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ABSTRACT

A variety of techniques was used to assess the validity of the Descriptive Tests of Mathematics Skills (DTMS) for making placement decisions. The DTMS is a group of four tests (Arthmetic Skills, Elementary Algebra Skills, Intermediate Algebra Skills, and Functions & Graphs) that was designed to help colleges place each admitted student in the appropriate mathematics course. The DTMS were administered in freshman level mathematics courses at 36 institutions that represented a broad spectrum of two-year and four-year colleges. A pre-post design was used in seven institutions, with a pretest only in the other colleges. Results indicated that the DTMS were: (1) sensitive to gains from instruction in a single semester; (2) highly correlated with course grades obtained concurrently; (3) predictive of end of course grades when the DTMS were administered at the beginning of the course; (4) a better predictor of course grades than SAT-Mathematical scores for remedial courses; (5) related to course difficulty as perceived by students; (6) capable of demonstrating a trait-treatment interaction in a precalculus-calculus sequence; and (7) related to the content of mathematics courses as judged by mathematics faculty members. (Author/RL)

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Brent Bridgeman
with a contribution by
Roberta G. Kline

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DESCRIPTIVE TESTS OF MATHEMATICS SKILLS

Brent Bridgeman

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This report is based upon research supported by the College Entrance Examination Board. Researchers are encouraged to express freely their professional judgment in the conduct of such projects; therefore, points of view or opinions stated do not necessarily represent official College Board position or policy.

Educational Testing Service

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Contents

Abstract

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Results indicated that the DTMS tests were:

(1) sensitive to gains from instruction in a single semester;

(2) highly correlated with course grades obtained concurrently;

(3) predictive of end of course grades when the DTMS tests were administered at the beginning of the course;

(4) a better predictor of course grades than SAT-Mathematical scores for remedial courses;

(5) related to course difficulty as perceived by students;

(6) capable of demonstrating a trait-treatment interaction in a precalculus-calculus sequence; and

(7) related to the content of mathematics courses as judged by mathematics faculty members.

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1. Introduction

The primary purpose of the Descriptive Tests of Mathematics Skills (DTMS) is "to assist colleges in the proper placement of admitted students within the sequence of mathematics courses offered by a given institution" (Jones, 1977). There are four DTMS tests: a 35-item Arithmetic Skills test, a 35-item Elementary Algebra Skills test, a 30-item Intermediate Algebra Skills test, and a 30-item Functions and Graphs Test. All tests are in a four-choice multiple choice format, and the testing time is 30 minutes for each test. Each test contains three or four descriptive clusters that represent groupings of similar items (e.g., operations with fractions, coordinate plane, and graphs). Complete test descriptions and technical data are available in the Guide to the Use of the Descriptive Tests of Mathematics Skills (College Board, 1979).

Cronbach (1971) has noted that it is not really a test that is validated but rather "an interpretation of data arising from a specified procedure" (p. 447). Thus, each decision made from each of the DTMS tests must be validated separately. For example, the Arithmetic Skills test might be valid for placing students into a course emphasizing arithmetic computation but not a course in applied arithmetic. Similarly, it might be valid for the arithmetic computation course at one school, but not at another school either because the courses differ, the students differ, or a combination of the two. With the number of courses open to beginning students (Jones & Williams [1974] identify 17 courses through the calculus) and the variety of two-year and four-year colleges, any truly comprehensive validation study is practically impossible. Each DTMS user should conduct its own validation study. The purpose of this study, then, was to determine whether the DTMS tests possess characteristics that are generally useful for tests used to make placement decisions. Areas investigated included analyses of content validity, sensitivity to instructional gains, concurrent validity, predictive validity, relationship to student perceptions of course difficulty level, and trait-treatment interactions. Each of these areas is a separate section in this report, and the rationale behind each of the analyses is presented in more detail in the appropriate section.

2. Method

Sample Selection

Criteria for selection of institutions were as follows:

(1) Broad geographical distribution (at least one institution from each group of states served by a College Board regional office).

(2) Both two-year and four-year institutions.

(3) Range of selectivity from fairly selective to open admissions.

Initial contacts were made by College Board field staff to institutions they thought might be willing to cooperate. Thus, the sample recruited represented institutions that were quite diverse on a number of dimensions, but it was not a random sample. Brief descriptions of the 36 participating institutions are presented in Appendix A. Colleges are identified by code letters; double letter codes (e.g., College AA) are used to identify two-year colleges, and single letter codes identify four-year colleges or universities. Basic data is from the 1977 College Handbook (CEEB, 1977). Tne selection ratio is the ratio of students accepted to students applying.

Each institution was asked to administer the tests either to all freshmen or to all students enrolled in mathematics courses that were open to freshmen from the most elementary course through calculus. The latter option was consistently chosen because it was logistically much simpler.

Procedures

For this project only, the four tests were printed in a single book accompanied by a single common answer sheet. Instructions on the test booklets asked students to take the two of the four tests that were most relevant to their high school mathematics preparation. Students with no more than one year of high school algebra were asked to take Arithmetic Skills and Elementary Algebra Skills tests; students with more than one year's study in algebra but not trigonometry were asked to take the Elementary Algebra Skills and Intermediate Algebra Skills tests; students with more than one year of algebra and at least one-half a semester of trigonometry were asked to take the Intermediate Algebra Skills and Functions & Graphs tests. The front of the test answer sheet requested some basic background information from each student including sex, birthdate, number of semesters in various high school mathematics courses, and the grades achieved in these courses.

Testing was at the beginning of the fall semester in 1978. At the end of the fall semester, the participating colleges were asked to supply final grades in the mathematics courses for all students who took the fall tests. In addition, posttest data were obtained from seven colleges that readministered the DTMS tests at the end of the semester. This more intensive data collection in a limited number of schools was planned and did not reflect a high drop-out rate among the other institutions.

Additional data collection procedures that were unique to particular analyses (e.g., the course satisfaction questionnaires and the content analysis) are described in the relevant chapters.

I. Gain Analysis

If a test is accurately targeted to the content of a course (and assuming instruction in that course is at least somewhat effective), then the test should be sensitive to gains in knowledge from the beginning of the course to the end. Gain analysis is particularly relevant for tests which may be used to exempt students from course requirements (Willingham, 1974).

Although analysis of score gain is a potentially valuable method of empirically assessing test validity, such analyses must be interpreted cautiously as there are a number of serious problems in assessing raw gains (Harris, 1963). Regression to the mean, for example, could produce spurious gains in a group that was placed into a remedial section on the basis of low test scores. However, since DTMS scores were not used for selection in the current study, the portion of the regression due to errors of measurement on that instrument was eliminated. Furthermore, given a highly reliable selection test and reasonably high correlations of pretest and posttests, regression effects should not be too large, and should be essentially nonexistent for middle-ability students who are self-selected into typical courses.

Inflated gain estimates also could result from students who find the answers to specific items from the pretest and remember these answers on the posttest. If, as a result of the pretest experience, the student finds out how to solve problems of the same type that caused difficulty, this should be considered as real learning; it would be a spurious gain only when learning a specific correct answer did not generalize to similar items in the same content domain. In the current study, this type of gain was reduced by not allowing the students to see the questions or their answers after the pretest administration. In addition, students knew that they would not be graded on their gains on the DTMS and, hence, were not motivated to memorize answers to specific questions. Nevertheless, some practice effect was undoubtedly present, and small gains must, therefore, be interpreted skeptically.

Gain analyses will be presented for courses in arithmetic, two different levels of algebra (elementary and "college" algebra), and precalculus.

Arithmetic Courses. Pretest and posttest DTMS scores were available for arithmetic courses from two institutions. The course in a two-year community college in a large southwestern city (College LL) was described as a course in prealgebra mathematics "designed to develop an understanding of fundamental operations using whole numbers, fractions, decimals, and percentages and to strengthen basic skills in mathematics . . . [it] includes an introduction to algebra." Students in this course generally had less than one year of algebra in high school. Of the 44 students included in the analysis for College LL, 35 reported a grade in high school general mathematics and 29 reported an algebra grade. On a 4.0 point scale (i.e., A=4.0, B=3.0, etc.) the average general mathematics grade was 2.1 and the average algebra grade was 1.8. Slightly over 90% of the students were white, and the sexes were equally represented.

The other course with a major arithmetic component was designed for special admissions students at a large midwestern university (College L).

Half of this course was a review of basic arithmetic skills while the second half introduced elementary algebra concepts. Students in this course generally had one year of high school algebra. For the 77 (out of 109) students who reported high school algebra grades, the mean was 2.2 on a 4.0 point scale. About 57% of the students in this group were female and about 60% were white.

Pretest and posttest means and standard deviations and gains for the Arithmetic Skills and Elementary Algebra Skills tests are presented in Table 3.1.

Table 3.1

Gains on the Arithmetic Skills and Elementary Algebra Skills Tests for Remedial Arithmetic Courses

Test	College LL			College L		
	N	M	SD	N	M	SD
Arithmetic Skills - pre	44	22.45	5.56	109	25.44	5.41
Arithmetic Skills - post		27.84	4.71		27.50	4.93
Gain		5.39			2.06	
Elementary Algebra - pre	40	10.28	4.98	108	12.88	5.30
Elementary Algebra - post		10.80	6.52		16.68	6.78
Gain		.52			3.80	

Students in both colleges apparently gained in the kinds of skills assessed by the Arithmetic Skills test. Although the end of course arithmetic skill level was nearly identical in the two colleges, students in College LL showed more gain because they started at a lower level. Comparison of these DTMS gains with gains on the Test of Standard Written English (TSWE) (Breland, 1977) suggests that the arithmetic skills assessed with DTMS may be more susceptible to change in a single course than are the writing skills assessed by TSWE. Of four schools in Breland's report, the largest gain was about .35 of a within-group standard deviation and the smallest gain was about .15 of a within-group standard deviation as compared to the DTMS gain of from .4 to a full standard deviation.

Analysis of the gain in each cluster of the Arithmetic Skills test presented in Table 3.2, reveals an interesting pattern.

Table 3.2

Gains on Each of Four Clusters on the Arithmetic Skills Test

	College LL (N = 44)			
	Cluster A	Cluster B	Cluster C	Cluster D
Pretest Mean (SD)	8.05 (1.01)	5.09 (2.82)	5.41 (2.12)	3.91 (1.70)
Posttest Mean (SD)	8.59 (.62)	7.93 (1.97)	7.11 (2.09)	4.20 (1.53)
Gain	.54	2.84	1.70	.29

	College L (N = 109)			
	Cluster A	Cluster B	Cluster C	Cluster D
Pretest Mean (SD)	8.28 (.92)	7.33 (2.50)	5.62 (2.33)	4.22 (1.44)
Posttest Mean (SD)	8.30 (.89)	8.31 (2.22)	6.59 (2.14)	4.30 (1.37)
Gain	.02	.98	.97	.08

Although gains are consistently higher in College LL (as was indicated on the total sum gains), the pattern of gains is remarkably consistent in the two institutions . Cluster A (operations with whole numbers) contains nine items and scores in both schools are at ceiling levels as reflected by the high means and reduced standard deviations relative to the other cluster scores. Thus, mean gains in this cluster are necessarily small. The largest gains are found in Cluster B (ten items on operations with fractions) and Cluster C (ten items on operations with decimals and percents). The small gains in Cluster D (six items on simple applications involving computation) may again reflect some test ceiling problems (though not as severe as in Cluster A) but may also reflect some greater difficulty in teaching these skills in a single semester course. Pretest-posttest correlations also reflect the lack of meaningful variation on Cluster A but indicate relatively stable measurement with Cluster D. In College LL, the pre-post correlations were .03, .31, .59, and .56 for Clusters A-D, respectively, while the comparable values in College L were .11, .48, .49, and .52.

The gains on the Elementary Algebra Skills test indicate that the half semester introduction to elementary algebra concepts at College L was considerably more effective than the "introduction to algebra" of unspecified duration at College LL. However, this should not be construed as a criticism of College LL, where limited resources were effectively used in improving the more basic arithmetic skills. This small gain also suggests that using the same form for pre- and posttests need not necessarily result in large gains, thus increasing the credibility of the other gains reported.

Willingham (1974) notes that analysis of score gains for students who earned different grades in a course may be one way of demonstrating the extent to which "the test confirms the teacher's judgments--and vice versa" (p. 164). Score gains for each final course grade in College LL are presented in Table 3.3. Final grades were not available from College L.

Table 3.3

Gains on the Arithmetic Skills Test by Course Grades at College LL

Grade in Course	N	Arithmetic Skills Pretest	Arithmetic Skills Posttest	Gain
A	17	26.0	31.3	5.3
B	17	21.5	26.6	5.1
C	6	19.0	25.8	6.8
D	4	16.5	21.3	4.8
F	0	----	----	---

Unlike the 1973 Feldman and Kane study cited by Willingham (1974), gains were not clearly related to course grades. However, it is important to note a critical difference between the studies. Students in the calculus course described by Feldman and Kane had little or no direct instruction in calculus before the course began, and pretest scores of students who eventually got As or Bs were little different from those of students who got Ds or Es. On the other hand, students in the current study presumably studied arithmetic skills for many years in secondary schools before they took the pretest in college. Posttest scores are largely reflective of these preexisting differences rather than indicating differential score gains as the result of instruction. Correlational evidence paints just about the same picture; the correlation of pretest scores with grades is nearly as high as the correlation of posttest scores with grades (.59 versus .64). Grading standards at most institutions are designed to reward final status and not gain. But these data are a good reminder that C students may work just as hard and benefit just as much from instruction as A students.

Elementary Algebra Courses. Two colleges with courses in elementary algebra reported data for the gain analysis. One college was the large midwestern university that also provided scores for the above arithmetic analysis (College L). Special admissions students who scored above a minimal level on a locally developed placement test were placed into the elementary algebra course rather than the developmental mathematics course described above. On the average, students in this course had about one year of algebra in high school. Thirteen of the sixteen students reported grades in high school algebra, and the average grade was 2.38 (out of 4.0).

The other institution reporting data for the analysis was a two-year public community college in a large southeastern metropolitan area (College JJ). The sample was about 60% female and 80% white. On the average, students had one year of high school algebra. Grades in high school algebra were reported by 102 of the 132 students; the average grade reported was 2.02.

Pretest and posttest means and standard deviations for the Elementary Algebra Skills test are presented in Table 3.4.

Table 3.4

Gains on the Elementary Algebra Skills Test for Elementary Algebra Students

	College L			College JJ		
	N	M	SD	N	M	SD
Elementary Algebra (pre)	16	9.13	3.91	132	11.95	5.12
Elementary Algebra (post)		14.13	6.28		19.42	6.38
Gain		5.00			7.47	

Substantial gains were evident in both courses. In College L, pretest scores were close to the level that could be achieved by random guessing (random guess level = number of items [35] ÷ number of choices per item [4] = 8.75). The increased mean and variance in the posttest scores suggests that they provide more meaningful measurement. In both colleges, the posttest scores are still quite low relative to the maximum possible score of 35. This might be due to the fact that no instruction was provided for many of the skills assessed on the test (suggesting that much of the Elementary Algebra Skills test was not a valid measure for these courses) or it might be that the test provides a valid indication of the fact that many students failed to learn a number of the skills taught. The analysis of gains by course grade in Table 3.5 helps to resolve these conflicting interpretations.

Table 3.5

Gains on the Elementary Algebra Skills Test by Course Grades at College JJ

Grade in Course	N	Elementary Algebra Skills Pretest		Elementary Algebra Skills Posttest		Gain
		M	SD	M	SD	
A	14	15.9	4.5	26.9	3.3	11.0
B	31	14.8	5.9	23.8	3.4	9.0
C	28	13.0	3.9	21.5	3.7	8.5
R*	58	8.9	3.5	14.2	5.0	5.3

*No Ds or Fs given in remedial courses; grade of R means that course must be repeated.

Since A students answered an average of 26.9 items correctly, it seems likely that most of the skills on the Elementary Algebra Skills test were taught at some level, but that many of these skills were learned by only the best students. The high correlation between scores on the Elementary Algebra Skills posttest and a composite score reflecting the average of class tests and points given for classwork ($r = .78$) also suggests that the Elementary Algebra Skills test measures algebra skills that are relevant to the specific course.

Unlike the gains on the Arithmetic Skills test, gains on the Elementary Algebra Skills test are systematically related to course grades achieved. Nevertheless, pretest scores of students who ended up having to repeat the course were substantially below pretest scores of students who eventually got As.

The analysis of gains in each cluster in Table 3.6 shows the greatest gains in Cluster B (17 items on operations with algebraic expressions).

Table 3.6

Gains on Each of Three Clusters on the Elementary Algebra Skills Test

	College L*			College JJ**		
	Cluster A	Cluster B	Cluster C	Cluster A	Cluster B	Cluster C
Pretest Mean (SD)	2.88 (1.63)	3.31 (1.66)	2.94 (1.65)	3.73 (1.75)	5.14 (2.94)	3.08 (1.73)
Posttest Mean (SD)	4.25 (2.24)	6.69 (3.42)	3.19 (1.64)	5.02 (1.97)	9.73 (3.68)	4.67 (1.86)
Gain	1.37	3.38	.25	1.29	4.59	1.59

*N = 16
**N = 132

Gains on Cluster A (9 items on operations with real numbers) and Cluster C (9 items on solution of equations, inequalities, and word problems) were less dramatic; indeed there was probably no real gain in Cluster C at College L.

College Algebra Courses. Three institutions with college algebra courses provided scores for this analysis. College HH is a two-year public community college in the suburbs of a major midwestern city. All of the students in the current analysis from College HH were white and 54% of them were male. Most of them had two years of high school algebra, and the average high school algebra grade was 3.20 (for the 10 out of 11 students who reported grades). College E is a four-year public college in a small eastern town. The students in the current analysis were 95% white and 55% female. Half of the students reported that they had one year of high school algebra and the other half reportedly had two years. The average grade for students with one year of algebra was 2.8, while the students with two years of algebra reported average grades of 2.5 for the second year course. College LL is a two-year public community college in a large southwestern city. Of the students in the college algebra course 73% were male and 95% were white. Most of the students had two years of high school algebra, and the average grade was 3.02 (with all of the 41 students in the analysis reporting a grade).

As indicated in Table 3.7, pretest differences among the three colleges on the Intermediate Algebra Skills test were fairly substantial. The relatively low mean and high standard deviation in College E probably is a result of the substantial number of students there who had only one year of high school algebra. Posttest scores, on the other hand, were

Table 3.7

Gains on the Intermediate Algebra Skills Test for College Algebra Students in Three Colleges

	College HH			College E			College LL		
	N	M	SD	N	M	SD	N	M	SD
Intermediate Algebra Skills (pre)	11	19.18	4.73	19	12.84	6.60	41	14.85	5.09
Intermediate Algebra Skills (post)		24.18	3.89		22.37	4.81		20.54	4.14
Gain		5.00			9.53			5.69	

more comparable, indicating some communality in course content even though this presumably required more learning for students in College E. Gains in all three institutions were substantial (i.e., greater than one standard deviation). The magnitude of these gains can be better evaluated by comparing them with gains of students with similar pretest scores on the Intermediate Algebra Skills test who were enrolled in math courses that did not emphasize instruction in algebra, although some algebraic concepts may have been included in these other courses. Specifically, gains on the Intermediate Algebra Skills test for one set of students from College E who enrolled in a course in business mathematics and a second set of students who enrolled in a probability and statistics course were evaluated. Although very little confidence can be placed in these results due to the very small sample sizes, the analysis of gains in these courses is included in this report as an illustration of the kind of comparative analysis that may be useful in local validation studies. As indicated in Table 3.8, gains were considerably smaller in these courses. Gains in the probability and statistics course

Table 3.8

Gains on the Intermediate Algebra Skills Test for Business Math and Probability and Statistics Students at College E

	Business Math			Probability & Statistics		
	N	M	SD	N	M	SD
Intermediate Algebra Skills (pre)	11	18.45	6.88	6	19.17	4.34
Intermediate Algebra Skills (post)		20.27	6.93		21.83	4.36
Gain		1.82			2.66	

were still over half a standard deviation. However, analysis of the cluster scores indicated that nearly all of this gain could be accounted for by the third cluster (10 items on the coordinate plane and graphs). Scores on that cluster were 4.83 at pretest and 7.00 at posttest for a gain of 2.17. For students in the college algebra courses, gains were consistent across all three clusters.

Precalculus Courses. Pretest and posttest DTMS scores were available for precalculus courses from two institutions. At college E (four-year public college in a small eastern town), the course was titled "Precalculus Mathematics." Most of the students reported that they had two years of high school algebra. The average algebra grade was 3.3. The sample was 56% male and 89% white. The second college reporting scores was a large private university in a major western city (College T). The course was titled "Introductory College Mathematics" and is listed as a prerequisite for the Calculus I course, although students also could qualify for Calculus I with high school courses in trigonometry and analytic geometry. The course content included sets, functions (including exponential, logarithmic, and trigonometric functions) graphing, systems of linear equations, and analytic geometry. Most students in the course reportedly had two years of high school algebra, with an average grade of 3.4 reported. The sample was 57% male and 56% white.

Pretest and posttest means and standard deviations and gains for both the Intermediate Algebra Skills and the Functions & Graphs tests are presented in Table 3.9.

Table 3.9

Gains on the Intermediate Algebra Skills and Functions & Graphs Tests for Precalculus Students in Two Colleges

	College E			College T		
	N	M	SD	N	M	SD
Intermediate Algebra Skills (pre)	35	18.69	4.90	127	19.98	4.33
Intermediate Algebra Skills (post)		24.43	3.42		24.78	3.75
Gain		5.74			4.80	
Functions & Graphs (pre)	34	14.94	4.15	81	16.16	5.09
Functions & Graphs (post)		23.50	3.54		24.53	3.39
Gain		8.56			8.37	

On both tests, gains were remarkably similar in the two colleges. The gain of about two standard deviation units on the Functions & Graphs test was especially striking. Analysis of gains on the individual clusters of the Intermediate Algebra Skills test was not particularly enlightening, with approximately equal gains on all clusters at both institutions. However, an interesting pattern emerged with the Functions & Graphs cluster scores. As indicated on Table 3.10, gains on Cluster C (13 items on trigonometric functions) appeared to be especially large. An average

Table 3.10

Gains on Each of Three Clusters on the Functions & Graphs Test

	College E*			College T**		
	Cluster A	Cluster B	Cluster C	Cluster A	Cluster B	Cluster C
Pretest Mean (SD)	4.35 (1.57)	4.15 (1.79)	6.44 (2.49)	5.49 (1.79)	4.35 (1.82)	6.30 (2.69)
Posttest Mean (SD)	6.20 (1.30)	6.26 (1.60)	11.03 (1.66)	6.59 (1.29)	6.77 (1.74)	11.17 (1.45)
Gain	1.85	2.11	4.59	1.10	2.40	4.87

*N = 34
**N = 81

of less than half of these items were answered correctly on the pretest, but by the posttest the average score was less than two points from the total possible. The reduced standard deviation on the posttest is an additional indication that the test ceiling had been reached.

An analysis of gains on the Intermediate Algebra Skills test classified by course grade is presented in Table 3.11. As was noted with the similar

Table 3.11

Gains on the Intermediate Algebra Skills Test by Grades for Precalculus Students

	College E						College T					
		Pretest		Posttest				Pretest		Posttest		
Grade in Course	N	M	SD	M	SD	Gain	N	M	SD	M	SD	Gain
A	7	24.0	3.9	27.0	2.0	3.0	30	22.8	3.4	27.8	1.6	5.0
B	13	19.2	4.7	25.8	3.2	6.6	26	20.7	4.4	25.9	2.8	5.2
C	8	16.1	3.4	22.3	2.4	6.2	35	18.4	3.6	24.2	3.1	5.8
D	6	14.7	2.3	22.2	3.2	7.5	23	18.5	4.7	22.0	3.9	3.5
F	1	20.0	---	20.0	---	---	7	17.9	4.9	19.6	4.2	1.7

analysis of gains on the Arithmetic Skills test, gains are not systematically related to grades assigned although grades are systematically related to posttest scores (r = .60 at College E and .68 at College T). It also should be noted that the Intermediate Algebra Skills test has only 30 items and gains in the "A" category might well have been greater if the test ceiling were not encountered. Analysis of gains by grade for the Functions & Graphs test presents an almost identical situation, and therefore will not be presented here.

Summary

The DTMS tests appear to be sensitive to instructional gains in college courses in arithmetic, elementary algebra, college algebra, and precalculus mathematics. They are probably poorer at assessing gains in other skill areas for which they were not specifically designed (e.g., business math and statistics). Analysis of cluster scores indicates certain clusters of items within a test might be more sensitive to gains in particular courses that emphasize those skills. Although within school sample sizes were frequently quite small, the replicability of the findings across institutions permits considerable confidence in the results.

4. Concurrent Validity

Where Course X is a prerequisite for Course Y, a placement test should be able to show when a student has already mastered the content of Course X and is, therefore, ready to go directly to Course Y. An indication of the validity of the placement test, then, can be determined by its correlation with an indicator of success in Course X. A simple pass-fail classification could be such a success indicator, but that classification would not reflect differing degrees of success that might be of interest. Course grades provide not only pass-fail information, but also indicate relative success among those who pass. Thus, scores on the appropriate test of the DTMS administered at the end of a course were correlated with end of course grades. Grades were coded A = 4, B = 3, etc. Students who withdrew from a course with an indication that they were failing at the time were asigned 0s, but students who simply withdrew with no indication of success or failure were deleted from these analyses. At College JJ, no grade lower than a C was given in remedial courses, but a "non-punitive" grade of R could be assigned indicating the student had to repeat the course. R grades were coded as 0. When available, numerical scores representing points accumulated over the semester or scores on a comprehensive final examination were also used as criterion variables as they permit a greater score range, hence possibly higher correlations, than do grades. An additional advantage of these scores is that they can be used to refute claims of possible criterion contamination in the grades. The correlation between grades and DTMS scores could be spuriously high if some faculty members assigned grades based partially on their students' performance on the DTMS posttest. But this contamination could not apply to numerical scores that were assigned based on performance that was completely independent of the DTMS. Even with the grades, serious criterion contamination seems unlikely. Scores were not reported to the institutions before final grades were received. Although some faculty members could have hand-scored the answer sheets and used these to partially determine grades, an informal survey indicated that this was not done.

Because more than one DTMS test is relevant for some courses and because better correlations are sometimes possible with longer, more reliable tests, scores from two DTMS test were added together and these composite scores, as well as individual subtest scores, were then correlated with the criterion scores.

Arithmetic Courses. At College LL, the correlation of the Arithmetic Skills test posttest score with grades was .64 (N = 45). Adding the Elementary Algebra Skills test score to the Arithmetic Skills test score resulted in a correlation of .59. This is a good indication that a longer test is not necessarily better than a shorter test if the extra items merely add error variance; recall that the posttest Elementary Algebra Skills test mean was only 10.8 in this sample. At College L, where the course included both arithmetic review and elementary algebra, final grades were not reported. However, a course score indicating the number of points on the 50-item course final examination was available. The correlation of the Arithmetic Skills test score with this course score was .42 (N = 109). The correlation of the Elementary Algebra Skills test score with this course score was .53 (N = 108) and the correlation of the score from the two DTMS test combined with the course score was .55 (N = 108). Considering that these are remedial courses serving a restricted range of student abilities, these correlations from short 35-item tests are remarkably high.

Elementary Algebra Courses. At College JJ, the correlation of the Elementary Algebra Skills test scores with grades was .75 (N = 139) and the correlation with a course score reflecting an average from tests, class work, and the final examination was .78. This very high correlation suggests that the Elementary Algebra Skills test can be an excellent indicator of success in elementary algebra courses.

College Algebra Courses. At College LL, posttest Intermediate Algebra Skills test scores correlated .75 (N = 41) with grades. The correlation of Elementary Algebra Skills test scores with grades was .62 (N = 29) and the correlation for the combined score was .70.

Precalculus Courses. The correlation of grades with Intermediate Algebra Skills test scores at College E was .60 (N = 35). The correlation with the Functions & Graphs test score was .61 (N = 35), and for the combined tests, the correlation was .70 (N = 35). At College T, the correlation of grades with Intermediate Algebra Skills test scores was .65 (N = 131), with Functions & Graphs test scores .60 (N = 131), and with the combined score was .72 (N = 131).

A high correlation of scores on a placement test and an indicator of success in a course (e.g., grades) suggests that the test is a potentially useful device for exempting students from the course. However, the correlation by itself does not indicate where the cutting score should be. To establish reasonable cutting scores, a cross-tabulation of test scores and grades is needed. Such a cross-tabulation for the precalculus course at College T is presented in Table 4.1. Course grades for various levels of the combined Intermediate Algebra Skills and Functions & Graphs tests are provided.

Table 4.1

Cross-tabulation of Course Grades and End of Course Scores from the Combined Intermediate Algebra Skills and Functions & Graphs Tests for a Precalculus Course

Course Grades	Scores on Intermediate Algebra Skills and Functions & Graphs					
	0-20	21-30	31-40	41-50	51-60	Totals
A	0	0	0	1	29	30
B	0	0	2	11	17	30
C	0	0	2	24	12	38
D	0	0	9	10	4	23
F	1	3	3	3	0	10
Totals	1	3	16	49	62	131

Although where to set cutting scores would have to be decided upon locally, a reasonable approach would seem to be to encourage students scoring over 50 on the combined tests to skip the course. None of the 62 students with this score received failing grades, and only 16 received grades lower than a B. Students on the 41-50 range also might be allowed to skip the course. However, such a decision would be reasonable only if C students in the precalculus course have a fairly good success record in the next course in the sequence (calculus). Scores of 40 and below clearly indicate very limited success in the precalculus course, and students with such scores probably should be required to take the course. These cutting scores are discussed only for illustrative purposes. Individual institutions might find other cutting scores more meaningful. They also might find that grouping scores into smaller score intervals provided more useful information, especially for very large courses.

Summary

Correlations for all courses were substantial, especially considering the restricted range of abilities in most of the courses and the unreliability of grades as a criterion. Evidence from the correlations and cross-tabulations suggests that the DTMS tests could be very useful for placement in a segmented sequence of mathematics courses.

5. Predictive Validity

A demonstration of predictive validity may be irrelevant for certain placement decisions (Willingham, 1974; Cronbach & Snow, 1977). Indeed, Cronbach (1971) states the case in the extreme, asserting that "a 'validity coefficient' indicating that Test X predicts success within a treatment tells nothing about its usefulness for placement." The point these authors make is that what is really needed is a demonstration of a trait-treatment interaction. Thus, they would argue that the regression line of math aptitude (as measured on the placement test) on achievement (as measured at the end of Course B) should be steeper for students who were placed directly into Course B than for students who took Course A first. In other words, it is of little use to predict that students would fail in Course B unless you can show that they would be more likely to succeed had they taken Course A first.

However, demonstration of a fairly high predictive validity of the placement test for students in "regular" courses would be a necessary (though not sufficient) condition for the later demonstration of a trait-treatment interaction. If the regression slope relating DTMS scores to math achievement were not fairly steep in the "regular" (or short sequence) group of students, there would be little hope of demonstrating a less steep slope for a remedial (or lower level) plus regular group (i.e., a long sequence). Furthermore, the basic assumption of a trait-treatment interaction study that performance in Course B should be maximized for all students may not be correct in some cases. Some students with very low scores may elect to enroll in programs that would never require them to take Course B rather than try to seek the additional coursework that might be necessary for them to succeed. This argument might not apply to English courses that would be required for all students, but might very well apply to calculus courses that can be completely avoided by students enrolled in certain programs.

Information on predictive validity might also be useful to a faculty advisor or counselor even if no formal remedial course sequence were available. If a valid placement test predicted that a student would have trouble even in the lowest level course, the advisor might suggest arranging other courses taken that semester so that a maximum amount of effort could be expended on the course where the greatest difficulty were predicted. Although knowledge of predictive validity may not be the ultimate or only indication of the worth of a placement test, it should still provide some valuable information.

Method

For assessing concurrent validity, the most relevant test would be one that closely matched the content of the course. But for assessing predictive validity, relevance should be determined in relation to prerequisite skills for the course. For example, a calculus test should not be used in determining predictive validity for a beginning calculus course because students would not be expected to be able to answer any calculus questions at the beginning of the course. However, a test of functions and graphs would be appropriate as these are important prerequisite skills for the study of calculus.

Pretest scores from the most relevant DTMS tests were correlated with final course grades (A = 4, B = 3, etc.). An attempt was made to use an additional criterion score with a wider range than grades, hence possibly yielding higher correlations with the DTMS predictors. Thus, instructors were asked to provide course scores reflecting point totals for the semester or numerical scores on the final exam. The correlations of these course scores with the predictors were nearly identical to the correlations for grades, and therefore are not included in this report. An attempt also was made to increase the reliability of the predictors by summing scores from two DTMS tests when course prerequisites appeared to be relevant to more than one test. Somewhat more surprisingly, this attempt was also unsuccessful. Despite the doubling in the test length, correlations of grades with one of the DTMS tests was usually about as high (or in some cases higher) than the correlation with the composite. Composite scores were not created for all institutions, hence the occasional blanks for the composite score on the following tables.

Results

Predictive validity coefficients are presented in Tables 5.1 to 5.6. Courses reporting grades for fewer than 15 students were not included in the tables. Median correlations across courses were in the .40s and .50s. Focusing on the 20 college courses with the largest samples (50 or more students), in only three was the correlation of the most relevant DTMS test with grades less than .40, and in 9 out of the 20 it was greater than .50.

Table 5.1

Correlations of Grades with Arithmetic Skills (AS) Scores for Courses with a Major Arithmetic Component

College	N	r with AS
HH	48	.52
L*	262	.68
LL	64	.59
B	32	.33
DD	30	.52
D	374	.57
G	25	.62
MM	47	.66
NN	28	.51

*Correlation with final exam score; grades not available at College L.

Table 5.2

Correlations of Grades with Arithmetic Skills (AS) and
Elementary Algebra Skills (EAS) Scores for
Elementary Algebra Courses

College	N	r with AS	N	r with EAS	N	r with AS & EAS
H	18	.55	18	.37	18	.50
L*	75	.54	69	.36	67	.55
JJ	166	.46	196	.54	162	.53
LL	24	.55	34	.51	24	.61
DD	42	.48	42	.46	---	---
II	37	.21	50	.41	37	.36
P	88	.64	107	.70	---	---
G	24	.33	59	.36	---	---
R	231	.27	203	.47	203	.46
O	52	.14	53	.27	49	.21
MM	28	.44	33	.68	---	---
NN	24	.38	32	.40	---	---

*Correlation with final exam score; grades not available at College L.

Table 5.3

Correlations of Grades with Elementary Algebra Skills (EAS) Scores for Intermediate Algebra Courses

College	N	r with EAS
HH	46	.62
H	49	.39
LL	19	.45
II	79	.46
Q	47	.41
NN	19	.25

Table 5.4

Correlations of Grades with Elementary Algebra Skills (EAS) and Intermediate Algebra Skills (IAS) Scores for College Algebra Courses

College	N	r with EAS	N	r with IAS	N	r with EAS & IAS
HH	46	.53	42	.37	42	.50
E	16	.44	23	.52	15	.47
LL	53	.30	60	.49	39	.45
B	99	.51	141	.47	--	---
S	--	---	99	.33	--	---
P	35	.58	33	.68	--	---
Q	25	.54	25	.50	--	---
NN	19	.44	25	.35	--	---

Table 5.5

Correlations of Grades with Intermediate Algebra Skills (IAS) Scores for Precalculus Courses

College	N	r with IAS
T	145	.45
E	47	.55
B	32	.48
G	30	.21
O	312	.49
KK	26	.58

Table 5.6

Correlations of Grades with Intermediate Algebra Skills (IAS) and Functions & Graphs (FG) Scores for Calculus Courses

College	N	r with IAS	N	r with FG	N	r with IAS & FG
T	114	.55	105	.52	105	.59
E	22	.36	21	.24	21	.37
B	54	.61	41	.51	---	---
S	85	.38	83	.44	80	.46
II	24	.75	24	.67	24	.77

Results were more mixed for courses outside the general algebra-calculus sequence. The Elementary Algebra Skills test was a good predictor ($r = .54$; $N = 104$) of grades in a "Technical Math" course at a New England vocational-technical college (College EE). And the Intermediate Algebra Skills test was a reasonably good predictor of grades in "Finite Mathematics" (at College B, $r = .28$, $N = 50$; at College F, $r = .45$, $N = 73$). But, the Intermediate Algebra Skills test was a poor predictor of statistics grades (at College E, $r = -.05$, $N = 10$; at College F, $r = .12$, $N = 10$). Although little confidence can be placed in this result due to the very small sample sizes, it should at least serve as a warning to colleges to proceed cautiously when using the DTMS tests outside the regular algebra-calculus sequence. This point is also relevant for courses in "Business Mathematics." At College LL, the Elementary Algebra Skills test was unsuccessful at predicting grades in a course titled "Business Mathematics" ($r = .04$; $N = 38$), but did predict grades in a course titled "Mathematics for Business and Economics I" at the same institution ($r = .44$; $N = 47$). Examination of the catalogue descriptions of the two courses helps to explain the discrepancy. The "Business Mathematics" course is described as, "A study of simple and compound interest, bank discount, payrolls, taxes, insurance, markup and markdown, corporate securities, depreciation, and purchase discounts" while the "Mathematics for Business and Economics I" course is described as, "A study of equations, inequalities, matrices, linear programming, linear quadratic, polynomial, rational, exponential, and logarithmic functions. Applications to business and economic problems are emphasized." Clearly, algebra skills are more related to the latter course than to the former. Two other institutions had business mathematics courses with descriptions more like the latter course described above, and correlations with grades in these courses also were similiar (at College S, r = .42, N = 233; at College NN, r = .39, N = 18).

Test Score - Grade Cross-tabulations

Although the correlations provide a good general index of the relationship between test scores and grades, they provide an incomplete picture of the relationship and are not useful in establishing cutoff scores. A cross-tabulation of grades and test scores (see Table 5.7)

Table 5.7

Cross-tabulation of Course Grades and Elementary Algebra Skills Scores for the Precalculus Courses at College O

Score Ranges on DTMS Elementary Algebra Test	Grades										
	A	B	C	D	F	WF	WP	W	I	No Grade	Total
0-10	0	0	3	0	6	1	6	0	0	2	18
11-15	0	1	3	7	18	3	12	1	0	3	48
16-20	1	0	18	10	28	1	12	2	1	2	75
21-25	5	20	22	20	30	2	12	3	1	0	115
26-30	13	31	28	7	12	1	3	1	0	2	98
31-35	9	4	6	1	1	0	1	0	0	0	22
Total	28	56	80	45	95	8	46	7	2	9	376

WF = Withdrew failing
WP = Withdrew passing
W = Withdrew
I = Incomplete

provides information that is much more useful. If College O (a campus of a major state university in a southeastern state) wished to use the Elementary Algebra Skills test to select students for their precalculus course or to advise students to expect difficulties, the data on Table 5.7 suggests that a score of 20 might be a reasonable cutoff. Only 2 students with scores of 20 or below received an A or a B in the course while 57 students with a score of 20 or below received an F or withdrew while failing. On the other hand, 91 students with scores above 20 received an A or a B, while 46 students with scores in this range received an F or withdrew while failing. Of course, cutting scores could be put at any number of different score levels depending on the social costs of excluding students who have some reasonable chance to succeed relative to the costs of instructing large numbers of students who will probably fail.

Comparisons with the SAT-Mathematical

The Scholastic Aptitude Test (SAT) is an excellent predictor of general freshman grade point averages. However, it is by design a general aptitude test not tied to the specific content of any course, and it must cover the full range of abilities. The DTMS tests, by way of contrast, are closely linked to mathematics course content, and any given test is designed to assess only a limited number of skills. Thus it was predicted that the DTMS tests, despite their relatively small number of items, might be better predictors of success in specific beginning mathematics courses than the SAT-Mathematical.

SAT-Mathematical scores from two institutions were available for this analysis. One was a two-year private junior college (College II) and the other was a four-year public university with an open admissions policy (College R). The institutions used locally developed tests for placement. At College II, the initial course was titled "Preparatory Mathematics" and was primarily a review of elementary algebra. For the 48 students from this course with complete data, the mean on the DTMS Elementary Algebra Skills test administered at the beginning of the semester was 13.68 (SD = 4.73); the mean SAT-Mathematical score was 344.8 (SD = 53.9). The standard deviation indicates that the restriction in range is not so severe as to preclude the possibility of a substantial correlation between grades and SAT-Mathematical scores. However, the actual correlation was very low ($r = .04$). The correlation of the Elementary Algebra Skill test with grades was considerably greater ($r = .41$). The difference between these correlations is statistically significant ($z = 2.16$; $p < .05$) according to the test described by McNemar (1949, pp. 124-125). The correlation between SAT-Mathematical scores and Elementary Algebra Skills scores was .25. A similar, though not quite as dramatic, difference in correlations was noted for the elementary algebra course at College R. For the 198 students with complete data, the mean Elementary Algebra Skills score was 15.68 (SD = 5.03) and the mean SAT-Mathematical score was 385.5 (SD = 65.3). The correlation of the SAT-Mathematical with grades was .26 and the correlation of Elementary Algebra Skills with grades was .47. Again, the correlation was significantly greater for the DTMS test

($z = 2.94$; $p < .02$). The correlation of SAT-Mathematical and Elementary Algebra Skills was .38.

For the 73 people with complete data in the elementary algebra course at College II, the mean SAT-Mathematical score was 383.7 (SD = 78.1) and the mean score on the Elementary Algebra Skills test was 18.49 (SD = 5.59). The correlation of the SAT-Mathematical scores with grades was .21 and the correlation of the Elementary Algebra Skills test with grades .46; the difference between these correlations with this small sample and the conservative two-tailed test is not significant ($z = 1.94$; $p > .05$), although with the possibly justifiable one-tailed test it would be significant. The correlation of SAT-Mathematical scores and Elementary Algebra Skills scores was .30.

For the 41 students with complete data in the "Mathematical Analysis I" course at College II, the mean SAT-Mathematical score was 414.4 (SD = 67.4) and the mean Intermediate Algebra Skills score was 12.74 (SD = 4.88). Correlation with grades for the SAT and DTMS scores were .18 and .52, respectively. These correlations are significantly different ($z = 2.23$; $p < .05$). The correlation of the SAT-Mathematical and Intermediate Algebra Skills scores was .48.

The predictive value of the SAT-Mathematical is much more apparent in the two more advanced courses at College II. Mean SAT-Mathematical scores were 454.3 (SD = 79.6; N = 40) in the elementary functions course and 562.1 (SD = 66.9; N = 19) in the calculus course. Correlations of SAT-Mathematical scores with grades in these two courses were .39 (elementary functions) and .55 (calculus). Although the SAT scores have more predictive validity for these more advanced courses, this should not imply that the DTMS tests have any less validity. The correlation of the Intermediate Algebra Skills score with grades was .37 for the elementary functions course and .75 for the small sample in the calculus course. Mean scores on Intermediate Algebra Skills in the two courses were 15.07 (SD = 4.58) and 22.68 (SD = 5.24). The mean score on the Functions & Graphs test for students in the calculus course was 17.13 (SD = 3.79) and its correlation with grades was .67.

For remedial level college mathematics courses, predictions of course grades from the DTMS tests are clearly superior to predictions from SAT-Mathematical scores. For more advanced courses, the DTMS tests appear to predict grades at least as well as scores from the SAT. The superiority of a test designed to assess certain specific skills over a general aptitude measure when predicting a criterion that is closely related to those skills was also noted by Breland (1977). He observed that TSWE scores provided better predictions of essay test performance at the end of an English course than did SAT-Verbal scores.

Regression Analyses

Although a demonstration of predictive correlation provides some information on the validity of the DTMS tests, it is of little practical significance if it cannot significantly improve predictions made from other information already in a students' record. Relatively large sample sizes are needed for these multivariate analyses, hence only regressions for a few of the largest courses will be presented here.

At College D, grades in high school algebra correlated .38 with grades for the 203 students in the "Introductory Mathematics" course. This course included some arithmetic review and some elementary algebra. Could adding scores from the Arithmetic Skills test to the high school grades significantly improve the correlation? The answer was a clear yes, with the multiple correlation increasing significantly ($p < .01$) to .58. The correlation from the Arithmetic Skills test score alone was .54 so also including the high school algebra mark in a prediction equation is of only marginal utility. Standardized regression weights were .22 for the high school grade and .46 for the Arithmetic Skills test score.

For the 295 students in the precalculus course at College O, high school algebra grades correlated .24 with grades in the college course. Adding scores from the Elementary Algebra Skills tests dramatically improved the multiple correlation to .60.

At College R, grades for the 162 students in the elementary algebra course were predicted using both high school grades and SAT-Mathematical scores. The correlation for grades alone was .21, adding the SAT score significantly improved the correlation to .36. With two variables already in the equation, the Elementary Algebra Skills test score still significantly ($p < .01$) improved the multiple correlation to .51. Looking at it the other way, the other two variables contribute only minimally to the predictions since scores from the Elementary Algebra Skills test score alone correlated .46 with grades in the elementary algebra course.

Summary

Scores on the DTMS, either by themselves or in combination with other data, appear to be good predictors of success in college mathematics courses. For remedial courses, they are apparently better predictors than SAT scores. For courses outside the general algebra-calculus sequence (e.g., some business mathematics courses) DTMS scores may be poor predictors of success.

6. Course Satisfaction Analysis

A questionnaire was developed in order to determine whether students believed the course in which they were placed (or in which they chose to enroll) was too hard, too easy, or at an appropriate level. Specifically, they were asked, "For someone with preparation in mathematics similar to your own, how would you describe the difficulty level of the course you are now finishing?" Five response choices were provided ranging from "much too easy" to "much too difficult." A second question asked, "Would you recommend this course to someone who had a mathematics background similar to yours?" Three response choices were provided: 1) "No, they should take a less advanced course first," 2) "Yes," 3) "No, they should skip this course and take a more advanced course." It was hypothesized that students with relatively high DTMS pretest scores would consider the course to be too easy while students with low scores would perceive it as too difficult.

Results

Questionnaires were returned from the developmental math course (arithmetic and some elementary algebra) at College L and from the precalculus course at College T. Response rates were very poor (27 out of 108 at College L and 37 out of 127 at College T). It is not known whether the low response rate was due to errors in distributing the forms or due to the failure of some students to put their responses in the appropriate boxes of the answer sheet (responses were to be placed in a special column of the DTMS answer sheet used for the posttest). At

College L, there is some evidence to suggest that the better students responded to the questionnaire. The mean score on the Elementary Algebra Skills test was 12.88 (SD = 5.30) in the total group and 15.15 (SD = 6.59) in the group that responded to the questionnaire. However, in College T, Intermediate Algebra Skills means were nearly identical in the total group and in the questionnaire group (19.98 vs. 19.89). In both institutions, however, results of this analysis must be treated as very tentative.

The correlation of the combined score from the Arithmetic Skills and Elementary Algebra Skills tests with the five-point perceived course difficulty score was -.64; consistent with predictions, students with high test scores tended to perceive the course as easier than did students with low test scores. Eleven students thought the course was "just about the right difficulty level," 13 thought it was too easy (3 "much too easy" and 10 "a little too easy") and only 3 thought it was too difficult (1 "much too difficult" and 2 "a little too difficult"). The correlation with the three-point scale indicating whether they would recommend an easier or more difficult course for students with preparation in mathematics similar to their own was .45, indicating that students with high test scores were more likely to recommend taking a more advanced course first. Only one student actually recommended taking an easier course first, so the basic discrimination was between the 16 students who would recommend the course they were currently taking and the 10 students who thought a more advanced course would be more appropriate.

At College T, scores on the Intermediate Algebra Skills test correlated -.40 with the perceived course difficulty score, and -.03 with the "recommend" score. Three of the 37 students who responded to the "difficulty" item failed to respond to the "recommend" item, and of the remaining 34 students, 24 of them indicated "Yes" they would recommend the course they were taking. This generally positive attitude may have been responsible for the lack of correlation in this group. The remaining 10 students were evenly divided between the two "No" categories. A cross-tabulation of Intermediate Algebra Skills scores and the course difficulty ratings is presented in Table 6.1.

Table 6.1

Cross-tabulation of Intermediate Algebra Skills Scores
and Perceived Course Difficulty Ratings

Perceived Course Difficulty	Intermediate Algebra Skills Scores								
	0-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	Total
Much too easy	0	0	0	2	1	0	2	0	5
A little too easy	0	0	0	0	1	1	0	0	2
Just about right difficulty level	0	1	0	2	7	6	3	0	19
A little too difficult	0	1	2	4	2	1	0	0	10
Much too difficult	0	0	0	0	1	0	0	0	1
Total	0	2	2	8	12	8	5	0	37

Of the 11 students who thought the course was too difficult, only 1 had an Intermediate Algebra Skills score greater than 21. In contrast, over half (12 out of 23) of the students who thought the course difficulty level was about right or too easy had scores greater than 21. Thus, the major prediction was confirmed; DTMS scores were related to the difficulty of mathematics courses as perceived by the students taking them.

7. Trait-Treatment Interaction

A demonstration that a test can predict which students are not likely to succeed if placed directly into a more advanced course (Course B) indicates that the test is useful in selecting students for that course, but says nothing about the students who were not selected. But if the ultimate goal is for all students eventually to succeed in Course B*, then for a placement test to be of value, it would be useful to demonstrate that some students are more successful if placed first into a less advanced course and then into Course B (long sequence) while other students do at least as well if placed directly into Course B (short sequence). In other words, there should be a trait-treatment interaction (see Cronbach & Snow, 1977, for a comprehensive discussion of this approach).

Ideally, at least from an evaluation point of view, students should be randomly assigned to the long sequence or short sequence groups. Course B should be exactly the same for long and short sequence groups, and there should be at least 100 students in each group. Unfortunately, it was not possible to find an institution meeting these criteria. Indeed, for the institution selected as offering the best approximation to a good trait-treatment interaction study (the precalculus-calculus sequence at College T), none of the above conditions were met. Instead of random

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*The reader should keep in mind that this is not always the ultimate goal; some students with very low placement test scores may decide to enroll in programs that would never require them to take Course B.

assignment, students were assigned to the long sequence (precalculus then calculus) or the short sequence (calculus only) on the basis of a locally developed placement exam, or by having had calculus in high school, or by having had a precalculus course in college. Students in the short sequence took calculus in the fall, while students in the long sequence took it in the spring. One must assume that the course was essentially identical in the fall and spring in terms of the quality of instruction and the material covered. For courses in some subject areas this assumption is clearly untenable, but it is probably not too unreasonable for large freshman sections of a standard calculus course in which the same textbook is used from one semester to the next and the mathematics department attempts to maintain a reasonably consistent standard. Because math grades are used as the criterion, it is also necessary to assume consistent grading standards across semesters. Again, this would not be a reasonable assumption in many courses, but it is probably not unreasonable for calculus courses in which grading is based on objective exams that are very similar from one semester to the next. Sample sizes were 114 in the short sequence group and 61 in the long sequence group. Although this provides less power than the 100 subjects per treatment recommended by Cronbach and Snow (1977, p. 46), it is at least better than the 40 or fewer subjects per treatment that Cronbach and Snow assert is typical for studies of this type.

Results

With grades in calculus as the criterion (Y) and scores on the Intermediate Algebra Skills test administered at the beginning of the fall semester as the predictor (X), the regression line for students in the short sequence was Y = .212X - 2.80. Their mean on X was 25.93 (SD = 3.35) and their mean on Y was 2.71 (SD = 1.29). The comparable line for students in the long sequence was Y = .059X + 1.01. The mean on X for long sequence students was 20.87 (SD = 4.16) and their mean on Y was 2.23 (SD = 1.09). Although the means in the two groups were clearly different, there was also some overlap in the distributions. Scores in both groups had a wide range (10 to 29 for the long sequence and 15 to 30 for the short sequence). Slightly over 20% of the students in the long sequence group had pretest scores of 25 or more, while 23% of the students in the short sequence group had scores of 24 or less. The regression lines are presented in Figure 7.1. Rather than a linear fit, the long sequence line should probably become steeper at the upper end. Of the nine students in this group with scores over 25, two received a grade of C in calculus, six received Bs and one received an A.

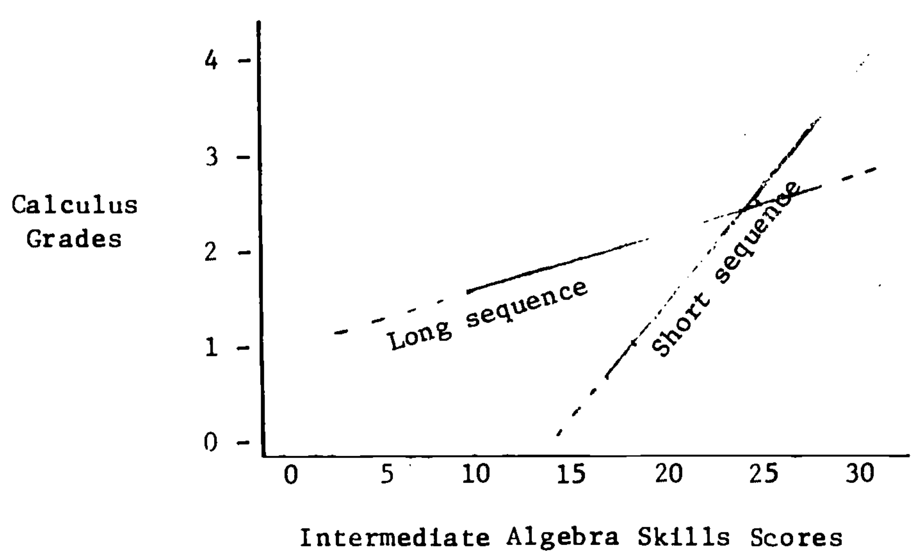

Figure 7.1. Trait-treatment interaction between Intermediate Algebra Skills scores and calculus grades.

The F-test of the difference in the slopes was significant ($F = 11.67$, $df = 1,171$, $p < .001$). Although the F-test lacks precise meaning because the two groups were not randomly sampled from the same population, the magnitude of the interaction suggests that there is a true differential effect for the longer sequence.

The regression lines intersect at an Intermediate Algebra Skills score of about 25, hence for scores around this level it would seem to make little difference which sequence students took. However, students with scores around 18 on the pretest would apparently be much better off in the long sequence where their predicted grade in calculus is a C whereas their predicted calculus grade would be a full letter grade lower if they skipped the precalculus course. This interpretation is consistent with the gain analyses presented in Chapter 3 in which it was demonstrated that the precalculus course at College T was quite effective in increasing students' skills in intermediate algebra.

8. Content Validity

College level mathematics courses typically form a closely linked segmented sequence in which success in later courses is assumed to depend on mastery of the content of the earlier courses (Willingham, 1974). Placement into the appropriate course in the sequence could then be done with a test that was a valid reflection of the content of the preceding course. The analysis described below was an attempt to yield some data on the content validity of the DTMS.

A questionnaire was developed in which faculty members were asked to rate items on the DTMS "test or two tests that most nearly match the content of your course." For each item, the instructors were asked to "make a judgment about the importance of the skill assessed by the item as a prerequisite for your course, i.e., how important it is for the student to possess that skill before beginning your course." Ratings were to be made on a three-point scale (1 = relatively unimportant, 2 = moderately important, and 3 = very important). They were also asked to rate "how important the skill is as an objective of your course, i.e., how important it is for the student to have attained the skill by the end of your course." The same rating scale described above was used again. Instructors were then asked "to make a rough judgment of the amount of class time (in minutes) that is spent on the skill assessed by the item." Since responses to this time question tended to vary widely from instructor to instructor, it was judged to be too unreliable to be used in the analyses.

Every item on a specific DTMS test might be related to important course objectives, but if these objectives represented only a small proportion of the total set of objectives for the course, then the test might not be very useful for placement purposes. Therefore, each instructor was asked "to make a global judgment of the percentage of important course objectives assessed by the test as a whole." Other items on the questionnaire requested information about course prerequisites and placement procedures. A copy of the questionnaire is in Appendix B.

The questionnaires were mailed to each institution in the study. The coordinator in each school was asked to distribute the questionnaires to "each instructor of a freshman mathematics course that is open to beginning students even though it may also contain substantial numbers of more advanced students"; instructors of remedial or developmental courses were also to be included.

Questionnaires were returned from faculty members representing 126 different courses. The faculty members were asked to classify the courses with the term that "best describes your course." Twelve categories were supplied (see Item 1 on the questionnaire in Appendix B) with an "other (specify)" category for courses not listed. The "geometry" and "analytic geometry" categories were not used at all, and 11 instructors used the "other" category. Thus, 115 courses were described with 10 of the provided descriptors. Only categories represented by responses from at least 12 instructors are presented below. These include arithmetic, elementary algebra, intermediate algebra, college algebra, and calculus.

Arithmetic Courses

Fourteen faculty members, 4 from two-year schools and 10 from four-year schools, used the term "arithmetic" to describe their courses. All of the courses were described as "remedial, compensatory, or developmental." For nine of the courses, students were required to enroll in the prescribed courses, while placement was advised for the other five. Half of the respondents indicated that the Arithmetic Skills test alone most nearly matched the content of their courses, while the other half indicated that the combination of the Arithmetic Skills and the Elementary Algebra Skills tests provided the best match.

Arithmetic Skills Test: Prerequisite/Objective ratings. Responses to the "importance as a prerequisite" and "importance as an objective" items suggested that the Arithmetic Skills test is well suited to the arithmetic courses sampled. As shown in Table 8.1, none of the 35 items was rated as "very important" as a prerequisite by as many as half of the respondents. In contrast, 33 items were rated as "very important" as objectives by at least half of the respondents. The "mean item response," on the table is the sum of the number of faculty responses in a category (i.e., very important as a prerequisite) divided by the number of items on the test. It provides an indication of the distribution of faculty responses for the test as a whole.

Arithmetic Skills Test: Coverage of course content. Of the 10 instructors who responded to the item on the percentage of important

Table 8.1

Arithmetic Courses

Arithmetic Skills Test

TEST # 1 -- COMBINED SCHOOLS (N= 14)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
1	3	5	6	2	5	7
2	3	5	6	1	5	8
3	6	5	1	1	3	10
4	3	5	6	2	4	8
5	3	5	6	2	4	8
6	3	6	5	2	4	8
7	5	6	3	3	5	6
8	5	6	2	0	2	12
9	6	5	2	0	1	13
10	3	8	3	1	6	7
11	7	4	2	0	1	13
12	8	4	1	0	6	8
13	6	5	2	0	2	12
14	4	9	1	2	5	7
15	4	7	2	0	4	10
16	5	6	2	0	4	10
17	3	6	5	2	4	8
18	6	4	3	0	1	13
19	5	8	0	0	3	11
20	4	7	2	0	4	10
21	6	6	1	1	4	9
22	5	7	1	0	3	11
23	6	5	2	0	2	12
24	6	6	1	1	4	9
25	7	4	2	0	2	12
26	6	5	2	0	2	12
27	6	4	3	0	1	13
28	6	7	0	1	7	6
29	7	5	1	0	2	12
30	7	6	0	0	3	11
31	6	5	2	0	2	12
32	7	2	3	0	2	11
33	7	4	1	0	2	11
34	7	4	1	0	1	12
35	7	5	0	0	3	10
TOTALS	188	191	80	21	113	352
Mean Item Response	5.4	5.5	2.3	.6	3.2	10.1

% OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
QUESTION # 1,	0	0	0	0	0	0	1	0	4	4	1

course objectives assessed by the Arithmetic Skills test, all indicated that more than 50% of their important objectives were assessed. Table 8.1, Question 1 shows the distribution of percentage of objectives assessed by the Arithmetic Skills test. Written responses by some faculty members noted that their course objectives not covered by the test include metric system problems, operations with negative numbers, factoring, and exponents. The questionnaire responses indicated that the items on the Arithmetic Skills test are closely linked to the objectives of these college arithmetic courses, and provide reasonably complete coverage of their most important objectives.

Elementary Algebra Skills Test: Prerequisite/Objective ratings. The seven arithmetic instructors who indicated that the Elementary Algebra Skills test also matched the content of their courses were all from four-year colleges. As would be expected, very few of the items on this test were seen as important prerequisites by the arithmetic instructors. Eight of the 35 items were marked as very important as an objective by half or more of the respondents. (See Table 8.2.) Five of the eight items were from Cluster A--Operations with Real Numbers. Two of the items were selected as very important objectives by all seven respondents. Both of these items involved manipulations (addition, subtraction, multiplication, and division) with negative numbers, and unlike most other items in the Elementary Algebra Skills test, neither item involved solving an equation for an unknown quantity.

Elementary Algebra Skills Test: Coverage of course content. Six of the seven faculty members responded to the item concerning the percentage

Table 8.2

Arithmetic Courses

Elementary Algebra Skills Test

TEST # 2 -- 4-YEAR SCHOOLS (N= 7)

ITEM #	PREREQUISITES U	MI	VI	OBJECTIVES U	MI	VI
36	6	1	0	1	2	4
37	6	1	0	1	4	2
38	6	1	0	1	4	2
39	6	0	1	1	1	5
40	6	0	1	0	3	4
41	5	1	1	0	0	7
42	5	1	1	0	0	7
43	6	1	0	3	3	1
44	6	1	0	0	2	5
45	7	0	0	6	1	0
46	5	1	1	0	2	5
47	7	0	0	6	0	1
48	6	1	0	4	2	1
49	7	0	0	5	2	0
50	6	1	0	1	3	3
51	6	1	0	2	4	1
52	5	0	1	0	2	4
53	5	1	0	2	3	1
54	5	1	0	3	2	1
55	5	0	1	3	1	2
56	6	0	0	5	0	1
57	6	0	0	5	1	0
58	5	1	0	3	2	1
59	6	0	0	3	3	0
60	6	0	0	5	0	1
61	6	0	0	5	1	0
62	6	0	0	5	0	1
63	6	0	0	5	1	0
64	6	0	0	2	3	1
65	6	0	0	2	3	1
66	6	0	0	5	1	0
67	6	0	0	5	0	1
68	6	0	0	2	2	2
69	6	0	0	4	1	1
70	6	0	0	4	1	1
TOTALS	205	14	7	99	60	67
Mean Item Response	5.9	.4	.2	2.8	1.7	1.9

OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
JESTION # 1	0	0	1	2	0	0	0	0	1	0	0
JESTION # 2	0	0	0	0	0	0	0	0	3	1	2

of important course objectives assessed by the Arithmetic Skills and Elementary Algebra Skills tests combined. Table 8.2, Question 2, reports the distribution of responses. Objectives noted by respondents as not assessed by the test are systems of measurement, geometry, graphs, and simple statistics (i.e., mode, median, and mean).

Taken by itself, the Elementary Algebra Skills test has little relevance to arithmetic courses. But, for some arithmetic courses, some of the items on this test, especially those in Cluster A, may be useful additions to the Arithmetic Skills test. In general, institutions wishing to use both tests to yield scores that are adequate reflections of the content of their arithmetic courses should review the Elementary Algebra Skills test items carefully. Only responses on a relatively small number of items judged to be relevant should be included in computing total scores. Thus institutions could instruct students to respond only to Cluster A on the Elementary Algebra Skills test. However, it may be more practical simply to rely on scores from the Arithmetic Skills test even though a few areas covered only on the Elementary Algebra Skills test would have to remain unassessed.

Elementary Algebra Courses

Thirty-six respondents, 19 from two-year schools and 17 from four-year schools, chose elementary algebra as the term that best described their courses. The majority of those courses, 30 or 83% overall, were classified as remedial, compensatory, or developmental by their instructors. Five courses were described as regular and one course was reported to be advanced or honors. In response to the item inquiring about prerequisites, 19 of the respondents reported no prerequisites for their elementary algebra courses; 13 reported that one year of high school algebra or its equivalent was prerequisite for their courses. The options "two years of high school algebra" and "at least ten weeks of trigonometry" were not chosen. Three faculty members circled the "other" category and specified that basic arithmetic skills were prerequisite. When responding to the item inquiring whether or not students were required or advised to enroll in their courses, 17 faculty members reported their courses were required while another 17 indicated that students were advised to enroll in their courses. Two respondents reported that, in some cases, students were required to enroll, while in other cases, students were only advised to enroll.

When asked which test(s) best matched the content of their courses, none of the respondents chose the Arithmetic Skills test alone; however, the majority of respondents, 21 chose the combination of the Arithmetic Skills Test and the Elementary Algebra Skills test. Ten faculty respondents reported that the Elementary Algebra Skills test alone best matched the content of their courses. Another five respondents chose the combination of the Elementary and Intermediate Algebra Skills tests as representing the best course content match.

Elementary Algebra Skills Test: Prerequisite/Objective ratings. The Elementary Algebra Skills test, either by itself or in combination with its antecedent or subsequent test, was chosen by 100% of the respondents as the test that best matched the content of their elementary algebra courses. Of the 35 items on the Elementary Algebra Skills test, 32 were rated by half or more of the respondents as being unimportant prerequisites. In contrast, none of the items was rated by more than 10 respondents as a very important prerequisite. (See Table 8.3.) Thus, the Elementary Algebra Skills test does not measure skills that students are already expected to have mastered before entering elementary algebra courses.

All 35 items were rated by at least 52% of the elementary algebra instructors as very important objectives. The mean item response for the very important as an objective category was 27.9 respondents out of a possible total of 36. These responses strongly indicate that the Elementary Algebra Skills test does assess skills that students should have mastered by the end of elementary algebra courses.

Elementary Algebra Skills Test: Coverage of course content. Thirty-three of the 36 faculty members reported the percentage of important course objectives assessed by the Elementary Algebra Skills test. (See Table 8.3, Question 1.) Thirty-two faculty members indicated that 50% or more of their course objectives were assessed by the test. The one faculty member who reported less than 50% commented that the test did not adequately address "simple algebraic operations, such as simple equations, hierarchy of operations, and simplification." Nevertheless, that faculty member still reported that 50% of the course objectives were assessed by the combination of the Arithmetic Skills and Elementary Algebra Skills tests. Fifteen of the respondents indicated that more than 80% of their course objectives were assessed. Course objectives noted by respondents as not

Table 8.3

Elementary Algebra Courses

Elementary Algebra Skills Test

TEST # 2 -- COMBINED SCHOOLS (N= 36)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
36	18	10	6	1	3	30
37	19	10	4	2	7	26
38	20	9	4	0	4	31
39	20	6	6	1	1	33
40	22	7	4	1	3	31
41	17	7	9	2	3	30
42	17	6	10	1	4	30
43	22	7	4	1	2	32
44	23	6	4	0	2	33
45	26	4	3	2	2	31
46	16	10	7	1	4	30
47	29	4	0	5	7	23
48	24	7	2	4	2	29
49	29	3	1	4	5	26
50	25	4	4	1	5	29
51	21	7	5	4	7	24
52	20	10	3	1	3	31
53	25	6	2	1	4	30
54	25	7	1	2	3	30
55	25	7	1	4	4	27
56	31	1	1	6	8	21
57	30	2	1	5	7	23
58	25	7	1	2	4	29
59	25	6	2	4	6	25
60	28	2	3	7	9	19
61	29	3	1	2	6	27
62	29	3	1	2	7	26
63	29	3	1	4	6	25
64	24	7	2	1	3	31
65	25	7	1	1	3	31
66	28	3	2	2	4	29
67	26	4	2	2	9	23
68	25	6	2	1	7	27
69	26	5	2	3	3	29
70	27	4	2	6	5	24
TOTALS	850	200	104	86	162	975
Mean Item Response	24.3	5.7	3.0	2.5	4.6	27.9

% OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
QUESTION # 1	0	1	0	0	0	2	4	2	9	11	4
QUESTION # 2	0	0	0	0	0	0	1	2	2	7	7

assessed by the Elementary Algebra Skills test included elementary geometry, quadratic equations, graphing, linear equations, algebraic fractions, fractional exponents, radical equations, and absolute values. Two respondents who chose the Arithmetic Skills and Elementary Algebra Skills tests commented that items on the Intermediate Algebra Skills test assessed some course objectives not assessed by the other two tests, but that it is too time consuming to administer all three tests. One of them suggested combining the content of the three tests into two tests.

Arithmetic Skills Test: Prerequisite/Objective ratings. The 21 faculty members who chose the combination of the Arithmetic Skills and Elementary Algebra Skills tests as the combination that best represented the content of their courses, all overwhelmingly reported that the majority of items on the Arithmetic Skills test represent very important prerequisites of their elementary algebra courses. The mean item response for the very important as a prerequisite category was 14.1 out of the total of 21 respondents. Complementary to this statistic is that the mean item response for the very important as an objective category was 8.6 out of 21. These two statistics indicate that the content of the Arithmetic Skills test is seen as covering very important prerequisite material of the majority of these courses. (See Table 8.4.)

Arithmetic Skills Test: Coverage of course content. Sixteen of the 21 respondents answered the question asking about the percentage of course objectives assessed by the Arithmetic Skills test. Eleven faculty members reported that it assessed 50% or less; five respondents reported

Table 8.4

Elementary Algebra Courses

Arithmetic Skills Test

TEST # 1 -- COMBINED SCHOOLS (N= 21)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
1	1	0	19	6	3	8
2	0	1	19	6	2	9
3	3	1	16	5	7	5
4	1	0	19	6	3	8
5	1	0	19	6	2	9
6	1	2	17	5	5	7
7	1	1	18	5	4	8
8	1	1	17	4	4	9
9	1	3	15	6	2	9
10	1	2	16	6	4	7
11	1	3	15	3	4	11
12	3	5	11	6	3	10
13	1	3	14	3	3	13
14	1	1	17	5	5	8
15	1	4	13	5	4	9
16	1	6	13	4	6	8
17	1	0	18	6	2	10
18	1	3	15	3	5	10
19	1	5	12	5	4	9
20	1	3	15	3	7	7
21	2	8	10	5	5	8
22	1	5	13	5	5	7
23	1	3	14	3	5	11
24	2	9	8	5	6	8
25	1	3	15	3	5	10
26	2	5	13	5	6	7
27	1	4	14	3	6	9
28	2	7	10	5	5	9
29	2	7	10	5	6	8
30	2	5	13	4	6	8
31	1	4	14	5	3	9
32	1	6	11	3	4	10
33	2	6	11	5	4	8
34	2	6	11	4	5	8
35	2	8	9	4	6	7
TOTALS	47	130	494	162	156	301
Mean Item Response	1.3	3.7	14.1	4.6	4.5	8.6

% OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
QUESTION # 1	2	1	4	1	1	2	0	0	0	2	3

that more than 80% of their course objectives were assessed. (See Table 8.4, Question 1.) Table 8.3, Question 2, shows that 19 of the 21 faculty members who selected the combination of the Arithmetic Skills and Elementary Algebra Skills tests indicated that more than 50% of their course objectives were assessed by these combined tests. Fourteen of them indicated that more than 80% of their objectives were assessed by these two tests. In combination then, the Arithmetic Skills test, covering mainly prerequisite material, and the Elementary Algebra Skills test, covering mainly course objectives, appear to be appropriate tests for the elementary algebra courses sampled.

Intermediate Algebra Courses

Intermediate algebra was selected by 12 respondents, 6 from two-year schools and 6 from four-year schools, as the term that best described their courses. Five of those courses were rated as remedial, compensatory, or developmental and seven were reported to be regular. Ten faculty respondents indicated that one year of high school algebra or its equivalent was prerequisite to their courses. Two respondents from the same institution marked the other category and specified the following: (a) admission as a regular, not special studies, student in the institution, and (b) attainment of a cutoff score on the SAT or on a local test.

In responding to the item asking them to choose the DTMS test(s) that most nearly matched the content of their courses, one instructor of a remedial course circled the Elementary Algebra Skills test alone. Seven faculty members, two of remedial courses and five of regular classes, circled the combination of the Elementary Algebra and the Intermediate

Algebra Skills tests. Three respondents, one of a regular course and two of remedial classes, chose only the Intermediate Algebra Skills test. One instructor of a regular course selected the combination of the Intermediate Algebra Skills test and the Functions & Graphs test.

Elementary Algebra Skills Test: Prerequisite/Objective ratings. Responses to the importance as a prerequisite and importance as an objective item indicate that the content of the Elementary Algebra Skills test is well matched to the objectives of the intermediate algebra courses represented by the eight respondents who chose it. Of the 35 items, 31 were rated by five or more respondents as representing content that is very important as objectives in their courses. The mean item response for the very important as an objective category was 5.7 out of a possible 8 respondents. (See Table 8.5.)

In contrast to this is that none of the 35 items were rated by more than four respondents as being very important prerequisites. Seventeen questions were not rated by any respondents as representing very important prerequisites.

Elementary Algebra Skills Test: Coverage of course content. Of the six faculty members who responded to the question inquiring about the percentage of course objectives assessed by the Elementary Algebra Skills test alone, three, two instructors of remedial courses and one instructor of a regular class, reported that it assessed 50% or less, although not less than 30%. The other three, all instructors of regular classes, reported that it assessed 80% or more of their course objectives. (See Table 8.5, Question 1). All six respondents were ones who had chosen

Table 8.5

Intermediate Algebra Courses

Elementary Algebra Skills Test

TEST # 2 -- COMBINED SCHOOLS (N= 8)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
36	1	3	3	0	1	7
37	1	6	0	1	2	5
38	1	3	3	0	3	5
39	0	3	4	1	2	5
40	1	2	4	0	3	5
41	1	2	4	0	2	6
42	1	4	2	0	2	6
43	1	6	0	0	2	6
44	1	5	1	0	1	7
45	1	6	0	0	1	7
46	1	3	3	0	2	6
47	4	3	0	0	2	6
48	2	5	0	0	2	6
49	1	6	0	0	2	6
50	1	5	1	0	1	7
51	4	1	2	0	3	5
52	1	3	3	0	3	5
53	1	4	2	0	2	6
54	2	4	1	0	2	6
55	2	5	0	0	1	7
56	3	4	0	0	3	5
57	1	5	1	0	1	7
58	3	3	1	0	2	6
59	5	2	0	0	4	4
60	5	2	0	1	4	3
61	1	6	0	0	2	6
62	3	2	2	1	2	5
63	3	4	0	0	3	5
64	1	5	1	0	1	7
65	2	4	1	0	1	7
66	1	6	0	0	2	6
67	3	4	0	0	4	4
68	3	4	0	0	2	6
69	3	4	0	0	1	7
70	5	2	0	0	4	4
TOTALS	70	136	39	4	75	201
Mean Item Response	2.0	3.9	1.1	.11	2.1	5.7

% OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81
QUESTION # 1	0	0	0	1	1	1	0	0	1	
QUESTION # 2	0	0	0	0	0	0	0	0	0	

the Elementary Algebra Skills test in combination with the Intermediate Algebra Skills test as the tests that best matched the content of their courses. Two respondents who chose that combination did not report the percentage of objectives assessed, but one of them noted that logic and sets were not covered by the Elementary Algebra Skills test or the Intermediate Algebra Skills test.

These data indicate that the content of these eight courses, described as intermediate algebra courses by their instructors, is assessed to some extent by the Elementary Algebra Skills test; however, the Elementary Algebra Skills test alone does not always assess the majority of objectives.

Intermediate Algebra Skills Test: Prerequisite/Objective ratings. Of the 11 respondents who reported that the Intermediate Algebra Skills test matched the content of their courses, seven did so in combination with the Elementary Algebra Skills test; three reported so alone, and one reported it in combination with the Functions & Graphs test. The 11 respondents together reported that the items on the Intermediate Algebra Skills test were unimportant as prerequisites, but that they were very important as objectives of their courses. The responses to the objectives rating task revealed that 16 of the 30 items were rated by half or more of the 11 respondents as assessing very important course objectives. When taken together, the moderately important and very important as objectives categories were chosen by at least half of the respondents for all but one item. (See Table 8.6.) These responses indicate that the items on the Intermediate Algebra Skills test match some of the content objectives of the 11 courses described as intermediate algebra by their instructors.

Table 8.6

Intermediate Algebra Courses

Intermediate Algebra Skills Test

TEST # 3 -- COMBINED SCHOOLS (N= 11)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
71	4	4	1	1	3	7
72	3	6	0	0	3	8
73	7	2	0	3	4	4
74	3	5	1	1	2	8
75	4	4	1	1	3	7
76	3	5	1	1	3	7
77	6	2	1	1	4	6
78	3	5	1	1	1	9
79	4	4	1	2	3	6
80	6	3	0	1	5	5
81	7	2	0	2	2	5
82	6	3	0	1	6	4
83	5	4	0	0	4	7
84	7	2	0	2	4	5
85	5	3	1	5	2	4
86	8	1	0	3	2	6
87	5	4	0	1	2	8
88	7	2	0	5	1	5
89	4	4	1	1	5	5
90	6	3	0	0	3	8
91	8	1	0	2	5	2
92	4	4	1	1	3	7
93	9	0	0	2	2	7
94	8	1	0	4	4	3
95	9	0	0	3	3	5
96	7	1	1	1	2	8
97	9	0	0	5	1	5
98	9	0	0	5	1	5
99	8	1	0	0	3	8
100	9	0	0	5	1	3
TOTALS	183	76	11	60	87	177
Mean Item Response	6.1	2.5	.36	2.0	2.9	5.9

# OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
QUESTION # 1	0	0	0	0	1	1	3	3	1	0	0
QUESTION # 2	0	0	0	0	0	0	0	1	2	2	2

Intermediate Algebra Skills Test: Coverage of course content. Of the seven respondents who chose the Intermediate Algebra Skills test and the Elementary Algebra Skills test as the combination that best matched the content of their courses, two reported that the combination assessed more than 90% of their course objectives; two reported they assessed 81% - 90% of course objectives; another two indicated they covered 71% - 80% of course objectives; and one judged that the two tests together assessed 70% of the course objectives. (See Table 8.6, Question 2).

Two of the three respondents who chose only the Intermediate Algebra Skills test as the best match reported that 61% - 70% of their course objectives were assessed by the test. The third respondent in this group did not reply to the item. It appears that the Intermediate Algebra Skills test assesses better than 50% of the course objectives of these courses.

The one respondent who chose the Intermediate Algebra Skills test in combination with the Functions & Graphs test reported that the intermediate level test assessed 51% - 60% of his course objectives, but that these two tests combined assessed 81% - 90% of the course objectives.

All 11 respondents who chose the Intermediate Algebra Skills test reported that it alone, or in combination with the preceding or subsequent test, assessed at least 50% of their course objectives. Some of the objectives not assessed by the Intermediate Algebra Skills test were logic, sets, quadratic equations, evaluation of functions and composite functions, absolute value inequalities, formula evaluation, and manipulation of vectors. One respondent noted that more emphasis on word problems was needed.

College Algebra Courses

College algebra was the term chosen by 15 respondents to describe their mathematics courses. Thirteen of these faculty members were from four-year schools and two taught at two-year institutions. Three respondents from four-year schools described their courses as remedial, compensatory, or developmental and 12 respondents, two from two-year schools and ten from four-year schools, described their courses as regular. Six faculty members (40%) reported that one year of high school algebra or its equivalent was prerequisite for their courses. Nine respondents (60%) indicated that two years of high school algebra or its equivalent were necessary prerequisites for their courses. Twelve faculty members (80%) replied that students were advised to enroll in their courses and three faculty members reported that their courses were required of their students. Ten respondents chose the combination of the Elementary Algebra Skills test and the Intermediate Algebra Skills test as the best match for their courses. The Intermediate Algebra Skills test and the Functions & Graphs test were chosen by five respondents as the best match. In both categories, one respondent was from a two-year school and the rest were from four-year institutions.

Elementary Algebra Skills Test: Prerequisite/Objective ratings. None of the 35 items was rated by more than six respondents as a very important prerequisite, and only five questions were rated by as many as six respondents. However, all but two items were rated by at least 80% of the respondents as either very important or moderately important as prerequisites. All 35 items were rated by 60% or more of the 10 respondents as representing content very important as an objective of their courses. (See Table 8.7.)

Table 8.7

College Algebra Courses

Elementary Algebra Skills Test

TEST # 2 -- COMBINED SCHOOLS (N= 10)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
36	0	5	5	1	1	8
37	1	3	6	1	2	7
38	0	5	5	1	1	8
39	0	4	6	1	1	8
40	0	5	5	1	1	8
41	0	4	6	1	2	7
42	0	4	6	1	1	8
43	2	5	3	1	1	8
44	0	5	5	1	1	8
45	1	6	3	1	1	8
46	0	5	5	1	2	7
47	5	3	2	1	3	6
48	2	7	1	1	3	6
49	2	6	2	1	1	8
50	0	4	6	1	1	8
51	2	5	3	1	2	7
52	0	5	5	1	1	8
53	1	5	4	1	1	8
54	1	5	4	1	3	6
55	2	5	3	1	2	7
56	4	5	1	1	3	6
57	1	5	4	1	1	8
58	1	6	3	2		8
59	2	3	5	2		7
60	2	4	4	2	0	8
61	1	5	4	1	2	7
62	1	7	2	1	2	7
63	1	8	1	1	1	8
64	0	5	5	1	1	8
65	0	6	4	1	1	8
66	2	4	4	1	1	8
67	2	6	2	1	3	6
68	1	4	5	1	1	8
69	1	5	4	1	1	8
70	1	5	4	1	1	8
TOTALS	39	174	137	38	50	262
Mean Item Response	1.1	4.9	3.9	1.1	1.4	7.5

% OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
QUESTION # 1	1	0	2	0	2	1	1	0	1	0	0
QUESTION # 2	0	0	0	0	0	0	0	0	0	0	0

<u>Elementary Algebra Skills Test: Coverage of course content</u>. Eight of the 10 respondents who chose the Elementary Algebra Skills test reported the percentage of course objectives assessed by this test. Six reported it assessed 50% or less and two marked 51% or better. (See Table 8.7, Question 1.)

For the ten courses described, the Elementary Algebra Skills test assesses some course objectives, but it also includes content regarded as moderately important to very important as prerequisites by a majority of respondents. In 60% of these cases, this test alone assessed 50% or less of the course objectives. It should be noted, however, that this test was not chosen alone, but only in combination with the Intermediate Algebra Skills test.

<u>Intermediate Algebra Skills Test: Prerequisite/Objective ratings</u>. The Intermediate Algebra Skills test was chosen by 15 faculty members. Of these 15, ten chose it in combination with the Elementary Algebra Skills test and five combined it with the Functions & Graphs test. Twenty-eight of the 30 items on the Intermediate Algebra Skills test were rated by eight or more respondents (more than 50%) as representing very important course objectives. The mean item response for this category was 10 out of a possible 15 respondents. In contrast, only one item was rated by eight or more faculty as a very important prerequisite and it was so rated by nine instructors. The mean item response for the very important as a prerequisite category was only 3.5 or slightly more than 20% of the respondents. (See Table 8.8.)

<u>Intermediate Algebra Skills Test: Coverage of course content</u>. Seven of the 10 faculty who chose the Intermediate Algebra Skills

Table 8.8

College Algebra Courses

Intermediate Algebra Skills Test

TEST # 3 -- COMBINED SCHOOLS (N= 15)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
71	1	8	6	2	2	10
72	1	5	9	1	3	10
73	3	9	3	0	4	11
74	3	7	5	2	3	9
75	2	8	5	2	3	9
76	2	7	6	2	2	10
77	7	6	2	0	4	11
78	2	6	7	2	2	10
79	0	11	4	2	2	10
80	1	9	5	1	3	10
81	11	2	2	0	5	9
82	5	7	3	4	3	7
83	3	8	4	2	2	11
84	3	9	3	0	3	12
85	6	7	2	0	4	11
86	8	6	1	0	3	12
87	3	7	5	1	2	11
88	11	3	1	0	5	10
89	3	6	6	2	3	9
90	3	8	4	1	2	12
91	12	2	1	2	3	10
92	2	6	7	2	3	9
93	10	3	2	2	3	10
94	12	2	1	0	5	10
95	8	6	1	1	3	11
96	3	8	4	2	4	8
97	11	3	1	1	3	11
98	10	4	1	2	6	7
99	3	9	3	1	3	11
100	10	4	1	2	4	9
TOTALS	159	186	105	39	97	300
Mean Item Response	5.3	6.2	3.5	1.3	3.2	10.0

# OBJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
QUESTION # 1	0	0	1	2	2	1	2	1	1	2	0
QUESTION # 2	0	0	0	0	1	0	0	1	4	1	1

test with the Elementary Algebra Skills test reported that the combination assessed 61% - 100% of their course objectives. (See Table 8.8, Question 2.) One faculty member who chose both tests reported that 40% of the course objectives were assessed. Two faculty who marked both tests did not reply to this question.

Functions & Graphs Test: Prerequisite/Objective ratings. Functions & Graphs was chosen by five respondents in combination with the Intermediate Algebra Skills test. The response pattern to the prerequisite-objective rating task shows that all 30 items were strongly rated as unimportant prerequisites. The mean item response for this category was 4.6 out of a possible 5 respondents. Sixteen questions were rated as very important objectives by three or more respondents. (See Table 8.9.) Of interest is the fact that all 13 items rated by only one respondent as a very important objective were from Cluster C--Trigonometric Functions. In fact, these 13 items comprise all of Cluster C and, in all cases, these items were ranked by the other four respondents as unimportant objectives. No other items were rated as unimportant. (See Table 8.9.) These data indicate that, except for the trigonometric items, the items of the Functions & Graphs test assess very important objectives of these five courses.

Functions & Graphs Test: Coverage of course content. Four of the five respondents reported that the Functions & Graphs test in combination with the Intermediate Algebra Skills test assessed 71% - 100% of course objectives. (See Table 8.9, Question 2.) One respondent indicated that even together the two tests assessed only 50% of course objectives. This faculty member indicated that the important course objectives not assessed

Table 8.9

College Algebra Courses

Functions & Graphs Test

TEST # 4 -- COMBINED SCHOOLS (N= 5)

ITEM #	PREREQUISITES U	PREREQUISITES MI	PREREQUISITES VI	OBJECTIVES U	OBJECTIVES MI	OBJECTIVES VI
101	5	0	0	0	1	4
102	5	0	0	4	0	1
103	3	2	0	0	1	4
104	5	0	0	4	0	1
105	2	2	1	0	1	3
106	3	0	2	0	0	4
107	5	0	0	4	0	1
108	5	0	0	0	0	5
109	5	0	0	4	0	1
110	5	0	0	4	0	1
111	3	1	1	0	0	5
112	5	0	0	4	0	1
113	5	0	0	0	1	4
114	5	0	0	4	0	1
115	5	0	0	0	1	4
116	5	0	0	4	0	1
117	5	0	0	0	3	2
118	5	0	0	4	0	1
119	5	0	0	0	1	4
120	5	0	0	4	0	1
121	5	0	0	0	2	3
122	5	0	0	0	0	5
123	5	0	0	0	1	4
124	5	0	0	4	0	1
125	5	0	0	0	1	4
126	4	1	0	0	1	4
127	5	0	0	4	0	1
128	5	0	0	0	1	4
129	5	0	0	0	1	4
130	5	0	0	4	0	1
TOTALS	140	6	4	52	16	80
Mean Item Response	4.6	.2	.1	1.7	.5	2.6

BJECTIVES ASSESSED:	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
STION # 1	0	0	0	0	3	1	0	0	1	0	0
STION # 2	0	0	0	0	0	1	0	0	2	1	1

by the two tests were: graphing parabolas (vertex, axis of symmetry, and maximum-minimum), absolute value inequalities, solving systems of equations using matrices (Gaussian elimination) and determinants (Cramer's rule), remainder and factor theorems, synthetic division, and rational roots theorem. In general, the Intermediate Algebra Skills and the Functions & Graphs tests assess more than 70% of the objectives of 80% of these courses. It also should be noted that each of the Cluster C items covering trigonometric functions were judged by only one respondent as representing important objectives.

Calculus Courses

Calculus was chosen by 14 faculty members as the term that best described their courses. Thirteen courses were described as regular while one was reported to be an advanced or honors course. In regard to prerequisites, three respondents reported two years of high school algebra or its equivalent and seven reported at least ten weeks of trigonometry as prerequisite. Four chose the other category and specified as follows: two faculty reported 2 years of high school algebra plus other courses such as 1 year of geometry, 1/2 year of trigonometry, and a course on functions and graphs, and analytic geometry; one respondent reported that elementary analysis is prerequisite to the course; one reported that a strong background in high school mathematics was required.

Eight faculty members reported that their students were advised to enroll in their courses and six indicated that their courses were required. Since there is no calculus test in the DTMS, calculus faculty were instructed to respond only to the Functions & Graphs test. Only the items on importance as a prerequisite were appropriate, hence they are the only items evaluated here.

Functions & Graphs Test: Prerequisite ratings. Generally, the items of the Functions & Graphs test were not overwhelmingly rated as prerequisites of the 14 calculus courses. (See Table 8.10.) The mean item response for the three levels of prerequisite were: very important as a prerequisite--5.5; moderately important as a prerequisite--5.1; and unimportant as a prerequisite--3.3. Although no item was rated as unimportant by more than half of the respondents, only five items were rated as very important by more than half of the respondents. All five of these important prerequisites were in Cluster A (8 items on algebraic functions). Thus, the items in Cluster B (9 items on exponential and logarithmic functions) and Cluster C (13 items on trigonometric functions) were not seen as particularly important prerequisites.

Summary

In general, faculty members rated the items on the DTMS tests as fairly representative of the key concepts in their courses. However, in certain individual cases there were significant discrepancies between course content and test coverage. Content validity for any particular

Table 8.10

Calculus Courses

Functions & Graphs Test

TEST # 4 -- 4-YEAR SCHOOLS (N= 14)

ITEM #	PREREQUISITES U	MI	VI	OBJECTIVES	MI	VI
101	1	7	6		5	2
102	4	4	6	8	2	1
103	1	4	9	8	3	1
104	4	3	7	8	2	1
105	0	2	12	6	1	5
106	0	3	11	6	2	4
107	5	5	4	8	2	1
108	2	5	7	3	6	3
109	5	5	4	8	2	1
110	4	5	5	9	1	1
111	0	4	10	7	2	3
112	6	3	5	9	0	2
113	2	7	5	4	6	2
114	5	5	4	9	0	2
115	2	10	2	4	5	3
116	5	7	2	8	1	2
117	4	9	1	7	3	2
118	5	4	5	8	1	2
119	4	8	2	6	3	3
120	4	3	7	8	1	2
121	4	7	3	5	4	3
122	2	4	8	5	1	6
123	4	9	1	4	5	3
124	5	3	6	9	1	1
125	3	4	7	7	2	3
126	2	5	7	4	4	4
127	5	3	6	7	2	1
128	3	4	7	2	6	4
129	4	6	4	2	7	3

9. Summary

The Descriptive Tests of Mathematics Skills (DTMS) is a group of four tests (Arithmetic Skills, Elementary Algebra Skills, Intermediate Algebra Skills, and Functions & Graphs) that was designed to help colleges place each admitted student in the appropriate mathematics course. The purpose of the study was to determine whether the DTMS tests possess characteristics that are generally desirable for tests used to make such placement decisions.

For this project, the DTMS tests were administered in freshman level mathematics courses at 36 institutions that represented a broad spectrum of two-year and four-year colleges. At some colleges, the tests were administered only at the beginning of the semester; in other colleges, they were administered both at the beginning and the end of the semester.

Results from a number of different kinds of analyses indicated that the DTMS tests are potentially very useful in helping to make placement decisions.

(1) Gain Analysis--If a test is accurately targeted to the content of a course (and assuming instruction in that course

(2) Concurrent Validity--In a sequence of courses where Course X is a prerequisite to Course Y, a placement test should be able to show when a student has mastered the content of Course X and is therefore ready to go directly to Course Y. Demonstration of mastery of course content, as indicated by grades in the course, was highly related to scores on the DTMS tests administered at the end of the course.

(3) Predictive Validity--It is often useful to know how well a placement test given at the beginning of the semester predicts success in a course, as indicated by end of semester grades. The DTMS tests were generally very good at making these predictions. For most courses, correlation coefficients were in the .40s and .50s. Better predictions were possible from DTMS scores than from high school algebra grades, and for remedial level courses, better predictions were possible from the DTMS tests than from the mathematical section of the Scholastic Aptitude Test.

(4) Relationship to Student Perception of Course Difficulty--Students who thought their math courses were easy generally had high DTMS scores, and students who thought the courses

on the placement test might do better in the advanced course if they first take a less advanced course. When the above conditions are met, there is a trait-treatment interaction. For the current report, a trait-treatment interaction study was attempted at only one institution. In the precalculus-calculus sequence at that college, there was a significant interaction suggesting that the DTMS tests could be a valuable tool for placing students in that course sequence.

(6) Content Analysis--College faculty members in the participating institutions rated the DTMS items as providing generally good coverage of the key concepts of their courses.

The data presented in this report provide promising preliminary evidence for the potential value of the DTMS tests for making college placement decisions. However, more research is clearly needed as colleges begin to make actual placement decisions with DTMS scores. It is only through the accumulation of evidence basd on these experiences that the true value and limitations of the DTMS can be determined.

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APPENDIX A

Descriptions of Participating Institutions
Grouped by Region of the Country

Region: New England

College Code	Description of Institution	Location	Selection Ratio	Admissions Information
AA	two-year public technical college for men and women	small city	.80	
BB	two-year public technical college for men and women	small city	.39	
CC	two-year public technical college for men and women	rural community	.77	
DD	two-year public community college for men and women	small city	.36	
EE	two-year public college for men and women	small city		
FF	two-year public technical college for men and women	suburban community	.37	
A	four-year public college for men and women	suburban community		SAT

Region: Middle States

College Code	Description of Institution	Location	Selection Ratio	Admissions Information
B	four-year public college for men and women	small town	.68	SAT (V: 410-500; Q: 440-550) - interview recommended
C	four-year public liberal arts college for men and women	suburban community	.56	open admissions for state residents SAT for placement
D	four-year public college for men and women	large city		
E	four-year public liberal arts college for men and women	small town	.65	SAT (V: 350-500; Q: 350-550)
F	four-year public liberal arts college for men and women	large town	.89	SAT
G	four-year private liberal arts college for men and women (church affiliated)	large town	.86	SAT (preferred; V: 425; Q: 440) or ACT

Region: Midwestern

College Code	Description of Institution	Location	Selection Ratio	Admissions Information
GG	two-year public community college for men and women	suburban community	1.00	open admissions - no minimum GPA - ACT used for counseling/placement
H	four-year public university for men and women	rural community	.70	ACT composite 21 or better for state residents - SAT for out-of-state residents (also top 50% of high school class for state residents)
I	four-year private university for men and women (church affiliated)	metropolitan area	.75	SAT or ACT required
J	four-year public college of arts and sciences for men and women	metropolitan area	.68	ACT composite 23 or better - top 50% of high school class
K	four-year public university for men and women	small city	.64	ACT composite 17 or better for top 50% - ACT composite 22 or better for lower 50%
HH	two-year public college for men and women			
L	four-year public university for men and women	small city	.82	ACT
M	four-year public university for men and women	suburban community	.86	ACT
N	four-year private university for men and women (church affiliated)	metropolitan area	.85	ACT or SAT

Region: Southern

College Code	Description of Institution	Location	Selection Ratio	Admissions Information
II	two-year private junior college for men and women (church affiliated)	small town	.93	SAT (preferred; V: 400-500; Q: 400-550) or ACT
JJ	two-year public community college for men and women	suburban community	1.00	open admissions - SAT (preferred) or ACT for placement
O	four-year public university for men and women	small city	.70	SAT (V: 370-480; Q: 400-510)
P	four-year public liberal arts and teachers college for men and women	suburban community	.90	SAT
Q	four-year public liberal arts college for men and women	small town	.88	open admissions - SAT for placement
KK	two-year public community college for men and women	rural community	1.00	open admissions
R	four-year public university for men and women	rural community	.78	SAT (V: 350-500; Q: 350-500)

Region: Southwestern

College Code	Description of Institution	Location	Selection Ratio	Admissions Information
LL	two-year public community college for men and women	suburban community		open admissions
MM	two-year public community college for men and women	suburban community		open admissions
NN	two-year public community college for men and women	suburban community		open admissions

Region: Western

College Code	Description of Institution	Location	Selection Ratio	Admissions Information
S	four-year public university for men and women	small city	.97	open admissions - SAT or ACT (preferred; ACT composite 15-23) for placement/counseling
OO	two-year public community college for men and women	suburban community		open admissions - TOEFL and Michigan Proficiency Test for foreign students
T	four-year private university for men and women	metropolitan area	.69	SAT - ACT
U	four-year public liberal arts, technical, business, and teachers college for men and women	metropolitan area	.99	ACT

APPENDIX B

Content Analysis Questionnaire

This questionnaire was completed by faculty respondents. A discussion of their responses is in Section 8--Content Validity--of this report.

CONTENT ANALYSIS

OF THE DESCRIPTIVE TESTS OF MATHEMATICS SKILLS

Thank you in advance for your assistance in completing this analysis of the content of the Descriptive Tests of Mathematics Skills (DTMS). This is one of the key elements in the validation of the DTMS that is being conducted by Educational Testing Service for the College Board. The information you provide will be extremely valuable in helping us to determine the relevance of DTMS content for particular courses.

Please do not be misled by the apparent length of this form. It contains space to evaluate all four of the DTMS tests, but you will be asked to fill out only those parts that pertain to the one or two tests that are most relevant to your course.

You should fill out one of these forms for each mathematics course that you teach that is open to beginning freshmen. As soon as you have completed the form, please mail it back in the return envelope provided.

If you have any questions please feel free to call collect.

Brent Bridgeman
Research Psychologist
Educational Testing Service
(609) 921-9000 EXT 2542

Name of Institution ______________________________

Your Name (Optional) ______________________________

Course No. ____________________ Course Title ____________________

For the following questions, please indicate your choice by drawing a circle around the appropriate number.

1. Which term best describes your course?
   - 01 Arithmetic
   - 02 Business Math
   - 03 Math for Elementary School Teachers
   - 04 Elementary Algebra
   - 05 Geometry (excluding Analytic Geometry)
   - 06 Intermediate Algebra
   - 07 Fundamental Concepts (Sets, Logic, Real number systems, Probability, and Statistics)
   - 08 College Algebra
   - 09 Trigonometry (as a separate course only, not as part of an algebra course)
   - 10 Elementary Functions
   - 11 Analytic Geometry (as a separate course)
   - 12 Calculus
   - 13 Other (Specify) ______________________________

2. Which term best describes the level of your course?
   - 01 Remedial, compensatory, or developmental
   - 02 Advanced or honors
   - 03 Regular

3. Which statement best describes the prerequisites for your course?
   - 01 None
   - 02 One year of high school algebra (or equivalent)
   - 03 Two years of high school algebra (or equivalent)
   - 04 At least 10 weeks of trigonometry
   - 05 Other (Specify) ______________________________

4. Briefly describe how students are placed into your course. If scores from nationwide testing programs (e.g., SAT, ACT, CGP) are used, please indicate the cut-off score employed.

5. Are students required to enroll in prescribed courses on the basis of the placement decision, or are students simply advised to enroll with the ultimate decision left to the student.

1 Required 2 Advised

6. Quickly scan the four tests in the accompanying booklet to identify the test or two tests that most nearly match the content of your course. For example, if you are teaching a remedial arithmetic course you might select only Test 1 (Arithmetic Skills), but for a college algebra course, you might select Tests 3 (Intermediate Algebra Skills) and 4 (Functions and Graphs). Since there is no calculus test in the DTMS, calculus instructors should select Test 4 (Functions and Graphs).

Circle the number for the description of the test or tests you have selected as most nearly matching the content of your course.

1 Test 1 (Arithmetic Skills)
2 Tests 1 and 2 (Arithmetic Skills and Elementary Algebra Skills)
3 Test 2 (Elementary Algebra Skills)
4 Tests 2 and 3 (Elementary Algebra Skills and Intermediate Algebra Skills)
5 Test 3 (Intermediate Algebra Skills)
6 Tests 3 and 4 (Intermediate Algebra Skills and Functions and Graphs)
7 Test 4 (Functions and Graphs)

In the next section you are asked to make three judgements about each item in the test or tests you selected above. First, you are asked to make a judgement about the importance of the skill assessed by the item as a prerequisite for your course, i.e., how important it is for the student to possess that skill before beginning your course. Next, you are asked how important the skill is as an objective of your course, i.e., how important it is for the student to have attained the skill by the end of your course. Finally, you are asked to make a rough judgement of the amount of class time (in minutes) that is spent on the skill assessed by the item. At the end of each test you are asked to make a global judgement of the percentage of important course objectives assessed by the test as a whole. Please complete the pages for the tests you indicated in item 6, and leave the other pages blank.

TEST 1 ARITHMETIC SKILLS

Circle the number of the response you choose.

	Importance as a PREREQUISITE			Importance as an OBJECTIVE			Number of minutes of class time spent on this skill
Number	Very Important	Moderately Important	Relatively Unimportant	Very Important	Moderately Important	Relatively Unimportant	
1	3	2	1	3	2	1	________
2	3	2	1	3	2	1	________
3	3	2	1	3	2	1	________
4	3	2	1	3	2	1	________
5	3	2	1	3	2	1	________
6	3	2	1	3	2	1	________
7	3	2	1	3	2	1	________
8	3	2	1	3	2	1	________
9	3	2	1	3	2	1	________
10	3	2	1	3	2	1	________
11	3	2	1	3	2	1	________
12	3	2	1	3	2	1	________
13	3	2	1	3	2	1	________
14	3	2	1	3	2	1	________
15	3	2	1	3	2	1	________
16	3	2	1	3	2	1	________
17	3	2	1	3	2	1	________
18	3	2	1	3	2	1	________

Item Number	Importance as PREREQUISITE: Very Important	Moderately Important	Relatively Unimportant	Importance as an OBJECTIVE: Very Important	Moderately Important	Relatively Unimportant	Number of minutes of class time spent on this skill
19	3	2	1	3	2	1	________
20	3	2	1	3	2	1	________
21	3	2	1	3	2	1	________
22	3	2	1	3	2	1	________
23	3	2	1	3	2	1	________
24	3	2	1	3	2	1	________
25	3	2	1	3	2	1	________
26	3	2	1	3	2	1	________
27	3	2	1	3	2	1	________
28	3	2	1	3	2	1	________
29	3	2	1	3	2	1	________
30	3	2	1	3	2	1	________
31	3	2	1	3	2	1	________
32	3	2	1	3	2	1	________
33	3	2	1	3	2	1	________
34	3	2	1	3	2	1	________
35	3	2	1	3	2	1	________

On the whole, what percentage of the important objectives of your course are assessed by this Arithmetic Skills Test? _____% Please specify on the bottom of this page any important course objectives that were not assessed by this test; if you also have selected the Elementary Algebra Skills test as relevant to your course, leave the bottom of this page blank.

TEST 2 ELEMENTARY ALGEBRA SKILLS

Circle the number of the response you choose.

Item Number	Importance as a PREREQUISITE: Very Important	Moderately Important	Relatively Unimportant	Importance as an OBJECTIVE: Very Important	Moderately Important	Relatively Unimportant	Number of minutes of class time spent on this skill
36	3	2	1	3	2	1	______
37	3	2	1	3	2	1	______
38	3	2	1	3	2	1	______
39	3	2	1	3	2	1	______
40	3	2	1	3	2	1	______
41	3	2	1	3	2	1	______
42	3	2	1	3	2	1	______
43	3	2	1	3	2	1	______
44	3	2	1	3	2	1	______
45	3	2	1	3	2	1	______
46	3	2	1	3	2	1	______
47	3	2	1	3	2	1	______
48	3	2	1	3	2	1	______
49	3	2	1	3	2	1	______
50	3	2	1	3	2	1	______
51	3	2	1	3	2	1	______

Item Number	Importance as a PREREQUISITE: Very Important	Moderately Important	Relatively Unimportant	Importance as an OBJECTIVE: Very Important	Moderately Important	Relatively Unimportant	Number of minutes of class time spent on this skill
52	3	2	1	3	2	1	______
53	3	2	1	3	2	1	______
54	3	2	1	3	2	1	______
55	3	2	1	3	2	1	______
56	3	2	1	3	2	1	______
57	3	2	1	3	2	1	______
58	3	2	1	3	2	1	______
59	3	2	1	3	2	1	______
60	3	2	1	3	2	1	______
61	3	2	1	3	2	1	______
62	3	2	1	3	2	1	______
63	3	2	1	3	2	1	______
64	3	2	1	3	2	1	______
65	3	2	1	3	2	1	______
66	3	2	1	3	2	1	______
67	3	2	1	3	2	1	______
68	3	2	1	3	2	1	______
69	3	2	1	3	2	1	______
70	3	2	1	3	2	1	______

On the whole, what percentage of the important objectives for your course are assessed by this Elementary Algebra Skills Test? ________%

If you also selected Test 1 (Arithmetic Skills) as relevant to your course, what percentage of the objectives for your course are assessed by Tests 1 and 2 combined? ________ %

Please specify on the bottom of this page any important course objectives that were not assessed by this test (or, if appropriate, by this test and Test 1); if you also have selected the Intermediate Algebra Skills Test as relevant to your course, leave the bottom of this page blank.

TEST 3 INTERMEDIATE ALGEBRA SKILLS

Item Number	Importance as a PREREQUISITE: Very Important	Moderately Important	Relatively Unimportant	Importance as an OBJECTIVE: Very Important	Moderately Important	Relatively Unimportant	Number of minutes of class time spent on this skill
71	3	2	1	3	2	1	________
72	3	2	1	3	2	1	________
73	3	2	1	3	2	1	________
74	3	2	1	3	2	1	________
75	3	2	1	3	2	1	________
76	3	2	1	3	2	1	________
77	3	2	1	3	2	1	________
78	3	2	1	3	2	1	________
79	3	2	1	3	2	1	________
80	3	2	1	3	2	1	________
81	3	2	1	3	2	1	________
82	3	2	1	3	2	1	________
83	3	2	1	3	2	1	________
84	3	2	1	3	2	1	________
85	3	2	1	3	2	1	________
86	3	2	1	3	2	1	________
87	3	2	1	3	2	1	________
88	3	2	1	3	2	1	________
89	3	2	1	3	2	1	________
90	3	2	1	3	2	1	________

Item Number	Importance as a PREREQUISITE: Very Important	Moderately Important	Relatively Unimportant	Importance as an OBJECTIVE: Very Important	Moderately Important	Relatively Unimportant	Number of minutes of class time spent on this skill
91	3	2	1	3	2	1	______
92	3	2	1	3	2	1	______
93	3	2	1	3	2	1	______
94	3	2	1	3	2	1	______
95	3	2	1	3	2	1	______
96	3	2	1	3	2	1	______
97	3	2	1	3	2	1	______
98	3	2	1	3	2	1	______
99	3	2	1	3	2	1	______
100	3	2	1	3	2	1	______

On the whole, what percentage of the important objectives of your course are assessed by this Intermediate Algebra Skills Test? _______%

If you also selected Test 2 (Elementary Algebra Skills) as relevant to your course, what percentage of the objectives for your course are assessed by Tests 2 and 3 combined? _______%

Please specify on the bottom of this page any important course objectives that were not assessed by this test (or, if appropriate, by this test and Test 2); if you also have selected the Functions and Graphs test as relevant to your course, leave the bottom of this page blank.

TEST 4 FUNCTIONS AND GRAPHS

Circle the number of the response you choose.

Item Number	Importance as a PREREQUISITE: Very Important	Moderately Important	Relatively Unimportant	Importance as an OBJECTIVE: Very Important	Moderately Important	Relatively Unimportant	Number of minutes of class time spent on this skill
101	3	2	1	3	2	1	______
102	3	2	1	3	2	1	______
103	3	2	1	3	2	1	______
104	3	2	1	3	2	1	______
105	3	2	1	3	2	1	______
106	3	2	1	3	2	1	______
107	3	2	1	3	2	1	______
108	3	2	1	3	2	1	______
109	3	2	1	3	2	1	______
110	3	2	1	3	2	1	______
111	3	2	1	3	2	1	______
112	3	2	1	3	2	1	______
113	3	2	1	3	2	1	______
114	3	2	1	3	2	1	______
115	3	2	1	3	2	1	______
116	3	2	1	3	2	1	______
117	3	2	1	3	2	1	______
118	3	2	1	3	2	1	______
119	3	2	1	3	2	1	______
120	3	2	1	3	2	1	______

Item Number	PREREQUISITE: Very Important	PREREQUISITE: Moderately Important	PREREQUISITE: Relatively Unimportant	OBJECTIVE: Very Important	OBJECTIVE: Moderately Important	OBJECTIVE: Relatively Unimportant	Number of minutes of class time spent on this skill
121	3	2	1	3	2	1	______
122	3	2	1	3	2	1	______
123	3	2	1	3	2	1	______
124	3	2	1	3	2	1	______
125	3	2	1	3	2	1	______
126	3	2	1	3	2	1	______
127	3	2	1	3	2	1	______
128	3	2	1	3	2	1	______
129	3	2	1	3	2	1	______
130	3	2	1	3	2	1	______

On the whole, what percentage of the important objectives of your course are assessed by this Functions and Graphs Test? ______%

If you also selected Test 3 (Intermediate Algebra) as relevant to your course, what percentage of the objectives for your course are assessed by Tests 3 and 4 combined? ______%

Please specify on the bottom of this page any important course objectives that were not assessed by this test (or, if appropriate, by this test and Test 3). If you are teaching a calculus course, leave the bottom of the page blank.