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The Influence of Mathematics Ability on Performance in Principles of Accounting

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Abstract

Although most accounting educators readily acknowledge that mathematical ability has a significant impact on student performance in accounting courses, to date no statistical research has appeared that numerically quantifies the effect. The present research estimates the incremental effect of mathematics ability on student performance in principles of accounting by means of regressing student performance in a principles course on the student's score on a 24-question mathematics pre-test, as well as on other determinants of performance such as Grade Point Average. The overall effect of math ability is estimated, and also the effect of math ability in specific areas of mathematics such as proportions and percentages. It is found that while each one of the math score variables is highly significant according to the standard t-statistic test, the overall explanatory power of the regression equation, as measured by its R-squared, is not increased very much in a numerical sense by the addition of any one of them to a regression equation that already includes as an explanatory variable Grade Point Average. This finding does not imply that mathematics is unimportant to student performance in accounting, but rather that mathematics ability is so highly correlated with other academic ability indicators that disentangling the effect of math ability from the effect of other ability indicators is statistically problematic. Nevertheless, the pre-test itself can be utilized to conveniently identify at-risk students in principles of accounting courses, especially for those with measured low arithmetical and percentages and proportions skills.

Background

The discipline of accounting is concerned with accurate numerical measurement of precisely defined operational concepts. It follows that practitioners of accounting should be comfortable with mathematics in general and numbers in particular. Most accounting educators believe that arithmetic skills are important for students to understand accounting systems and financial statement analysis. It seems obvious that academic and professional success in accounting will be facilitated by a high level of mathematical skill.

Most business schools have implemented math requirements in basic calculus and matrix algebra, but the amount of application of these techniques tends of be limited in many business courses, with the result that some students may postpone taking required math courses until late in their college careers. A perennial debate topic in faculty lounges concerns the usefulness of higher mathematics in the applied business disciplines, and the extent to which mathematical techniques could and should be utilized in coursework. Professors of accounting, finance and economics tend to be aligned in these debates against professors of marketing and management.

Although accounting educators tend to be more favorably disposed toward mathematics than some other business educators, none of the contributions to the professional literature on determinants of success in accounting have singled out mathematics ability for special emphasis. The most voluminous component of the determinants of success literature examines factors influencing performance of students in principles of accounting courses: Eskew and Faley (1988); Bouillon, Doran and Smith (1990); Doran, Bouillon and Smith (1991); Bouillon and Doran (1992); Danko, Duke and Franz (1992); Norton and Reding (1992); Jones and Fields (2001). These authors statistically document strong positive relationships between performance in principles of accounting and the following independent variables: ACT or SAT scores, Grade Point Average (GPA), majoring in accounting, grade in Principles I courses (relevant to Principles II performance). Weaker and more problematic relationships have been found between performance and secondary school courses in accounting, sex (normally female students do better than male students), personality characteristics, effort measures, and intervention variables such as supplementary instruction.

While none of the above-cited studies differentiated between verbal and quantitative SAT and ACT scores, there exists a certain amount of evidence that suggests the special importance of mathematical ability. For example, the annual NASBA report *Candidate Performance on the Uniform CPA Examination* includes the table "Performance of First-Time Candidates by SAT and ACT Scores," which clearly manifests the strong positive relationship between both verbal and mathematics SAT/ACT scores and performance on the CPA examination. However, it is impossible to determine from inspection of this table the *relative* importance of verbal versus mathematical ability. The only thing that can be safely concluded is that both have strong effects. Another indication of the relevance of mathematics is the finding by Pritchard, Potter and Saccucci (2004) that students with majors in accounting and finance exhibit better computational and algebra skills, as measured by special-purpose math tests written by the authors, than do students majoring in marketing and management.

Related work in the disciplines of economics and finance has statistically documented the positive effect of mathematics ability on student performance. For example, Ballard and Johnson (2004) cite six prior studies indicating a positive effect of mathematics ability (usually measured by the quantitative SAT/ACT score) on performance in economics courses. The innovation of the Ballard-Johnson study is to use student performance on a specially devised mathematics pre-test as a predictor of success in principles of economics courses. One advantage of this approach is that it enables insights into the relationship between economics performance and specific types of mathematical operations presumed to be especially important in the study of economics: ratios, algebraic manipulation, graphical illustration and interpretation, and so on. A similar study by Pritchard, Romeo and Saccucci (2000) looks at the relationship between a special purpose math pre-test and performance in introductory finance courses. In this study, we report results from an analogous research project involving principles of accounting.

Our purpose here is to augment our understanding of the effect of mathematical skill on academic success in accounting in two ways. First, our intention is to statistically estimate the *incremental* effect of mathematical ability on performance in principles of accounting, holding constant other important determinants. Mathematical ability is obviously correlated with general intellectual ability. Therefore, because of the positive relationship between general intellectual ability and success in accounting courses, a positive relationship between mathematical ability and success in accounting is to be expected. But what is the effect of mathematical ability specifically—holding constant general intellectual ability—on success in accounting courses? A second interest is in differentiating the effects of various specific types of mathematical ability on success in academic accounting. Several different branches of mathematics are relevant to the discipline of accounting. Are some of these branches more important than other branches in determining a student's success in principles of accounting? As in the case with overall math ability, the importance of each area is to be assessed in terms of incremental explanatory power.

A by-product of the research is a mathematics pre-test oriented specifically to the discipline of accounting. The test itself is appended to this article, and an appendix table gives average performance on each test item over the several hundred students who took the test. Thus an accounting educator interested in administering the test to his/her own classes would have a basis for comparison. In a practical sense, the test is capable of providing information on at-risk students as well as specific mathematical areas where review may be useful.

The methodology of this research is empirical. At the beginning of the semester, students in principles of accounting courses were given a mathematics pre-test. The test items cover certain areas especially relevant to accounting. After the end of the semester, each student's performance on the math pre-test (overall and in each area) was matched with his/her overall performance in the principles of accounting course. Regression analysis of the data indicates that: (1) the positive effect of math skills on accounting performance is strongly significant; (2) controlling for the student's general ability and other key factors bearing on accounting performance, the measured incremental effect of math skill on performance is quite small; (3) in numerical terms, the measured incremental effect of the different branches of mathematics on accounting performance is very similar, albeit there are some slight differences that may be significant.

The remainder of the paper is organized as follows. Section 2 describes the project and the data obtained from it. Section 3 presents the statistical results. Section 4 provides a brief evaluation and conclusion.

Project Data

The mathematics testing instrument, devised by the authors specifically for this research, is entitled "Assessment of Mathematics Skills for Students in Principles of Accounting." It consists of 24 items broken down as follows:

- 8 items involving principally arithmetic (AR items);
- 8 items involving principally percentages and proportions (PP items);
- 8 items involving principally algebra (AL items).

The 24 items are also categorized as follows:

- 9 items involving substantial word exposition (WE items);
- 15 items not involving substantial word exposition.

Appendix Table A.1 lists the items included in the test. As can be seen, AR items involve only numbers plus the basic arithmetical operators for addition, subtraction, multiplication or division. Calculators could not be used, so these items test the student's ability to perform arithmetic operations without relying on an electronic tool. PP items involve either arithmetical operations on fractional numbers, or translation between proportional and percentage expression of numbers. AL items involve algebraic solution for an unknown x. WE items involve a high ratio of literal information to numeric information. The 9 WE items include 2 AR items, 4 PP items, and 3 AL items.

The math pre-test instrument was administered unannounced on the first day of class in all sections of Principles of Accounting I and II at a regional Midwestern public university at the beginning of the fall semester, 2005. Virtually all students enrolled in the Principles sequence took the test, for which 25 minutes was allowed. Calculators could not be used, but scratch work could be done on the test sheet. To provide some incentive to significant effort on the test, the following statement was included in the instructions: "Although your score on this test will not be directly incorporated into the determination of your course grade, it may have an effect on your grade in borderline cases." A second incentive to effort resided in another statement included in the instructions: "You will be informed of your score on this test within two weeks." Within two weeks of taking the pre-test, each student respondent received a personalized feedback report containing a list of the questions together with the respective correct answers and percentages of respondents answering correctly. The report was personalized by listing the student's name at the top, along with his/her total number answered correctly, followed by a list of those questions answered correctly.

The test instrument is appended to this paper. A special purpose Visual Basic program was written for entering data from the test forms, computing test scores, and outputting data files. This program, the dataset itself, and the Word files utilized for creating the feedback reports are available from the authors upon request.

The 24 items included in the pre-test are listed in the order they appear on the testing instrument in Appendix Table A.1. Shown for each item is the question, the correct answer, the question category, and the percentage of respondents answering the question correctly. Responses to individual items are numerically coded as binary variables: 0 for an incorrect answer, 1 for a correct answer. Raw scores are the number of items of a specific type answered correctly. For each student respondent five math scores (MSCORE1 through MSCORE5) are computed. The math score variables represent the percentage of questions of a particular type answered correctly. In percentage form, all five scores range from a theoretical low of 0 to a theoretical high of 100.

The first page of the testing instrument collected additional respondent information as follows:

AGE	age (under 18 = 1 to over 23 = 5)
SEX	sex (female = 1; male = 0)
CLASS	class standing (freshman = 1; sophomore = 2; junior = 3; senior = 4)
ACCTMAJ	accounting major (accounting = 1; non-accounting = 0)

When the results were being electronically recorded shortly after the beginning of the semester, the following information was added for each respondent:

COURSE	level of Principles course (Principles I = 0; Principles II = 1)
TIMEDAY	starting hour of the class period (in military time)

After the end of the semester, the data set was completed with the addition of the following variables (if available) for each respondent:

CSCORE	course score: points scored by the student as a percentage of the total number of points available in the course
GPA	grade point average in other courses (on a 4-point scale)
ACT	composite ACT score (maximum = 36)
MACT	mathematics ACT score (maximum = 36)

CSCORE was obtained from the records of the instructors involved in the project. In most cases, the observation was lost if the student had withdrawn from the course during the term. In some cases, however, instructors were willing to extrapolate, from the work that the student had done prior to withdrawal, an estimate of the percentage of total points that would have been earned had the student completed the course. Normally these percentages were on the low side. GPA, ACT, and MACT for each student were obtained from university records. For the majority of respondents, GPA was taken as the cumulative Grade Point Average earned at the authors' university through the end of the term prior to the term of the project. However, since a substantial minority of the students involved in the project were recent transfer students from various community colleges, for whom GPAs are not computed based on prior work, the GPA in these cases was computed as the GPA earned in other courses during the term of the project, excluding the principles of accounting course. For a substantial number of students, mostly transfer students but a few non-transfer (e.g., international students), ACT scores were not available in university records.

The math pre-test was completed by 535 students. Some 16 sections were involved (eleven of Principles I, five of Principles II), taught by seven different instructors. Course score (CSCORE) was obtained for 468 participants, GPA for 506 participants, composite ACT and math ACT for 420 participants. CSCORE, GPA and composite ACT and math ACT scores were all available for 373 participants.

Prior to reporting the substantive statistical results, some comment is merited on the mathematics pre-test used in this project. As is well known, standardized tests produced by such major corporate entities as Educational Testing Service (ETS) have become very important in higher education. These tests are exhaustively formulated and pre-tested by large teams of educators prior to general release. Therefore they achieve very high standards of reliability, consistency and validity. It might be wondered whether there is any justification—aside from convenience—for the investigators involved in this project to utilize a special purpose test rather than a standardized test. Two responses to this concern are offered.

First, the major application of standardized tests in higher education is for college admission decisions. It is essential, for purposes of college admissions, that the performance of any one applicant be accurately compared to the mean performance of a very large reference group. The present project, on the other hand, is not concerned with comparing the performance of the students who took the test with that of a larger reference group. The questions of interest may be tentatively answered on the basis of a single application of the test—with the proviso that the sample size be sufficiently large. The sample size amounted to several hundred, which compares favorably with the majority of prior contributions to the determinants of success literature.

Second, as indicated in the introduction, there is a substantial amount of precedent in the literature for the use of special purpose tests and other instruments in research of this sort. The purpose of the research is usually to estimate the effect of very specific characteristics and abilities of students on their achieved academic success. A relatively short special purpose instrument can often measure these special characteristics and abilities more precisely than a large standardized instrument. The investigators in this research, all of them senior-level faculty with several decades of combined experience in higher education, were especially interested in whether specific types of mathematical ability are more closely related to student success in principles of accounting courses than other types. The test instrument was designed accordingly. With respect to the fundamental issue of validity (whether the overall pre-test actually measures general mathematical ability), we point to the relatively high simple correlation (see Table 2 below) between math ACT score (MACT) and score on the overall pre-test (MSCORE1): 0.677.

Statistical Results

Table 1 presents selected descriptive statistics for the variables included in the regression analysis. For each variable, the number of available observations (cases) is listed. These range from a maximum of 535 for the math scores and other information obtained from the test instrument, to a minimum of 420 for the ACT scores (composite and mathematics).

The mean math scores shown in Table 1 are directly comparable, since each represents not the absolute number of questions of a certain type answered correctly, but rather the percentage of questions of a certain type answered correctly. The lowest of the five scores is MSCORE3 (47.032), pertaining to percentages and proportions, while the highest is MSCORE2 (74.509), pertaining to arithmetic calculations. The fact that the weakest area is found to be percentages and proportions is consistent with the casual empiricism of many accounting professors (including those conducting this research) that students seem to have special difficulty in converting and interpreting ratio concepts. The latter result (pertaining to arithmetic items) cannot be attributed, as might be suspected, to electronic calculators, because as mentioned above the student respondents to the math pre-test were not allowed to use them.

In Table 1, the first variable is CSCORE (course score), the dependent variable measuring the student's performance in the accounting class. All of the other variables are independent variables: potential determinants of performance. First, there is a list of personal and situational variables that prior research has suggested may be significant determinants of performance: SEX, AGE, CLASS, COURSE, TIMEDAY, ACCTMAJ. This list is followed by two general academic ability variables: ACT (composite ACT score) and GPA (grade point average). ACT measures the student's general academic potential prior to commencing college, while GPA measures the student's performance in other college courses than principles of accounting since the time of matriculation. Finally, there are the specific math ability variables: MACT is the student's mathematics ACT score, and MSCORE1 through MSCORE5 represent the student's score on each of the five dimensions of the math pre-test: overall, arithmetic, percents and proportions, algebra, and word exposition.

Table 2 is a matrix of simple correlation coefficients among the more important variables in the research: the performance variable CSCORE, the general academic ability variables GPA and ACT, and the specific math ability variables MACT and MSCORE1 through MSCORE5. One of the major pitfalls in multiple regression analysis is the problem of multicollinearity, caused by excessively high correlations among different explanatory variables in the equation. Evidently, when two explanatory variables are closely correlated, it is difficult for regression analysis to isolate the separate effects of the two variables. A general rule is that simple correlation coefficients in excess of 0.5 in absolute value are a warning sign that multicollinearity may seriously affect the results. Most of the simple correlation coefficients among the MSCORE variables are well above 0.5, which indicates that it would be unwise to include more than one at a time in a regression equation. Among the lower of the correlation coefficients in the table is that between ACT and GPA: 0.329. The initial ability of the student, as measured by pre-college ACT, does not have as strong a correlation with performance in college, as measured by GPA, as might be expected. This suggests that both ACT and GPA might be used together as determinants of accounting performance without incurring a serious multicollinearity problem.

The basic statistical analysis tool utilized in this research is multiple regression. The analysis is performed in steps designed to estimate the incremental explanatory power of two categories of variable: general academic ability, and mathematical ability. Within the latter category, we look first at the incremental explanatory power of math ACT versus the incremental explanatory power of overall math pre-test score, and second at the incremental explanatory power of scores on the specific components of the math pre-test. The regression analysis is reported in three tables: Table 3 (Determinants of Performance Excluding Math Ability Indicators); Table 4 (Determinants of Performance Including Math Ability Indicators), and Table 5 (Comparison of Incremental Explanatory Power of the Five Math Pre-Test Scores).

Table 3 shows estimates of the incremental explanatory power of the general academic ability variables ACT and GPA, when added to personal and situational variables SEX, AGE, CLASS, COURSE, TIMEDAY and ACCTMAJ. Equation (1) in Table 3 contains only personal and situational variables. None of these variables are statistically significant even at the 5 percent level, although both ACCTMAJ and COURSE come close. The positive numerical value of the estimated regression coefficients of these variables indicates that accounting majors tend to do better than non-accounting majors, and that students in Principles II tend to do better than students in Principles I. Both these results are plausible and consistent with prior research. What is surprising is that this entire set of explanatory variables, including ACCTMAJ and COURSE, has such a small amount of explanatory power with respect to the dependent performance variable CSCORE. The overall explanatory power of Table 3 equation (1) is quite low: the R-squared statistic of 0.017 indicates that only 1.7 percent of the total variation in the dependent variable CSCORE is statistically associated with variation in the included personal and situational variables. The low explanatory power of equation (1) is underscored by the result for the F-statistic. This is the only equation, among the total of 15 equations reported in Tables 3, 4 and 5, for which the F-statistic is not statistically significant.

Equation (2) in Table 3 adds ACT only to the list of explanatory variables, equation (3) adds GPA only, and equation (4) adds both ACT and GPA. Clearly the GPA variable has considerably more incremental explanatory power, when added to the personal and situational variables, than does the ACT variable. When ACT alone is added to the explanatory variables, R-squared rises only to 0.157. When GPA alone is added to the explanatory variables, R-squared rises more substantially to 0.553. When both GPA and ACT are utilized as explanatory variables, the R-squared is 0.568. As a whole, the Table 3 results indicate that general academic ability variables are far more important determinants of performance in principles of accounting than are personal and situational variables.

Table 4 shows estimates of the incremental explanatory power of the two basic mathematical ability variables, MACT (math ACT score) and MSCORE1 (overall math pre-test score), when added to the other potential explanatory variables for performance in accounting. The format of Table 4 follows that of Table 3, with the math ability variables added at the bottom. Table 4 equation (1) adds MACT only to what was equation (4) in Table 3. Surprisingly, the estimated regression coefficient for MACT is negative, albeit statistically insignificant. From other results to be described, this paradoxical result is most plausibly attributed to multicollinearity: specifically to the high simple correlation coefficient (0.791) between ACT and MACT (see Table 2). Most importantly, when ACT is removed from the list of explanatory variables, as in Table 4 equation (2), the estimated regression coefficient on MACT becomes positive (as expected), and strongly significant (also as expected). Since the general academic ability variable ACT is removed from Table 4 equation (2) because of the multicollinearity problem, it is also not used, for purposes of comparability, in any of the remaining equations reported in Tables 4 and 5.

Table 4 equation (3) is analogous to equation (2), except that MACT is removed from the list of regressors, and MSCORE1 is added to the list. A comparison of equation (3) with equation (2) suggests that the overall score on the math pre-test utilized in this research (MSCORE1) is a somewhat stronger predictor of success in principles of accounting than is the math ACT score (MACT). This is suggested both by the higher R-squared of equation (3) relative to equation (2), and by the higher t-statistic for the math ability variable in equation (3) relative to that in equation (2). The differential, while not great, does provide some support for the researchers' intention that the instrument utilized in the project tests specific areas of mathematics especially useful in the study of accounting.

Equations (4) and (5) in Table 4 are truncated versions respectively of equations (2) and (3). They drop from the list of explanatory variables those that are statistically insignificant by the conventional t-statistic test. The motivation for dropping insignificant variables is to try to reduce statistical clutter, i.e., to reduce the standard errors of the estimated regression estimators. When this is done, only GPA, ACCTMAJ, and either MACT or MSCORE1, remain in the regression equation. Curiously, when the other variables are eliminated, ACCTMAJ loses its statistical significance. However, it is left in the remaining analysis for two reasons: (1) it is significant at conventional confidence levels in some of the estimated regression equations reported in Table 5 below; (2) when it is not significant, its t-statistic is still large enough to be deemed significant using a slightly less stringent confidence level. From a qualitative standpoint, the basic indications regarding the relative incremental explanatory power of MACT and MSCORE1, as described in the previous paragraph, are unaffected by truncating the regression equations.

Table 5 also estimates the incremental explanatory power of the five scores derived from the pre-test: MSCORE1 (overall), MSCORE2 (AR—arithmetic), MSCORE3 (PP—percents and proportions); MSCORE4 (AL—algebra), and MSCORE5 (WE—word exposition). A base is provided in the form of Table 5 equation (1), which regresses CSCORE on GPA and ACCTMAJ. Equation (1), therefore, excludes any of the math ability measures. Both of the included explanatory variables in Table 5 equation (1) are strongly significant, and the equation's R-squared is 0.543, indicating that 54.3 percent of the variation on the performance variable CSCORE is statistically associated with variation in GPA and ACCTMAJ. Table 5 equation (2) is a repetition of Table 4 equation (5), provided for easy reference. This is the equation that adds to GPA and ACCTMAJ the student's overall score on the math pre-test (MSCORE1). The R-squared is raised to 0.557 relative to 0.543 in the baseline equation (1). Adding the math ability variable MSCORE1 increases the explanatory power of the regression equation by only 2.58 percent above the baseline level. While this amount is clearly very significant in a statistical sense, as attested by the high t-statistic of MSCORE1 of 3.88, it is not a very large amount in absolute numerical terms.

Equations (3), (4), (5) and (6) in Table 5 add to the baseline variables (GPA and ACCTMAJ) respectively MSCORE2 (arithmetic items), MSCORE3 (percentage and proportion items), MSCORE4 (algebraic items), and MSCORE5 (word exposition items). As can be seen, the increment in the regression equation's explanatory power is very similar for all four of the specific area scores. Also the t-statistics of the specific MSCORE variables are generally comparable to that for MSCORE1. Although the numerical values are very close, the ranking of the values may possess some meaningful informational content. If the R-squareds are sorted in descending order, the ordered MSCORE variables are: (1) MSCORE5 (word exposition); (2) MSCORE2 (arithmetic); (3) MSCORE1 (overall); (4) MSCORE3 (percentage and proportion); and (5) MSCORE4 (algebra). The same ordering results from sorting according to the MSCORE variables' respective t-statistics. The differences among the R-squareds and t-statistics are not statistically significant, and could well be the result of random variation. On the other hand, they might be meaningful. Certainly the suggestion that word comprehension is most important and algebra is least important (albeit not unimportant in an absolute sense), will not be unduly surprising to the intuition of most accounting educators. In particular, the indication that the word exposition score has the highest incremental explanatory power is reasonably consistent with the intuition of most accounting educators that an essential ingredient for success in accounting is the ability to systematically reduce complicated qualitative conditions to relatively straightforward numerical computations. This finding also suggests that measures of reading comprehension may be useful as a predictor of success in accounting courses and as an identifier of at-risk students.

Evaluation and Conclusion

This central purpose of this research has been to estimate the incremental effect of math ability, as measured by performance on a math pre-test covering several different areas of mathematics that would appear to be especially relevant to the study of accounting, on student performance in principles of accounting, as measured by percentage of total available points earned (CSCORE), holding constant other determinants of success. The statistical analysis was structured to enable: first, estimation of the incremental explanatory power of general academic ability measures over a set of personal and situational variables; and second, estimation of the incremental explanatory power of math ability variables over a reduced set of statistically significant general ability and situational variables.

It was found that a substantial set of personal and situational variables account, in a statistical sense, for only a small part (under 2 percent) of the total variation in CSCORE. The two measures of general academic ability utilized in the research are composite ACT score and GPA achieved in other courses. Of the two, GPA was found to have the statistically stronger effect on performance in accounting principles, raising the explanatory power of the regression equation to 55.3 percent when used separately from ACT and to 56.8 percent when used together with ACT.

Two measures of mathematics ability were then examined: MACT is the student's score on the mathematics component of the ACT, and MSCORE1 is the student's percentage score on a mathematics pre-test written specifically for this research. Both have statistically significant but numerically small incremental effects on CSCORE, holding constant other determinants. While both effects are small, the numerical effect for MSCORE1 is somewhat larger than that for MACT, which may be due to the fact that the special purpose math pre-test utilized in this research was specifically designed to emphasize areas of mathematics assumed to be especially important to the study of accounting. The fundamental conclusion from the project is thus that mathematics ability does have statistically significant incremental explanatory power over and above that contained in the GPA measure of general academic ability and certain other determinants of success in principles of accounting—but not very much incremental explanatory power.

Another research objective was to try to ascertain the relative importance of various dimensions of mathematical ability on success in principles of accounting. Of the 24 items included in the pre-test, eight involved arithmetic computations (AR items), eight involved working with proportions and percentages (PP items), and eight involved basic algebraic manipulations (AL items). A second categorization subdivided the items into nine items involving substantial word exposition (WE items), and those not involving substantial word exposition. While no strong evidence was found that some of these dimensions of mathematical ability are substantially more or less important than the others, the incremental explanatory power of the word exposition score MSCORE5 was highest, and the incremental explanatory power of the algebra score MSCORE4 was lowest. This indication would probably be consistent with the intuition of most accounting educators.

What implications might this research hold for accounting educators desirous of increasing their teaching effectiveness in principles of accounting? As is the case with any research on the determinants of success in academic accounting, there are two basic motivations for conducting this type of research: (1) to identify at-risk students on the basis of their prior academic performance as well as other pre-determined personal and situational variables; (2) to evaluate the potential effectiveness of potentially controllable (intervention) variables such as grading policy, material coverage, teaching style, assignments, reviews, counseling, tutoring, and so on. It is a common practice for instructors at the beginning of the term to have students submit information cards including personal information as well as basic academic information such as general GPA and prior courses in accounting. On the basis of a large amount of published research, not to mention common sense, students with low GPAs are likely to be at-risk students.

On the basis of the present research, instructors might add queries as to math ACT or SAT scores, as well as previous math courses taken and grades earned. It appears that there would be a slight but statistically significant amount of incremental informational content in the responses to such queries, as far as identification of at-risk students is concerned. With respect to intervention, it must be conceded that the usefulness of this research is somewhat limited. Even if it had been ascertained that mathematical ability—as opposed to general academic ability—is an extremely important incremental determinant of performance in accounting, accounting instructors cannot afford the time that would be involved in trying to improve the general mathematical skills of their students. One exception, however, might be with respect to proportions and percentages, as well as the arithmetical operations on fractions that underlie them. Recall that the lowest of the five math pre-test scores is MSCORE3, pertaining to percentages and proportions: 47.032 out of 100. Taking a half hour or so in an early class period to explain these concepts thoroughly might well possess a payoff sufficient to merit the modest time investment that would be involved.

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Table 1
Variables Included in the Regression Analysis

NAME	EXPLANATION	MEAN	STD. DEV.	CASES
CSCORE	Course Score (percent)	73.952	12.645	468
SEX	Sex (1 = female; 0 = male)	0.338	0.473	535
AGE	Age (1 = under 18 to 5 = over 23)	2.811	0.841	535
CLASS	Class (1 = fresh. to 4 = senior)	2.487	0.644	535
COURSE	Course (1 = Principles II; 0 = Principles I)	0.214	0.411	535
TIMEDAY	Time of Day (military time)	1082.9	191.79	535
ACCTMAJ	Accounting Major (1 = major; 0 = non-major)	0.100	0.301	535
ACT	ACT Composite	21.402	3.427	420
GPA	Grade Point Average	2.704	0.761	506
MACT	ACT Mathematics	21.411	3.964	420
MSCORE1	Math Score 1: Overall (percent)	60.397	18.874	535
MSCORE2	Math Score 2: Arithmetic (percent)	74.509	16.283	535
MSCORE3	Math Score 3: Percents & Proportions (percent)	47.032	27.018	535
MSCORE4	Math Score 4: Algebra (percent)	59.649	23.875	535
MSCORE5	Math Score 5: Word Exposition (percent)	50.799	23.442	535

Table 2
Correlation Matrix:
Academic Capability Variables

	CSCORE	GPA	ACT	MACT	MSCORE1
CSCORE	1.000				
GPA	0.727	1.000			
ACT	0.378	0.329	1.000		
MACT	0.326	0.299	0.791	1.000	
MSCORE1	0.327	0.286	0.591	0.677	1.000
MSCORE2	0.241	0.171	0.387	0.464	0.780
MSCORE3	0.295	0.258	0.542	0.613	0.888
MSCORE4	0.280	0.272	0.530	0.601	0.840
MSCORE5	0.321	0.273	0.554	0.589	0.891
	MSCORE1	MSCORE2	MSCORE3	MSCORE4	MSCORE5
MSCORE1	1.000				
MSCORE2	0.780	1.000			
MSCORE3	0.888	0.580	1.000		
MSCORE4	0.840	0.510	0.583	1.000	
MSCORE5	0.891	0.637	0.832	0.744	1.000

Table 3
Determinants of Performance
Excluding Math Ability Indicators

Dependent Variable: CSCORE

	Estimated Regression Coefficients (t-statistics in parentheses)			
Independent Variable	(1)	(2)	(3)	(4)
constant	77.296** (16.80)	47.376** (7.11)	34.920** (9.71)	20.288** (4.03)
ACT	—	1.390*** (7.56)	—	0.595 (4.29)
GPA	—	—	12.571** (23.32)	12.434** (18.57)
SEX	0.285 (0.23)	1.008 (0.78)	–0.808 (–0.96)	–0.788 (–0.85)
AGE	–0.722 (–0.83)	–0.255 (–0.23)	0.899 (1.52)	1.888* (2.37)
CLASS	–0.082 (–0.07)	0.254 (0.18)	0.749 (0.93)	0.462 (0.47)
COURSE	2.773 (1.82)	1.988 (1.22)	0.681 (0.66)	–0.289 (–0.24)
TIMEDAY	–0.002 (–0.64)	–0.004 (–1.18)	–0.000 (–0.02)	0.000 (0.07)
ACCTMAJ	3.742 (1.87)	1.695 (0.85)	3.636** (2.70)	3.009* (2.10)
R-squared	0.017	0.157	0.553	0.568
F-statistic	1.31	9.72**	80.33**	59.13**
Cases	468	373	461	368

* = significant at 95 percent confidence level; ** = significant at 99 percent confidence level.

Table 4
Determinants of Performance
Including Math Ability Indicators

Dependent Variable: CSCORE

Independent Variable	Estimated Regression Coefficients (t-statistics in parentheses)				
	(1)	(2)	(3)	(4)	(5)
constant	20.345** (4.02)	24.831** (5.10)	31.307** (8.49)	32.193** (12.00)	36.562** (21.20)
ACT	0.621* (2.91)	—	—	—	—
GPA	12.442** (18.51)	12.709** (18.88)	11.927** (21.27)	12.230** (18.68)	11.641** (21.12)
SEX	–0.801 (–0.86)	–0.791 (–0.84)	–0.397 (–0.47)	—	—
AGE	1.887* (2.36)	1.776* (2.20)	0.880 (1.51)	—	—
CLASS	0.462 (0.47)	0.328 (0.33)	0.803 (1.01)	—	—
COURSE	–0.288 (–0.24)	–0.167 (–0.14)	0.318 (0.31)	—	—
TIMEDAY	0.000 (0.06)	0.000 (0.11)	0.000 (0.11)	—	—
ACCTMAJ	3.024* (2.11)	3.114* (2.15)	3.204** (2.40)	2.422 (1.72)	2.457 (1.89)
MACT	–0.029 (–0.16)	0.369** (3.11)	—	0.347** (2.94)	—
MSCORE1	—	—	0.081** (3.64)	—	0.086** (3.88)
R-squared	0.568	0.558	0.566	0.545	0.557
F-statistic	54.42**	56.73**	73.85**	145.50**	192.30**
Cases	368	368	461	368	461

* = significant at 95 percent confidence level; ** = significant at 99 percent confidence level.

Table 5
Comparison of the Incremental Explanatory Power of the Five Math Pre-Test Scores

Dependent Variable: CSCORE

	Estimated Regression Coefficients (t-statistics in parentheses)					
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
constant	39.941** (26.42)	36.562** (21.20)	33.663** (15.60)	39.025** (25.60)	38.319** (23.61)	38.027** (24.54)
GPA	12.310** (23.16)	11.641** (21.12)	11.953** (22.53)	11.807** (21.48)	11.869** (21.43)	11.608** (21.22)
ACCTMAJ	2.850* (2.16)	2.457 (1.89)	2.749* (2.16)	2.686* (2.06)	2.411 (1.83)	2.547* (1.97)
MSCORE1 (overall)	—	0.086** (3.88)	—	—	—	—
MSCORE2 (arithmetic)	—	—	0.097** (4.01)	—	—	—
MSCORE3 (percents)	—	—	—	0.048** (3.17)	—	—
MSCORE4 (algebra)	—	—	—	—	0.047** (2.63)	—
MSCORE5 (word)	—	—	—	—	—	0.075** (4.28)
R-squared	0.543	0.557	0.558	0.553	0.550	0.561
F-statistic	272.53**	192.30**	193.09**	188.66**	186.37**	194.70**
Cases	461	461	461	461	461	461

* = significant at 95 percent confidence level; ** = significant at 99 percent confidence level.

Table A.1:
Information on Test Items

#.	Question	Correct Answer	Type of Question	Percent Answering Correctly
1.	122,302 + 652,365 = ?	774,667	AR	92.52
2.	1/5 + 2/25 + 6/50 = ? Express the answer as a decimal.	0.40	PP	41.50
3.	If $4x - 4 = 20$, then x = ?	6	AL	90.65
4.	861,365 – 241,211 = ?	620,154	AR	96.07
5.	Convert the decimal number 0.257 into a percent. The result is:	25.7	PP	78.13
6.	The formula for calculating sales tax is $S = A \times r$, where S is the sales tax, A is the cost of the product, and r is the sales-tax rate. If a television costs $500 and the sales tax is $25, what is the local sales-tax rate in percentage terms?	5	AL-WE	38.88
7.	The cost of a long-distance phone call is 15 cents for the first minute, and then 3 cents per minute for every additional minute. How many cents would a 24 minute phone call cost?	84	AR-WE	80.56
8.	The population of Galesburg is expected to increase 2% from the current population of 45,000. If this prediction is accurate, what would be its new population?	45,900	PP-WE	52.15
9.	If 2 less than 3 times a certain number is the same as 4 more than the product of 5 and 3, what is the number?	7	AL-WE	40.56
10.	56.7 x 3.1 = ?	175.77	AR	48.22
11.	Jake's salary was $58,000. Then he received a 10 percent increase in salary. What is his new salary?	63,800	PP-WE	61.50
12	If x = –2, then $3x^2 - 5x - 6$ = ?	16	AL	71.21
13.	1575 ÷ 25 = ?	63	AR	84.11
14.	XYZ company's profits this year are $2,500,000. Its profit rate on sales (in ratio terms) is 0.10. What are its sales this year?	25,000,000	PP-WE	18.50
15.	If $x = -2$, then $\frac{(x+3)(x-3)}{5}$ = ?	–1	AL	70.09
16.	$\left(\frac{350-200}{15}\right) \times 6 = ?$	60	AR	85.23
17.	If 50 is 20 percent of x, then x = ?	250	PP	60.00
18.	If $2x + 3y = 14$ and $x - y = 2$, then x = ? and y = ?	$x = 4$ $y = 2$	AL	61.68
19.	If Janice has 12 quarters, 3 dimes, 6 nickels and 7 pennies, how much money does she have?	$3.67	AR-WE	85.42
20.	Take 62 percent of $12,000. The result is:	7,440	PP	40.93
21.	What are the two roots of $x^2 - 5x + 6 = 0$? (i.e., factor this expression)	$x_1 = 2$ $x_2 = 3$	AL	48.04
22.	12,000 x .03 x 2/3 = ?	240	AR	23.93
23.	On the first of January the local bank agrees to lend you $20,000 for college tuition, room, and board. They charge you 6% interest per year payable on a monthly basis. How much interest must you pay at the end of January?	100	PP-WE	23.55
24.	A fruit basket contains x apples and y oranges. There are 6 more oranges than there are apples. Jack and Jill decide to split the fruit equally. Each of them gets 13 pieces of fruit. How many apples and oranges were there in the fruit basket?	10 apples 16 oranges	AL-WE	56.07
Type of Question: AR = arithmetic; PP = proportions and percentages; AL = algebra; WE = word exposition.				

ASSESSMENT OF MATHEMATICS SKILLS

for Students in

PRINCIPLES OF ACCOUNTING

Please provide the following information about yourself:

Name: ______________________________

Major: ______________________________

Class Standing: ☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior

Age: ☐ under 18 ☐ 18-19 ☐ 20-21 ☐ 22-23 ☐ over 23

Sex: ☐ Male ☐ Female

Assessment Information

- **The purpose of this assessment is to determine the influence of mathematics skills on performance in Principles of Accounting courses.**
- **Do not start the test until told to do so by your instructor.**
- **Calculators may not be used. Do all scratch work on the test sheet.**
- **There are 24 fill-in type questions on this test.**
- **You will have 25 minutes to work on the test.**
- **Do not spend too much time on any one question. If you are having trouble with a question, go on to the next question.**
- **You will be informed of your score on this test within two weeks.**
- **Although your score on this test will not be directly incorporated into the determination of your course grade, it may have an effect on your grade in borderline cases.**

Thank you for your assistance!

1. 122,302 + 652,365 = ?

2. 1/5 + 2/25 + 6/50 = ? Express the answer as a decimal.

3. If $4x - 4 = 20$, then x = ?

4. 861,365 – 241,211 = ?

5. Convert the decimal number 0.257 into a percent. The result is:

6. The formula for calculating sales tax is $S = A \times r$, where:

   S is the sales tax

   A is the cost of the product

   r is the sales-tax rate

   If a television costs $500 and the sales tax is $25, what is the local sales-tax rate in percentage terms?

7. The cost of a long-distance phone call is 15 cents for the first minute, and then 3 cents per minute for every additional minute. How many cents would a 24 minute phone call cost?

8. By the end of the year, the population of Galesburg is expected to increase 2% from the current population of 45,000. If this prediction is accurate, what would be its new population at the end of the year?

9. If 2 less than 3 times a certain number is the same as 4 more than the product of 5 and 3, what is the number?

10. 56.7 x 3.1 = ?

11. Last year Jake's salary was $58,000. At the end of the year he received a 10 percent increase in salary. What is his salary this year?

12. If x = –2, then $3x^2 - 5x - 6$ = ?

13. $1575 \div 25 = ?$ ________________

14. XYZ company's profits this year are $2,500,000. Its profit rate on sales (in ratio terms) is 0.10. What are its sales this year? ________________

15. If $x = -2$, then $\frac{(x+3)(x-3)}{5} = ?$ ________________

16. $\left(\frac{350-200}{15}\right) \times 6 = ?$ ________________

17. If 50 is 20 percent of x, then $x = ?$ ________________

18. If $2x + 3y = 14$ and $x - y = 2$, then $x = ?$ and $y = ?$

$x =$ _____

$y =$ _____

19. If Janice has 12 quarters, 3 dimes, 6 nickels and 7 pennies, how much money does she have? ________________

20. Take 62 percent of $12,000. The result is: ________________

21. What are the two roots of $x^2 - 5x + 6 = 0$? (i.e., factor this expression)

$x_1 =$ _____

$x_2 =$ _____

22. 12,000 x .03 x 2/3 = ? ________________

23. On the first of January the local bank agrees to lend you $20,000 for college tuition, room, and board. They charge you 6% interest per year payable on a monthly basis. How much interest must you pay at the end of January? ________________

24. A fruit basket contains x apples and y oranges. There are 6 more oranges than there are apples. Jack and Jill decide to split the fruit equally. Each of them gets 13 pieces of fruit. How many apples and oranges were there in the fruit basket?

____ apples

____ oranges

Blank page for scratch work.