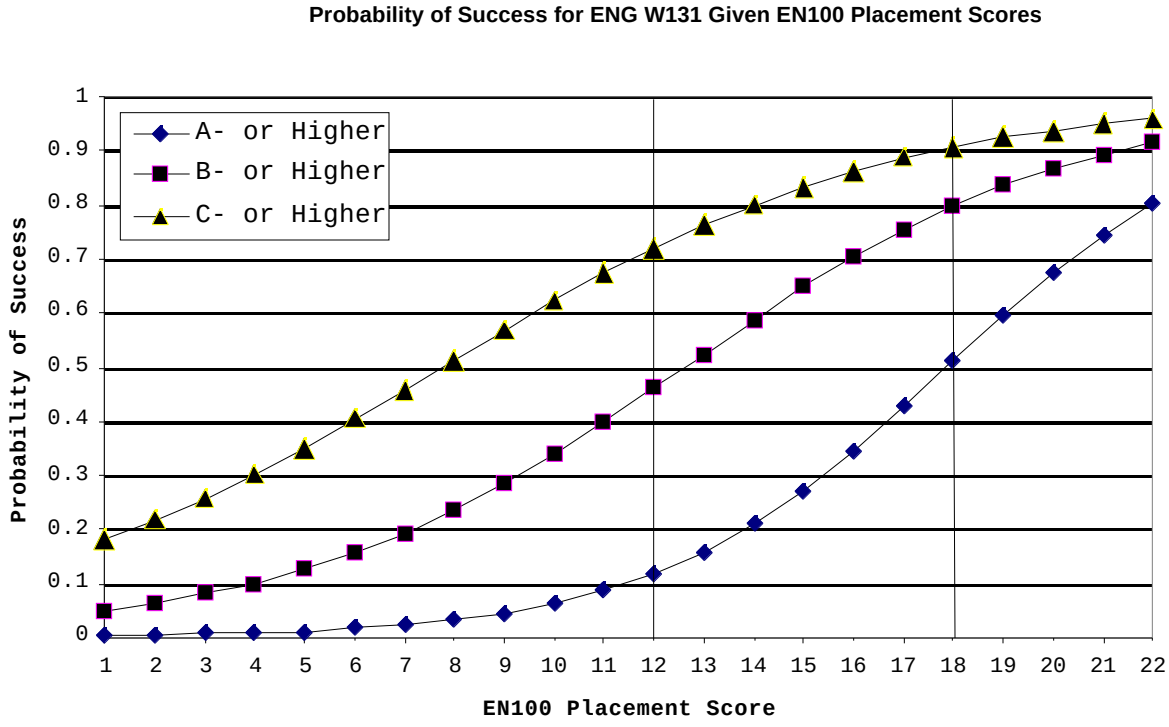

Figure 10. Estimated Probability of Success in English W131 Placement Scores (A- or Higher, B- or Higher, and C- or Higher)

Results of Gender and Ethnic Analyses

As in the previous placement validity reports, the Student *t*-test for independent samples was used to explore gender-related differences in academic achievement of freshmen students at IUPUI. The results of the present study indicated some statistically significant gender differences in achievement as reflected in performance on the respective placement tests and/or outcome measures. Specifically, with regards to COMPASS mathematics placement tests, statistically significant differences were obtained only for the Pre-Algebra Test (MA401) scores for the fall 2000 cohort [M(females) = 40.07, M(males) = 43.78; t(1651) = -5.08, p < .001] with males scoring higher. There were no statistically significant gender-related differences observed for placement domain scores in Algebra, College Algebra, and Trigonometry. Also, no statistically significant gender-related differences were observed for the common final exam scores in mathematics [M(females) = 26.79, M(males) = 26.35); t(1629) = 1.24, *ns*]. However, there was a statistically significant difference obtained for gender analysis based on the final course grades in mathematics [M(females) = 2.27, M(males) = 2.06); t(2466) = 3.90, p < .001]. With respect to performance on the English Placement Test, female students performed significant better than male students [M(females) = 13.94, M(males) = 13.72; t(2728) = -2.67, p < .01]. Similarly, a statistically significant gender-related difference was obtained for the English course grades [M(females) = 2.73, M(males) = 2.42; t(1596) = 5.24, p < .001], with female students performing significantly better than male students. Consistent with last year's observation for the IUPUI computerized Reading Placement Test, there was a statistically significant gender difference in COMPASS Reading Test scores, as male students obtained slightly higher reading scores than their counterparts [M(females) = 82.83, M(males) = 85.28; t(2521) = -5.02, p < .001]. Furthermore, statistically significant gender

differences were observed for the semester GPAs, as the average GPA was slightly higher for female students than male students [M(females) = 2.29, M(males) = 2.06; t(2364) = 4.75, p < .001]. Perhaps the observed statistical significant results obtained in the present study could be attributed to the somewhat disparate sample sizes for the gender groups for the respective predictor and outcome measures.

In general, the aforementioned results are consistent with findings of previous validity studies, which suggest a need to conduct a thorough investigation on gender-related differences in academic performance, as reflected in placement test scores and/or course grades for beginning students at IUPUI. The issue on gender research is, therefore, left for further study.

The analyses based on the ethnicity of students produced some statistically significant results that are similar to those obtained for gender analysis. Specifically, with respect to performance on the placement tests, statistically significant ethnic-related differences were obtained for the COMPASS Pre-Algebra Test (MA401) and Reading Test (RD200) scores, as well as for the English Placement Test (EN100) ratings (see Table 4). Note that the issue of disproportionate sample sizes between ethnic categories was addressed by selecting a random sample of “White” students (n = 700), whose performance was then compared against a group of “Other” students (n = 685). The “Other” group consisted of students who were identified in the IUIS database by any one of the following ethnic codes: *A* (Asian, Pacific Island), *B* (Afro-American), *C* (Hispanic), *I* (American Indian, Alaskan Native), and *N* (Non-resident Alien). Table 4 shows a summary of the descriptive statistics and results of the t-test analysis based on ethnicity. Given the exploratory nature of the present investigations on gender and ethnic related differences, it seems

worthwhile to investigate further the link between ethnicity and academic performance for beginning freshmen at IUPUI.

Table 4.
Results Based on Ethnicity Analysis
(for a random sample of Fall 2000 Cohort)

Variable	Ethnic Group[4]	N	Mean	SD	t_{obs}	df
EN100: English	White Other	588 428	13.97 12.99	2.17 2.14	7.17***	1014
MA401: Pre-Algebra	White Other	340 347	43.62 37.27	15.11 13.46	5.82***	685
MA402: Algebra	White Other	217 127	44.07 44.58	12.29 12.48	-.37	342
MA403: College Algebra	White Other	24 10	43.17 43.50	7.30 4.55	-.13	32
MA404: Trigonometry	White Other	58 28	50.22 52.96	18.37 15.44	-.68	84
RD200: Reading	White Other	543 387	84.72 79.78	11.09 13.27	6.17***	928
ENG Writing Course Grades	White Other	318 343	2.64 2.41	1.20 1.27	2.35*	659
MATH Course Grades	White Other	506 450	2.16 1.99	1.31 1.34	1.98*	954
MATH Common Final Exam Scores	White Other	334 226	26.29 25.87	7.03 7.82	.68	598

* $p < .05$, ** $p < .01$, *** $p < .001$

[4] For purposes of data analysis, the "Other" group consisted of the following IUIS ethnic codes: *A* (Asian, Pacific Island), *B* (Afro-American), *C* (Hispanic), *I* (American Indian, Alaskan Native), and *N* (Non-resident Alien). The "White" group comprised students coded as *W*. The 3 students who were coded as *R* (Refused to Answer) were simply recoded as system missing (.).

Discussion and Conclusion

The purpose of the present study was to assess the predictive validity of the placement test scores for placement in mathematics and writing courses at IUPUI. Note that this is the first formal study of COMPASS Mathematics and Reading test scores as predictor measures at IUPUI. Overall, the findings of the present study indicate that the average validity coefficients for mathematics were lower than those obtained for the previous IUPUI computerized adaptive Mathematics Placement Test. The average correlations for English were about the same (mid-teens) as those reported in the previous Placement Validity Reports.

Because of the statistical artifacts associated with interpretation of correlation coefficients, the logistic regression approach offered an alternate means of determining the effectiveness of the placement criteria. Therefore, graphs indicating estimates of probabilities of success were constructed for each placement test score. The intent is that the probability graphs will provide some additional help to counselors and other academic advisors seeking to use the placement tests as one source of information in guiding the student to an appropriate course.

Of course, the logistic regression techniques have limitations too, such as the influence of range restriction in extreme cases. For instance, if very few or no students are unsuccessful (e.g., below a grade of B) or, for course placement, the course is either very easy or very hard, it is difficult to estimate probabilities of success (Noble & Sawyer, 1997). Similarly, estimated probabilities of success are also influenced by sample size. Generally speaking, the sample sizes required to estimate the logistic regression weights are larger than those needed for linear regression. Thus, we can expect relatively large sampling error whenever

small sample sizes (say, $n < 100$) are employed in logistic regression analyses (see Noble & Sawyer, 1997).

Note that the general factors for explaining the results of placement validity studies are outlined in the 1996 Placement Validity Report (cf. Mzumara, Shermis, & Wimer, 1996). As noted earlier, a decrease in the observed validity coefficients for mathematics may be an artifact of using the new COMPASS placement tests and initial placement cutoffs in mathematics courses at IUPUI. The relatively low validity coefficients for mathematics suggest a reverse in the upward trend in validity coefficients as indicated in last year's report. With the recent revision in placement cutoffs for mathematics, however, it will be important to study the impact of the new cutoffs for course placement in mathematics. The relatively low average correlation for English could probably be attributed (at least in part) to the influence of score range restriction and small sample size, particularly for the honors (ENG W140) course.

Notwithstanding the methodological limitations of placement validity studies, several recommendations are outlined in the next section.

Recommendations

Based on the findings of the present study and our prior experience, the following suggestions should be helpful in making incremental/quality improvement in course placement at IUPUI. For convenience, recommendations are presented separately for each placement test area.

Mathematics

To facilitate improvement in validity coefficients for mathematics, the Department of Mathematical Sciences should continue to conduct local empirical studies including monitoring of students' placement distributions

and performance in mathematics courses and adjust or fine-tune the placement cutoffs as needed. We note that the most recent revision in placement cutoffs occurred on October 1, 2000. As the COMPASS tests are copyrighted, unfortunately, it may not be possible to improve the content (particularly the item bank) of the adaptive mathematics placement tests.

English

As suggested in the previous Placement Validity Reports, we recommend and/or encourage the English Department faculty to seek or adopt alternative methods of assessment (e.g., portfolios), in conjunction with traditional forms of assessment, to obtain a wider range of scores. Perhaps expanding the current score range for the current English placement test would help to minimize the influence of score range restriction. (Details regarding possible reasons for the score range restriction are discussed in the Department of English placement test reports.) Some thought might also be given to using a graded writing assignment as an outcome measure instead of relying solely on course grades, since these sometimes include non-ability factors in their composition. Also, it might be worthwhile for faculty in the Department of English to review periodically the prompts administered to students (as was done in July 2000), with efforts to updating the content of the English Placement Tests.

Reading

As reading test scores are not used for course placement, we recommend that the use of the COMPASS/ASSET Reading Skills Test be discontinued as a part of the regular requirement for beginning freshmen at IUPUI. Alternatively, if the reading test scores are useful as general reading assessment indicators and/or for conducting research on student retention, then the University College faculty should consider using the

locally-developed Web-based Reading Placement Test (RD100), as the exploratory correlations between reading test scores and semester GPAs suggest that the previous test is psychometrically as sound as the COMPASS Reading Skills Test (RD200).

General Remarks

As we have suggested in previous reports, it might be worthwhile for future placement validity studies to include an analysis of the nature and content of the outcome measures. It is likely that any one year's examination is different in its content coverage of the curriculum, standards or difficulty. Such year-to-year differences in skills tested may account for a considerable amount of any change in performance on the examinations. A content validity analysis would provide some useful and/or supplementary information that would help explain some of the observed inconsistency in the relationships between predictor and outcome scores.

It is noteworthy that placement tests are designed to be used in conjunction with counselors' recommendations, and provide one source of information about the student's current ability level. Decisions regarding course placement ought to include a student's previous academic record and not be made on the basis of placement test scores alone. Because the IUPUI placement recommendations (at least for mathematics) are advisory, the placement tests are designed for use in conjunction with counselors' advice to students. Thus, the use of multiple predictors for course placement is desirable (see Sawyer, 1996). Rather than use placement test scores alone, additional predictors (if available) may include one or more of the following variables: high school (HS) overall grade point average (GPA), HS subject GPA, HS (percentile) rank, and HS courses completed. It seems likely that the more information counselors have about a student, the better the chance of their making an appropriate placement decision. (Note that data collection and management for research purposes will be

facilitated with development of an information system and/or database that stores a variety of predictor and outcome data in a way that is easily accessible for research. Such a database has yet to be developed at IUPUI.)

It is noteworthy that placement tests cannot measure motivation or other affective variables in academic learning. Placement tests, however, are a useful tool in providing students with a healthier and more valid learning experience in the respective college courses. As such, placement testing offers the University a practical way to accommodate the more diverse academic needs and talents of the entering students.

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APPENDIX A

Logistic Regression and Probability of Success

Ordinarily, logistic regression estimates the relationship between a dichotomous outcome (i.e., a university course grade of "C" or higher) and one or more predictors (Hosmer & Lemeshow, 1989). In most respects, logistic regression employs same general principles as linear regression, but fits a non-linear model with a predicted outcome bounded by 0 and 1. The advantages and utility of logistic regression approach, compared to traditional correlation methods, in validating placement criteria are discussed elsewhere in the literature (e.g., see Noble & Sawyer, 1997; Sawyer, 1996; Grimm & Yarnold, 1995; and Hosmer & Lemeshow, 1989).

Logistic regression produced a student's estimated probability of success, using the following formula:

$$P[\text{success} \mid K = x] = e^{(a+b*X)} / [1 + e^{(a+b*x)}]$$

where a and b are regression coefficients estimated on the data,

x is the score the placement test,

K is the cutoff score on the placement test, and

e is the base of the natural logarithms, approximately 2.718 (Hosmer & Lemeshow, 1989; Noble & Sawyer, 1997).

APPENDIX B

RESULTS FOR LOGISTIC REGRESSION

Table B.1

Logistic Regression Statistics for MATH M010 Given MA401 Scores (n = 527)

(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA401 Score	.053	.013	15.797	1	.001
Constant	-3.056	.485	39.651	1	.001
-2 Log-likelihood = 548.007 Hosmer and Lemeshow $\chi^2 = 1.399$, $df = 8$, $p = .994$ Overall Percentage Correct: 77.0%					
B- or Higher					
MA401 Score	.045	.011	17.101	1	.001
Constant	-1.502	.375	16.029	1	.001
-2 Log-likelihood = 712.439 Hosmer and Lemeshow $\chi^2 = 7.466$, $df = 8$, $p = .487$ Overall Percentage Correct: 56.4%					
C- or Higher					
MA401 Score	.034	.011	9.170	1	.002
Constant	-.357	.379	.886	1	.346
-2 Log-likelihood = 648.849 Hosmer and Lemeshow $\chi^2 = 8.854$, $df = 8$, $p = .355$ Overall Percentage Correct: 68.3%					

Table B.2

Logistic Regression Statistics for MATH 001 Given MA401 Scores (n = 483)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA401 Score	.009	.008	1.234	1	.267
Constant	-2.347	.449	27.297	1	.001
-2 Log-likelihood = 376.619					
Hosmer and Lemeshow $\chi^2 = 6.639$, $df = 8$, $p = .576$					
Overall Percentage Correct: 86.7%					
B- or Higher					
MA401 Score	.005	.006	.690	1	.406
Constant	-.969	.326	8.845	1	.003
-2 Log-likelihood = 611.376					
Hosmer and Lemeshow $\chi^2 = 17.114$, $df = 8$, $p = .029$					
Overall Percentage Correct: 67.1%					
C- or Higher					
MA401 Score	.001	.006	.020	1	.889
Constant	.434	.315	1.898	1	.168
-2 Log-likelihood = 642.877					
Hosmer and Lemeshow $\chi^2 = 20.418$, $df = 8$, $p = .009$					
Overall Percentage Correct: 61.7%					

Table B.3

Logistic Regression Statistics for MATH 001 Given MA402 Scores (n = 207)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA402 Score	.014	.035	.166	1	.684
Constant	-2.346	1.126	4.338	1	.037
-2 Log-likelihood = 160.148 Hosmer and Lemeshow χ^2 = 14.161, *df* = 7, *p* = .048 Overall Percentage Correct: 87.0%					
B- or Higher					
MA402 Score	.034	.026	1.618	1	.203
Constant	-1.481	.845	3.069	1	.080
-2 Log-likelihood = 276.292 Hosmer and Lemeshow χ^2 = 16.391, *df* = 7, *p* = .022 Overall Percentage Correct: 62.3%					
C- or Higher					
MA402 Score	.005	.029	.034	1	.854
Constant	.753	.917	.675	1	.411
-2 Log-likelihood = 247.389 Hosmer and Lemeshow χ^2 = 4.607, *df* = 7, *p* = .708 Overall Percentage Correct: 71.5%					

Table B.4

Logistic Regression Statistics for MATH 110 Given MA402 Scores (n = 206)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA402 Score	.043	.024	3.040	1	.081
Constant	-3.769	1.144	10.861	1	.001
-2 Log-likelihood = 160.778 Hosmer and Lemeshow $\chi^2 = 10.370$, $df = 8$, $p = .240$ Overall Percentage Correct: 86.4%					
B- or Higher					
MA402 Score	.031	.018	3.072	1	.080
Constant	-1.534	.799	3.682	1	.055
-2 Log-likelihood = 281.197 Hosmer and Lemeshow $\chi^2 = 15.006$, $df = 8$, $p = .059$ Overall Percentage Correct: 58.3%					
C- or Higher					
MA402 Score	.007	.020	.135	1	.714
Constant	.759	.902	.708	1	.400
-2 Log-likelihood = 232.639 Hosmer and Lemeshow $\chi^2 = 6.226$, $df = 8$, $p = .622$ Overall Percentage Correct: 74.8%					

Table B.5

Logistic Regression Statistics for MATH 111 Given MA402 Scores (n = 286)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA402 Score	.028	.015	3.536	1	.060
Constant	-2.628	.791	11.044	1	.001
-2 Log-likelihood = 307.697					
Hosmer and Lemeshow $\chi^2 = 8.696$, $df = 8$, $p = .369$					
Overall Percentage Correct: 76.6%					
B- or Higher					
MA402 Score	.009	.012	.605	1	.437
Constant	-.517	.622	.690	1	.406
-2 Log-likelihood = 395.747					
Hosmer and Lemeshow $\chi^2 = 8.383$, $df = 8$, $p = .397$					
Overall Percentage Correct: 52.8%					
C- or Higher					
MA402 Score	.011	.014	.550	1	.458
Constant	.763	.741	1.062	1	.303
-2 Log-likelihood = 295.909					
Hosmer and Lemeshow $\chi^2 = 4.217$, $df = 8$, $p = .837$					
Overall Percentage Correct: 78.7%					

Table B.6

Logistic Regression Statistics for MATH 153 Given MA402 Scores
($\underline{n}$ = 49)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA401 Score	.031	.033	.874	1	.350
Constant	-3.131	1.828	2.934	1	.087
-2 Log-likelihood = 45.857 Hosmer and Lemeshow χ^2 = 14.046, *df* = 7, *p* = .050 Overall Percentage Correct: 81.6%					
B- or Higher					
MA401 Score	.040	.029	1.855	1	.173
Constant	-2.726	1.582	2.969	1	.085
-2 Log-likelihood = 61.247 Hosmer and Lemeshow χ^2 = 14.709, *df* = 7, *p* = .040 Overall Percentage Correct: 61.2%					
C- or Higher					
MA401 Score	.023	.027	.740	1	.390
Constant	-.927	1.435	.417	1	.518
-2 Log-likelihood = 66.156 Hosmer and Lemeshow χ^2 = 12.622, *df* = 7, *p* = .082 Overall Percentage Correct: 61.2%					

Table B.7

Logistic Regression Statistics for MATH 153 Given MA403 Scores
($\underline{n}$ = 33)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA401 Score	.027	.070	.144	1	.704
Constant	-2.858	3.057	.874	1	.350
-2 Log-likelihood = 27.925					
Hosmer and Lemeshow $\chi^2 = 8.402$, $df = 7$, $p = .299$					
Overall Percentage Correct: 84.8%					
B- or Higher					
MA401 Score	.073	.057	1.625	1	.202
Constant	-3.801	2.501	2.310	1	.129
-2 Log-likelihood = 40.243					
Hosmer and Lemeshow $\chi^2 = 5.477$, $df = 7$, $p = .602$					
Overall Percentage Correct: 69.7%					
C- or Higher					
MA401 Score	.043	.051	.736	1	.391
Constant	-1.891	2.166	.762	1	.383
-2 Log-likelihood = 44.962					
Hosmer and Lemeshow $\chi^2 = 3.063$, $df = 7$, $p = .879$					
Overall Percentage Correct: 54.5%					

Table B.8

Logistic Regression Statistics for MATH 163 and MATH 221 Given MA404 Scores
($\underline{n}$ = 91)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
MA404 Score	.015	.013	1.267	1	.260
Constant	-1.781	.770	5.342	1	.021
-2 Log-likelihood = 105.707					
Hosmer and Lemeshow χ^2 = 13.837, *df* = 8, *p* = .086					
Overall Percentage Correct: 72.5%					
B- or Higher					
MA404 Score	.046	.014	10.046	1	.002
Constant	-2.616	.814	10.329	1	.001
-2 Log-likelihood = 113.198					
Hosmer and Lemeshow χ^2 = 8.954, *df* = 8, *p* = .346					
Overall Percentage Correct: 63.7%					
C- or Higher					
MA404 Score	.057	.016	12.860	1	.001
Constant	-2.509	.835	9.026	1	.003
-2 Log-likelihood = 105.251					
Hosmer and Lemeshow χ^2 = 12.001, *df* = 8, *p* = .151					
Overall Percentage Correct: 67.0%					

Table B.9

Logistic Regression Statistics for the ENG W001 Data (n = 254)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
English Placement Score	.204	.153	1.784	1	.182
Constant	-3.135	1.545	4.119	1	.042
-2 Log-likelihood = 284.960 Hosmer and Lemeshow $\chi^2 = 3.554$, $df = 2$, $p = .169$ Overall Percentage Correct = 77.4%					
B- or Higher					
English Placement Score	.145	.140	1.072	1	.301
Constant	-1.301	1.399	.866	1	.352
-2 Log-likelihood = 349.734 Hosmer and Lemeshow $\chi^2 = 2.954$, $df = 2$, $p = .228$ Overall Percentage Correct: 55.1%					
C- or Higher					
English Placement Score	.095	.155	.375	1	.541
Constant	.021	1.548	.000	1	.989
-2 Log-likelihood = 298.697 Hosmer and Lemeshow $\chi^2 = 2.708$, $df = 2$, $p = .258$ Overall Percentage Correct: 72.4%					

Table B.10

Logistic Regression Statistics for the English W131 Data (n = 1016)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
English Placement Score	.343	.056	37.612	1	.001
Constant	-6.132	.821	55.812	1	.001
-2 Log-likelihood = 1075.122					
Hosmer and Lemeshow χ^2 = .404, *df* = 2, *p* = .817					
Overall Percentage Correct: 76.6%					
B- or Higher					
English Placement Score	.255	.051	25.287	1	.001
Constant	-3.216	.725	19.691	1	.001
-2 Log-likelihood = 1336.041					
Hosmer and Lemeshow χ^2 = .466, *df* = 2, *p* = .792					
Overall Percentage Correct: 60.7%					
C- or Higher					
English Placement Score	.223	.063	12.561	1	.001
Constant	-1.725	.888	3.769	1	.052
-2 Log-likelihood = 980.418					
Hosmer and Lemeshow χ^2 = .704, *df* = 2, *p* = .703					
Overall Percentage Correct: 80.8%					

Table B.11

Logistic Regression Statistics for the English W140 Data (n = 35)
(A- or Higher, B- or Higher, and C- or Higher)

Variable	Estimated Coefficient	Standard Error	Wald Statistic	df	p
A- or Higher					
English Placement Score	-.045	.398	.013	1	.910
Constant	.243	7.911	.001	1	.975
-2 Log-likelihood = 44.991					
Hosmer and Lemeshow $\chi^2 = 1.743$, $df = 2$, $p = .418$					
Overall Percentage Correct: 65.7%					
B- or Higher					
English Placement Score	-.310	.384	.652	1	.420
Constant	6.447	7.641	.712	1	.399
-2 Log-likelihood = 47.142					
Hosmer and Lemeshow $\chi^2 = 2.283$, $df = 2$, $p = .319$					
Overall Percentage Correct: 57.1%					
C- or Higher					
English Placement Score	.495	.471	1.104	1	.293
Constant	-8.876	9.287	.914	1	.339
-2 Log-likelihood = 40.658					
Hosmer and Lemeshow $\chi^2 = 1.879$, $df = 2$, $p = .391$					
Overall Percentage Correct: 71.4%					