The Descriptive Tests of Mathematical Skills: Predictive Validity for a College Algebra Course for a Population of African-American Males

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ABSTRACT

THE DESCRIPTIVE TESTS OF MATHEMATICAL SKILLS: PREDICTIVE VALIDITY FOR A COLLEGE ALGEBRA COURSE FOR A POPULATION OF AFRICAN-AMERICAN MALES

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This study investigated the predictive validity of the Descriptive Tests of Mathematical Skills (DTMS) Elementary Algebra Skills (EAS) test for a college algebra course in a population composed almost exclusively of African-American males (large sample size) using regression analysis. A moderate psychometric index was found between score earned on the EAS and first attempt grade earned in College Algebra. Further, a significant difference was found in the mean earned grade in the Algebra course between those who failed and those who passed the EAS using a cut score of 24.5 out of 35. The evidence found in this study adds to the body of evidence on the predictive power of the EAS of the DTMS as a tool in minimum competency testing. The evidence serves to support the use of the EAS of the DTMS as a placement tool at historically black colleges or universities.

INTRODUCTION

The Descriptive Tests of Mathematical Skills (DTMS) of the College (Educational Testing Service, 1979; revised, 1988) includes four tests: Basic Arithmetic Skills (BAS), Elementary Algebra Skills (EAS), Intermediate Algebra Skills (IAS), and Calculus Readiness: Functions and Graphs (CR). Each is in a four-choice multiple choice format, and the maximum testing time for each is 30 minutes. The BAS and EAS tests are 35-item tests. The IAS and CR are 30-item tests. These tests can be used separately or in any combination to conduct minimum mathematics competency placement of students for many types of courses including, but not limited to, freshman level mathematics courses.

The purpose of the study was to add to the body of evidence regarding the validity of the DTMS as a tool used to place students in a mathematics course using a large sample. This study investigated the relationship between students' scores earned on the EAS of the DTMS and their grades earned in a College Algebra course at four year, private, liberal arts, and historically black college in the South (hereafter referred to as 'Liberal College') in an attempt to estimate the predictive validity of the Elementary Algebra Skills (EAS) portion of the Descriptive Tests of Mathematical Skills (DTMS) of the College Board and grades earned in the College Algebra course. The student body at Liberal College was all male of which approximately 97.359%[1] were African-American. The overall enrollment at the college was approximately 2,500 students.

There is little research regarding the use of the DTMS in minimum competency placement testing programmes designed to validate the mathematical skills of entering freshmen students into college. Many of the instruments used for measuring mathematical skills of the

[1] Note: all constants reported are precise to two significant figures.

entering freshmen are locally developed, but a few are standardised tests (one of which is the Elementary Algebra Skills (EAS) test of the Descriptive Tests of Mathematical Skills (DTMS)).

Prior researchers estimated the predictive validity of the Elementary Algebra Skills (EAS) test of the DTMS, other tests of the DTMS, or combinations of the aforementioned. For example, Bridgeman (1980) found the DTMS was "predictive of end of course grades when administered at the beginning of the course" (page 82) . Correlation between the score earned on the EAS and grade in a college algebra course ranged from a low of .30 to a high of .58 for 10 colleges or university with sample sizes ranging from 16 to 99 subjects. Bridgeman (1982) compared the validity of the EAS and IAS to the Scholastic Aptitude Test - Mathematics (SAT-M) and found the EAS or IAS a better predictor of performance for a remedial algebra course than the SAT-M, whereas the EAS, IAS, and SAT-M performed about equally well for predicting performance in a calculus course. He found a psychometric indices of .46 and .47 between the grade earned in an Elementary Algebra course and the score earned on the EAS based on 73 subjects at a small private 2-year college and on 198 subjects at a large public 4-year college, respectively. Suddick and Collins (1985) found a test-retest reliability coefficient of .72 for the EAS of the DTMS for older, adult transfer students using a small sample. Suddick and Collins (1982) also investigated the predictive validity of the EAS and IAS for grades earned in a calculus or statistics course for older upper division students. They found that students who passed either the EAS or IAS performed significantly better than did those who failed the DTMS, were remediated, and then earned a grade in either the statistics or calculus course. Suddick and Collins (1984) further investigated the predictive validity of the EAS for grades earned in a calculus course for older Master's level students. Suddick and Vaccarro (1983) discussed the issues involved in minimum competency testing using the BAS for business

students. Dwinell (1985) investigated the predictive validity of the BAS and EAS to estimate exit from a remedial mathematics course for students who earned failing scores on the Basic Skills Examination - Mathematics test and found the EAS contributed the "most variance to an estimate of prediction of exit from [remedial] math courses" (page 12).

Nonetheless, all of the aforementioned research reports used the original version of the DTMS as an instrument. The DTMS was revised in 1988, and very little research exists that investigated the predictive validity of the revised DTMS. Meyer, Woodard, and Suddick (1994) investigated the predictive validity of the BAS and EAS (revised DTMS) for grades earned in an advanced mathematics concepts and structure course for upper-division elementary education students and found a moderate predictive validity coefficient (R = .49) using a small sample.

Notwithstanding, all of the studies heretofore mentioned have been conducted at colleges or universities that are not analogous Liberal College where the data was collected in this study. In addition, some of the studies did not account for a percentage of African-Americans in the sample, while others had over 90% White subjects; ergo, the possibility exists that the predictive models from those studies may not generalise to the population studied in this project. Notwithstanding, this research assumes that the studies previously noted are valid and, therefore, the research question in this study includes whether or not the models from previous studies of the EAS of the DTMS are comparable to the model generated in this study.

SUBJECTS

The subjects were a subset of the set of entering freshmen at Liberal College in the Fall of 1994. Approximately 98.011% of the entering freshmen of the class of 1994 were United States citizens, with the remainder from the Caribbean, Africa, or Asia. The placement testing policy at Liberal College requires all entering freshmen to take three DTMS tests : EAS, IAS, and CR. Cut scores for the three DTMS tests were as follows: 24.5 for the EAS, 21 for the IAS, and 21 for the CR Ergo, a student who selects 24 correct answers or less on the EAS is required to enroll in a 0 semestre credit hour remedial mathematics course (which is a review of high school algebra). The student is required to earn a "C" or better in the course in order to enroll in College Algebra. A student who selects 25 correct answers or more is permitted to enroll in College Algebra. Further, if a student selects 20 correct answers or less on the IAS, then he is required to enroll in College Algebra, but a student who selects 21 correct answers or more on the IAS is permitted to enroll in Pre-calculus, and if he selects 21 correct answers or more on the CR test, he is permitted to enroll in Calculus I.

Hence, the subjects of the study are the subset (n= 412) of the entering freshmen (N=605) who entered Liberal College in the Fall of 1994. All 605 entering freshmen took the three DTMS tests : EAS, IAS, and CR and the 412 subjects of this study were those who failed the IAS and CR; thus, were placed in either the remedial course or in College Algebra. The focus of this study is restricted to those 412 Liberal College students' performance on only the Elementary Algebra Skills (EAS) test of the DTMS and the grade the students earned on their first attempt at passing College Algebra.

METHOD

A small pilot study (n = 47) was conducted in the Spring of 1997 using scores earned on the EAS of the DTMS and grade earned in College Algebra from Fall 1993 through Fall of 1994 for a random sample of entering freshmen in the Fall of 1993 to 1) determine an adequate period of grade records needed to ensure that enough time was allowed for those who placed in the remedial mathematics course to successfully compleat the course and be able to attempt to earn a grade in College Algebra (to be discussed in the next paragraph); and, 2) test underlying statistical assumptions (normally independent distribution, underlying continuity, linearity, and homoscedasity) for conducting a regression analysis. The underlying assumptions were found to be tenable based on the results of the pilot study.

A record of performance on the EAS of the DTMS for the 412 subjects was obtained. The scores earned were integer values from 0 to 38, inclusive, but were considered continuous for the study. Also, mathematics departmental records of grades earned by students in College Algebra at Liberal College for the period of Fall 1994 through Spring 1996, inclusive, was used. The grade records period of Fall 1994 through Spring 1996 was used because by using the these parametres maximisation of the number of subjects in the study was possible. Some students defer enrolling in their mathematics courses at the college for well over a year, therefore, 1994 - 1996 covers a reasonable time for entering College Algebra and earning a grade and yet restricts the time for entering College Algebra so that the predictive power of the EAS of the DTMS was not compromised.

The grade earned in College Algebra is based on the 4-point plus - minus scale. The grade was considered a continuous variable. Only the grade a subject earned on his first attempt

in College Algebra was recorded . The definition of earned grade used in this study was an "A" (4.0) to an "F" (0.0). The grades "W," "WP," and "WF" which signify withdrawal, withdrawal passing, and withdrawal failing, respectively, were not considered as an earned grade in the course. Thus, if a "W" was assigned for subject X, for example, in the Fall of 1994, but he earned a "D" in the Spring of 1995, then a 1.0 (the numeric equivalent for a "D") was recorded for Subject X. The grades were recorded twice independently, then the two files were compared with the departmental records, and a final data set was thus produced.

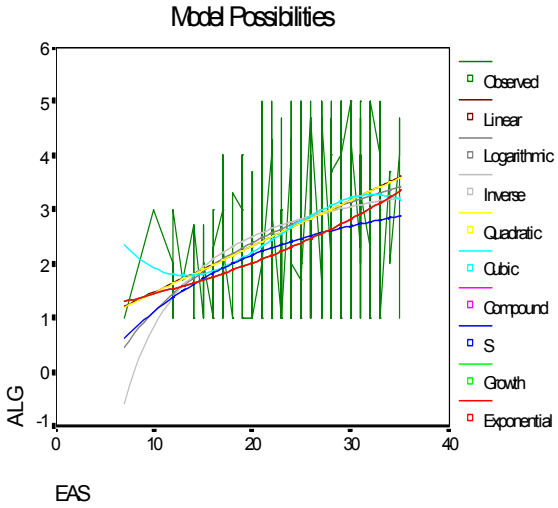
Regression analysis using dummy coding was performed to ascertain the validity of the placement model using the EAS of the DTMS for this population. The grades earned in College Algebra were assumed independent. Residual analyses were performed which confirmed the tenability of the assumptions necessary for inference in regression analysis; namely, that the dependent variable, grade earned in the College Algebra course, was normally distributed, the relationship between the independent and dependent variables was linear, and that there was homogeneity of variances.

RESULTS

By the Spring of 1996, of the 412 subjects originally considered there were 353 subjects who earned a grade in College Algebra. KR20 reliability of the EAS instrument was .8638. Different models were considered (linear, quadratic, exponential, etc.) using the score earned on the EAS as the independent variable and the grade earned in College Algebra on the first attempt. The linear model was found to be the best model because: 1) the models differed only slightly (see graph 1), 2) the linear model is parsimonious, and 3) analysis of partial

regression plots uncovered no trend in the data which caused the linear model to need to be excluded.

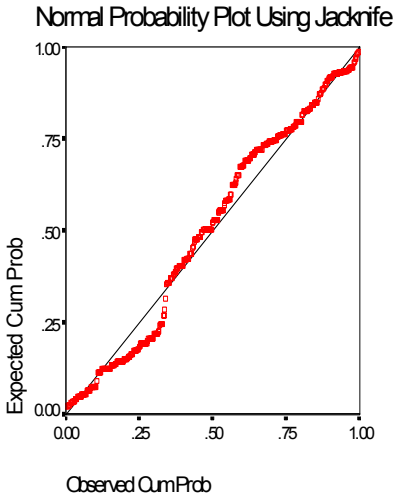
Graph 1



Let ALG denote the grade earned in the College Algebra course. Let EAS denote the score earned on the EAS. Let LEV denote the binary variable "0" if the subject earned a 24 or less score on the EAS and "1" if the subject earned a 25 or more score on the EAS. Let INT denote the interaction term LEV*E. The final model was ALG = .229 + .050EAS - .517LEV + .031INT + error. The predictive validity coefficient was .332 (df = 3, 349; p <.001). The mean grade earned in College Algebra between levels differed significantly; the mean for level 0 was 1.231 (approximately a "D+") and the mean for level 1 was 2.008 (approximately a "C").

Further, the assumption of normality was tenable because the normal probability plot using jackknife residuals for a linear model fitted to the data showed no obvious deviation from normalcy (see graph 2). The assumption of homogeneity of variances was tenable because analysis of predicted-A versus the jackknife residual showed no blatant departure from the assumption.

Graph 2



The reliability of the model was investigated using a random sample of 1995 entering freshmen data. The bootstrap and. circular systemic sampling was used to draw a sample of 67 elements. The researcher applied the ALG = .229 + .050EAS - .517LEV + .031INT model to the data, produced estimates for ALG, then computed the correlation between ALG and estimated ALG . The resulting correlation was .353, therefore shrinkage was .021 or 6.325%.

DISCUSSION

Students having the prerequisite minimum competency skills in mathematics as measured by the EAS of the DTMS did have a significantly higher average level of performance in College Algebra (2.008) than did the students who did not have the prerequisite minimum competency skills in mathematics as measured by the EAS of the DTMS and were successfully remediated (1.231). This difference between the grades earned in College Algebra between the levels was practically significant.

The implication of the above result suggests that use of the EAS of the DTMS to identify students with deficient skills for College Algebra is viable so that appropriate remediation can be effected for said students. Furthermore, for the group who were placed in the remedial course, the correlation between the grade earned in the remedial algebra course and grade earned in the College algebra course was .468 ($p < .01$). This significant moderate correlation suggests that appropriate remediation is helpful for the students who enter the college with deficient skills.

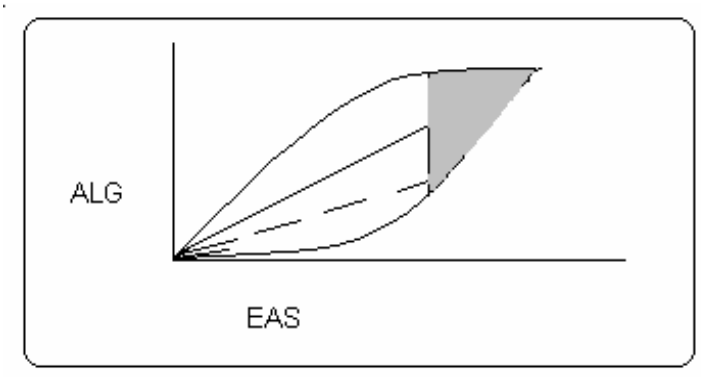
Recall there were 605 freshmen who entered Liberal College in the Fall of 1994 and 412 subjects who failed the IAS or CR and, thus, were part of the sample used in this study. Also, recall LEV denotes the binary variable "0" if the subject earned a 24 or less score on the EAS and "1" if the subject earned a 25 or more score on the EAS. There were 188 subjects in LEV 0 and 224 in LEV 1. The mean score earned on the EAS for the 412 subjects was 24.23, with a standard deviation of 5.42.

There were 353 subjects who earned a grade in College Algebra - - 139 subjects in LEV 0 and 214 in LEV 1. Therefore, fifty-nine subjects took the EAS but did not earn a grade in the College Algebra course; 10 of who passed the EAS and 49 of whom did not. Of the 10 who had passed, three appealed their placement (they had earned a 24 on the EAS, but had passed the IAS or CR) and were placed in a higher course. The mean score on the EAS for the 7 who had passed the EAS (LEV 1), but had not entered a mathematics class by the Spring of 1996 was 27.571. The mean score on the EAS for LEV 1 was 28.28 with a standard deviation of 2.48. Thus, the group who deferred taking the College Algebra scored on average slightly lower than the overall group who passed the EAS.

Of the 49 who had not passed the EAS, 4 subjects had not enrolled in the remedial math course from Fall, 1994 through Spring, 1996; the mean performance on the EAS for these 4 subjects was 16.750. Thirty-six subjects had enrolled in the remedial math course, but failed it on the first attempt and were still attempting to either pass the remedial math course or had passed it but had not earned a grade in the College algebra course from Fall, 1994 through Spring, 1996; the mean performance on the EAS for these 36 subjects was 18.333. Nine subjects passed the remedial course on the first attempt, but had not earned a grade in the College Algebra course from Fall, 1994 through Spring, 1996; the mean performance on the EAS for these 9 subjects was 18.222. The overall mean performance on the EAS for the group who did not pass the EAS was 19.41 with a standard deviation of 3.78. Thus, the group who deferred taking the remedial math course or who deferred taking the College Algebra course after passing the remedial course earned scores on the EAS that were on average lower than the overall group who failed the EAS.

The sample was restricted to the 412 of 605 freshmen because the subjects who passed the IAS or CR were exempted from the College Algebra course, and therefore placed in either Pre-calculus or Calculus. All of those who passed the IAS or CR had passed the EAS, thus the a truncation occurred that was from the upper part of the population (see figure 1).

Figure 1



The truncation effected two of the assumptions necessary for inferences from the regression. It did not effect the assumption of homogeneity of variance - - the variance of ALG was stable across EAS, LEV, and INT. It did effect the assumption of normality - - there was a positive skew to the distribution of grades earned in College Algebra. However, since regression analysis is robust to mild violations of the normality assumption, the assumption of normality was tenable. The truncation had an effect on the assumption of linearity and on the strength of the relationship between the score earned on the EAS and the grade earned in College Algebra. This truncation had the effect of lowering the estimate of R found in the study.

Nonetheless, given this limitation, the moderate psychometric index (R = .332) for the EAS of the DTMS predicting the grade earned in a College Algebra course found in the study seems to add evidence to support the use of the EAS of the DTMS as a placement tool for a College Algebra course for a population of African-American males. Further, this psychometric index is within the range found by Bridgeman (1980) for the EAS and grade in College Algebra for the previous version of the DTMS.

The effect of the truncation is clear if the sample were to include those freshmen who passed the EAS and either the IAS or CR, thus who were placed in a higher course, but chose to take College Algebra before attempting either Pre-Calculus of Calculus I. Thirty-two such subjects exist, and when they are included in the study (all assigned to LEV 1), the predictive validity coefficient rises from .332 to .355 ($df = 3,381$. $p < .001$). The model in this instance is ALG = .044 + .058EAS + 1.247LEV - .031INT.

Moreover, if those who passed either the IAS or CR were included in the sample by estimating a grade in College Algebra equal to the mean grade earned in College Algebra defined by the grade earned on the EAS an interesting outcome is found. The psychometric

index in this instance is .466. Albeit this result is exploratory and conditional, but it does make for an interesting comparison with past studies of the DTMS. This is because all of the studies previously conducted differed in that the samples were not truncated as in this study.

For example, Bridgeman (1982) found the correlation between the grade earned in an Elementary Algebra course and the score earned on the EAS for a sample of 73 subjects at a small private 2-year college in the South was .46. Further, Bridgeman found the correlation between the grade earned in an Elementary Algebra course and the score earned on the EAS for a sample of 198 subjects at a large public 4-year college in the South was .47. For the revised DTMS, Meyer, Woodard, and Suddick (1994) found the correlation between the grade earned in an Elementary Mathematics Concepts and Structures course and the score earned on the EAS for a sample of 60 subjects at a medium sized public 4-year college in the Midwest was .49.

It would seem *if* truncation had not been the case in this study, then the resulting psychometric index would be *very similar* to psychometric indexes found in previous studies which were not restricted to African-American males! This indicates that the predictive validity of the EAS of the DTMS for African-American males may be quite similar to the predictive validity of the EAS of the DTMS for a more general population. However, it may not because the statement is conditional. Thus, given the exploratory and speculative nature of the claim that the predictive validity of the EAS may be similar from African-American males and a more general population, it is recommended that studies should be conducted where sample derived from the population is not truncated as was the case in this study to ascertain if such a result occurs in a full sample from population of African-Americans.

Nonetheless, this study investigated the predictive validity of the DTMS in a population composed almost exclusively of African-American males (large sample size) which

has not been done before. The evidence found in this study adds to the body of evidence on the predictive power of the EAS of the DTMS as a tool in minimum competency testing. The evidence serves to support the use of the EAS of the DTMS as a placement tool at historically black colleges or universities since a significant difference between performance in a College Algebra course was found between those who failed the EAS of the DTMS and those who passed it.

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