

Basic Math Skills and Performance
In An Introductory Economics Class

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March 18, 2003

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ABSTRACT

We measure math skills with a broader set of explanatory variables than has been used in previous studies. To identify what math skills are important for student success in introductory microeconomics, we examine (1) the student's score on the mathematics portion of the ACT, (2) whether the student has taken calculus, (3) whether the student has been required to take remedial mathematics, and (4) the student's score on a test of *very* basic mathematical concepts. All four measures of math skill have significant effects in explaining performance in an introductory microeconomics course. We find similar results, regardless of whether we use self-reported information from students, or official administrative records from the university. The results suggest that improvements in student performance may depend on improved mastery of basic algebra.

Keywords: mathematical skills, microeconomics, student performance

JEL codes: A12, A22

Basic Math Skills and Performance In An Introductory Economics Course

Several authors have documented the positive effect of mathematical skills on performance in college economics courses. (Discussion follows.) However, in these studies, math skills have been measured by the student's score on the mathematics portion of the Scholastic Aptitude Test (SAT), or by whether the student has taken a course in calculus or business math. In this article, we attempt to identify more specifically what types of math skills are important for student success in introductory microeconomics. We include whether the student has taken a calculus course, and we include the student's score on the math portion of the ACT test. However, we also define math skills by whether the student has been required to take a remedial math class, and by the student's score on a test of very basic mathematical skills. These basic math skills include the ability to calculate the slope of a line, or to calculate the area of a triangle, or to divide by a fraction.

This test of elementary math skills was administered during the second week of an introductory course in microeconomics. The results of the math quiz are interesting in their own right, because they indicate that substantial numbers of college students are unable to solve even very basic math problems. In addition, we find that the scores on this test have a strong and statistically significant effect on performance in the introductory economics course. The relationship between basic math skills and success in an introductory economics course is further confirmed by the fact that, even after controlling for other variables, students who were required to take a remedial math course

did significantly worse in the economics course than did students who were not required to do so.

These results have two implications. First, the results suggest that student success depends on a variety of quantitative skills, including some very basic skills. Thus, the results indicate that measures of relatively sophisticated math skills, such as whether the student has taken calculus, should be supplemented with measures of more elementary math skills. If a student who has taken calculus does well in an introductory economics course, it may not be because of the calculus *per se*. Rather, students with calculus experience may do better in introductory economics courses because those who take calculus are more likely to have mastered the very basic mathematical concepts that are more crucial for success.

The second implication of these results is that one of the most effective ways to improve student performance in introductory economics courses would be for students to master very elementary mathematical concepts.

THE LITERATURE

A large body of research assesses the determinants of student success in economics courses. Perhaps the largest part of this literature is concerned with the impact of attendance on students' grades. Durden and Ellis (1995), Fisher, Guilfoyle, and Liedholm (1998), Park and Kerr (1990), Romer (1993), and Schmidt (1983) all find a positive effect of attendance on course grade. Other research has focused on the suggestion that females perform more poorly than males in economics classes that use multiple-choice examinations, and on multiple-choice exams in general. (See Anderson,

Benjamin, and Fuss (1994), Lumsden and Scott (1987), and Siegfried (1979) in support of this hypothesis, and Williams, Waldauer, and Duggal (1992) in contrast.)

Many of these studies attempt to control for students' math abilities by including a dummy variable for whether students have taken calculus, or by including a measure of math aptitude, such as the student's score on the mathematics portion of the Scholastic Aptitude Test (SAT). Durden and Ellis (1995) find that the Mathematics SAT score is positively and significantly related to student success in economics, and the same is true for the student's experience with calculus. Williams, Waldauer, and Duggal (1992) find Math SAT to be a major determinant of student success on all exam types except essay exams. Anderson, Benjamin, and Fuss (1994) find that calculus has a significant and beneficial effect on student grades in introductory economics. Brasfield, Harrison, and McCoy (1993) find that having completed a sequence of Business Math courses contributes positively to students' grades. In addition, Lumsden and Scott (1987) find that achieving an A level in mathematics contributes positively and significantly to student success on multiple-choice economics exams.

Ely and Hittle (1990) recognize the possible discrepancy between completion of math courses and possession of actual math skills. They attempt to proxy for math understanding by using variables that ask students to rate the adequacy of their previous math courses in preparing them for their current course in finance or managerial economics. Ely and Hittle also include a measure of "math affinity," which is meant to proxy for a student's attitude toward mathematics. They find positive and significant coefficients on the variable rating the adequacy of previous math experience and on the

math-affinity variable, but no impact is found for the number of years of high-school mathematics or the types of courses that a student took.

All of the researchers who have contributed to this literature agree that math skills are important. However, math skills come in many forms, and we would like to know which math skills are most crucial for success. We argue that, by focusing on calculus, researchers have diverted attention from the elementary math skills that are just as critical for success in introductory economics courses.

THE DATA

The data for this study were collected from two sections of Principles of Microeconomics in the Fall Semester of 1998, and two additional sections in the Fall Semester of 1999. The four sections were of approximately equal size, and all were taught by the same professor. In each semester, the two sections met consecutively, on the same days of the week. In a given semester, the same exams were given in both sections. Exams in the first section were carefully collected, and the same exam was then given in the second section. The dependent variable in our study is called “percent correct.” This is the percentage of questions answered correctly on the three examinations given in the introductory microeconomics course. All questions were in the multiple-choice format.

The data for the independent variables were gathered from a survey given in class; these data were supplemented with information from university records. The sample population of this study consists of the 1462 individuals who participated in the survey and completed the course; these students are a subset of the 2313 students enrolled in the

courses. Because some of the students did not participate in the survey, there is a possibility of bias in our estimates if those who filled out the survey were systematically different from those who did not. (See Chan, Shum, and Wright 1997; Douglas and Sulock 1995.) We return to this point below. The survey consists of 26 questions, dealing with demographics, motivation, and previous math experience. The survey also includes questions such as whether introductory microeconomics is required for the student's major, and whether the student has taken economics in high school or at another university.

Finally, the survey includes ten simple, multiple-choice math questions. The math portion of the survey was designed to supplement traditional sources of information regarding student math skills. The math quiz provides additional information, including: (1) actual student mathematical knowledge during the semester in which the economics course is being taken (without the kind of preparation that students often undertake before taking a college entrance exam), and (2) student knowledge of extremely basic material, some of which is not covered by collegiate entrance exams.¹ See Table 1 for the math quiz itself, as well as for the percentage of the classes answering each math question correctly. The distributions of all of the explanatory variables collected in our study are reported in Table 2.

<Table 1 and Table 2 about here>

These data were collected from students at a large Midwestern university, at which the vast majority of students take the ACT, rather than the SAT. We use the student's scores on the math and English portions of the ACT as explanatory variables. Consequently, our results cannot be compared directly with those of other studies that

have used SAT scores. However, we do not consider this to be a major shortcoming, since the ACT (like the SAT) is a well-respected measure of student aptitude.

The mean score on the math quiz is 7.76 out of 10. As indicated in Table 1, some 20 percent of the students could not solve $x = \frac{a}{b}$ for b, given that $x = 4$ and $a = 8$.

Further, 28.5 percent of the students could not divide $1/2$ by $2/3$; 33.4 percent of the students could not find the area of a right triangle; and between 24 percent and 29 percent of the students could not find the slope of a line, depending on whether the line slopes upward or downward. These results suggest that a significant number of students would probably have difficulty interpreting graphs, computing and using elasticities and consumer surpluses, etc.

Interestingly, the correlation between the official university grade-point average (GPA) and the math-quiz score is only 0.19, and the correlation between GPA and the score on the math portion of the ACT is only 0.31. This is probably because many fields of study have only minimal math requirements. Consequently, some students with low math aptitude may still be able to maintain a high GPA, even though their lack of math skills will be an obstacle to success in an economics course. In addition, the correlation coefficient between GPA and whether the student has taken calculus is only 0.11. This may be because, in many cases, students who take calculus also take difficult courses in the sciences and engineering. Consequently, although these students are likely to have better math skills, their mathematical abilities may not necessarily translate into a higher overall GPA.

At our university, students with sufficiently low scores on a math-placement exam are required to take a remedial-math course. (In our sample, 24 percent of the students

were faced with this requirement.) In our regressions, we also use a dummy variable for whether the student was required to take remedial math.

Thus, we have four distinct measures of quantitative ability: (1) the score on the math portion of the ACT, (2) the score on the math quiz administered early in the semester, (3) whether the student has taken calculus, and (4) whether the student has been required to take remedial math. The correlations among these measures are often surprisingly small. This indicates that quantitative ability is multifaceted, and not easily summarized by a single measure. In our regressions, we find that all of these measures have significant explanatory power.

We attempt to control for motivation, attendance, and ability, by using variables generated from the survey or provided by the university. These variables include students' self-reported and actual GPA, self-reported and actual ACT score, reported attendance patterns, and reported hours spent studying, working, and in other activities.

Maxwell and Lopus (1994) find that students tend to overstate their GPA. We also find evidence of overstatement by the students who participated in our survey. When we compare the self-reported GPA and ACT with the actual data from university administrative records, we find that students overstated their scores on average, although the extent of the overstatements is quantitatively small.² Because the overstatements are small, they do not bias the regression results substantially. The coefficients and standard errors from regressions using the official university data are not significantly different from the coefficients and standard errors from regressions using the student-reported data.³ This indicates that there is likely to be little difference between the conclusions of research conducted with self-reported data and those with data from official

administrative records.⁴ This point may be important for those who desire to conduct similar studies. At many colleges, it is difficult to acquire administrative records, and it may be considerably easier to acquire self-reported data.

Before reporting the regression results, we begin with Table 3, in which we show the simple correlation coefficients among several of the key variables.⁵ As expected, there are positive correlations among the calculus variable, the math-quiz score, and the math and English ACT scores. It is also not surprising that all four of these variables are negatively correlated with the variable for whether the student has been required to take a remedial math course. However, it is interesting to note that most of these correlations are rather modest in absolute value. This suggests that no single variable is likely to provide a truly comprehensive measure of ability. We also check for multicollinearity between the various math and academic variables and between the math variables and race and gender. We first check informally for evidence of multicollinearity by dropping independent variables and examining the effects on the coefficients and standard errors. This process reveals no serious evidence that multicollinearity is a problem. In addition, we calculate the variance inflation factors (VIF) as another way to check for multicollinearity. This procedure also suggests that multicollinearity is not a problem.⁶

<Table 3 about here>

Because some students did not participate in the survey, we also have to address the problem of selectivity bias in our survey sample. The 1462 students for whom we have survey information were about 63.2 percent of the individuals who were enrolled in the four sections of introductory microeconomics. We do not have as much information on the students who did not take the survey, although we do know that, on average,

poorer students were more likely to have missed taking the survey. In Figure 1, we compare the distributions of the final grades earned in the course for the entire class and the sample of students who took the survey. The figure shows that, on average, students from the sample (Survey series) did better than the class as a whole (Class series). Those who took the survey averaged 73 percent of questions correct on all exams, whereas those who did not take the survey averaged only 64 percent of questions correct. We perform a Chi-squared test on the distribution of total points for those who took the survey and those who did not. The Chi-squared test indicates that there is a significant difference between students who did and did not take the survey ($\chi^2 = 56.86, p < 0.001$).

<Figure 1 about here>

In terms of our regression results, we argue that the selection bias is not a problem. Consider an equation determining attendance, with an error u . This equation can be represented as

$$Attendance_i = \alpha + \sum \beta_j x_{ij} + u_i, \quad (1)$$

where α is the constant and β_j is a vector of coefficients on the exogenous variables x_j for all observations, i . Importantly, all of the math variables are included in the vector of exogenous variables. We argue that the error term, u , is positively correlated with the error e in the grade equation (2) that specifies the relationship between a student's grade and a vector of explanatory variables:

$$Grade_i = \gamma + \sum \delta_j z_{ij} + e_i. \quad (2)$$

In this regression equation, γ is the constant and δ_j is the vector of coefficients on the exogenous variables z_j for all observations i . Such a relationship between the error terms would indicate that students who are more likely to attend class (and thus more likely to

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participate in the survey) are also more likely to get higher grades and have better math skills. For given values of the math variables, only observations with sufficiently high u_i values are observed in the data set, so the expected value of the error e is positive.

Furthermore, the higher the values of the math variables (math-quiz score, math ACT, not being required to take remedial math), the less high u_i has to be to put the observation in the data set, so there is a negative correlation between math skills and the expected value of the error, e . This expected value of the error is like an omitted variable in the grade equation. So when the regression (2) is run, this negative correlation between math variables and the expected e should cause the coefficients on the math variables to be underestimated. Thus, having the missing observations in our data set would only strengthen our results.

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For some students, we do not have values for two important explanatory variables: Some transfer students do not have ACT scores,⁷ and incoming freshmen do not have a university GPA. Because we do not want to drop the transfer students from our analysis, we replace their missing ACT scores with predicted ACT scores. Predicted ACT scores are found by an OLS regression of ACT score on explanatory variables that include information on a student's academic performance, individual characteristics, and family background. For all nontransfer students, the actual value of their ACT score is used.

To include first-semester freshmen in the analysis and use GPA as an explanatory variable, we create a categorical dummy variable for GPA. The reference category is "first-semester freshmen". Subsequent categories are created on the basis of ranges of

GPA; for example, one category includes all students with a GPA between 3.5 and 4.0, and another includes those with a GPA between 3.0 and 3.499.

RESULTS

In Table 4, we show the results from OLS regressions of “percent correct” on a range of explanatory variables. The results in Table 4 are for our preferred specification, in which we exclude some variables that do not pass an F-test. In addition, the results in Table 4 do not include some of the more subjective variables, such as self-reported motivation and attendance, and expected grade in the course. However, we did include these variables in some specifications, and we discuss the results below. The results for the quantitative-skills variables are fairly consistent across a wide variety of specifications. Additional results are available on request.

<Table 4 about here>

Further, in Table 4, we report on regressions for two different sub-samples. The first includes first-semester freshmen, and uses a set of dummy variables for GPA. In the second regression, we restrict the sample to those students who have been at the university for at least one semester, because these are the ones who have established a university GPA.⁸ We find that the most important determinants of student performance are GPA and the variables that measure math skills. We also find that the coefficient on the gender variable is significant: all else equal, men answered 1.76 percent more exam questions correctly than women in this course ($p < 0.01$).⁹ On the other hand, our coefficients indicate that race is not a very important variable.¹⁰

Our regressions indicate that previous study of economics (such as taking an economics course in high school or at another college) has no significant impact on student performance in this class.¹¹ Students who had previously taken an introductory *macroeconomics* course actually did slightly *worse*. One possible explanation is that, at our university, the first few weeks of introductory microeconomics are somewhat similar to the first few weeks of introductory macroeconomics. As a result, some students who have already had the introductory macroeconomics course may do well on the first examination, but they may then be lulled into complacency, and do less well later in the semester.

The number of weekly hours that students report working at paid jobs has a negative impact on the percentage of questions answered correctly in this class ($p < 0.01$). The same is true for hours spent participating in extracurricular activities ($p < 0.1$). On the other hand, the reported number of hours spent studying had a small, but positive impact on performance in the class ($p < 0.01$).

The math-quiz score is positively and significantly related to student performance, even after controlling for other measures of quantitative skill. This suggests that very basic math skills may be more important than previously recognized. Our coefficients indicate that, all else equal, a student who answers all 10 math questions correctly would have a higher score on the examinations than a student who is at the mean of the distribution of math-quiz scores ($p < 0.001$). The difference is about 1.61 percent of the examination questions correct. In addition, scoring a perfect 10 on the math quiz implies an improvement of 7.2 percent of the questions, relative to a student who received a zero

on the math quiz. In some cases, a difference this large would be sufficient to move the student from a course grade of 2.5 to a course grade of 3.5, on a 4.0 scale.

In addition to using the total number of math-quiz questions correct, we also ran a regression in which each math question is entered individually (*i.e.*, this regression has a set of ten dummy variables, one for each question on the math quiz). Math-quiz questions 1, 4, 6, and 7 are independently significant ($p < 0.01$). These questions deal with very basic concepts in arithmetic, algebra, and geometry. Thus, our regression results indicate that student achievement is associated with a variety of measures of quantitative skill, including measures of some very basic skills.

Students were not given a grade for taking the math quiz. This raises the question of whether the quiz is a reliable measure, because some students may not have felt motivated to try very hard.¹² We can examine the reliability of student scores on the math quiz by comparing them to other measures of student performance, such as their grade in the course, their GPA, their Math ACT score, and their score on the university's math-placement exam. In the case of the math quiz, measures of reliability (Cronbach's alpha) suggest that it is consistent with other measures of student math ability, and it is a reliable measure overall.

Continuing with the regression results of Table 4, all of the other variables representing quantitative skills are also statistically significant. The dummy variable for calculus has a coefficient of 2.83, indicating that a student who has had calculus would correctly answer 2.83 percent more of the exam questions than a student who has not had calculus, all else equal ($p < 0.001$). The coefficient on the dummy variable for having been required to take a remedial math course is -1.59 ($p < 0.05$). Students who are

required to take remedial math have deficiencies in their quantitative skills, and this has an effect on their performance in introductory microeconomics, even after controlling for other measures of mathematical skill. The student's score on the math portion of the ACT is also significant, with a coefficient of 0.58 ($p < 0.001$). Thus, all else equal, a one-point increase in the math ACT score is associated with an increase of 0.58 percent in the number of exam questions answered correctly.

If we combine the coefficients for calculus, the math quiz, and the remedial-math course, we see that our measures of quantitative skills have a very substantial effect on student performance. All else equal, a student who has had calculus and has a perfect score on the math quiz would be expected to answer 11.62 percent more exam questions correctly than a student who has had to take remedial math and who misses all of the questions on the math quiz. A difference of this magnitude would be certain to have a large effect on the student's grade in the course.¹³

Our results indicate that quantitative skills are multi-dimensional, and that several aspects of quantitative skill have independent effects. Thus, we do not mean to suggest that our simple math quiz is superior to the other variables. However, we believe it is appropriate to emphasize the importance of very basic math skills. This is because it may be possible for instructors to do something about deficiencies in these basic mathematical concepts, by providing or recommending remedial services. More importantly, it may be possible to do so sufficiently quickly that it has a beneficial effect on student performance in the introductory economics course. On the other hand, even though the calculus variable has explanatory power, the fact is that many students in introductory economics

courses have not had calculus, and there is probably not enough time to teach calculus on the side during an economics course.

Sensitivity tests are reported in Table 5. For each of the regressions reported in Table 5, the data set has been cleaned, by removing the students for whom we have reason to believe that their math-quiz score is unreliable. We first drop all students who fall into the bottom two categories in terms of motivation, attendance, or expected grades. (See Table 2.) In addition, columns 2 and 3 of Table 5 report the coefficients and t statistics for a regression similar to that in Table 4, but dropping students who scored a 5 or less on the math quiz, yet earned a 3.0 or better in the course. For the same regression, columns 4 and 5 report coefficients and t statistics, dropping students who scored 5 or less on the math quiz, but earned the mean or higher on the math portion of the ACT exam. Finally, in columns 6 and 7, we report coefficients and t statistics for the same regression, dropping students who scored 5 or less on the math quiz, but scored a 12 or above on the university's math-placement exam. (Students who get 12 or above on the math-placement exam are not required to take the remedial math class.) This meant dropping roughly 100 students in each of the three situations examined. Not surprisingly, our results are stronger for the selected subsample in all three cases. The coefficient on math-quiz score rises and becomes more significant statistically.

Similarly, looking at smaller subsets of the sample population, we also find that the results of the regression specified in Table 4 are highly robust. For example, we consider the more limited sample of all white sophomore and junior students who are required to take the class for their major, whose native language is English, who have no previous experience with economics, who do not attend infrequently or rarely, and who

report that they are at least somewhat motivated to do well in the course. This yields a sub-sample of 646 students. The coefficient on the math quiz in this case is 0.58 ($p < 0.05$), whereas the coefficient on calculus is 4.06 ($p < 0.001$) and the coefficient on remedial math is -3.45 ($p < 0.005$). The coefficients and significance levels of other important variables, such as gender, GPA, and ACT scores, are also highly similar to those of the original regression reported in Table 4. Other similarly homogenized sets of data tell the same story.

CONCLUSION

We study the determinants of success in an introductory microeconomics course, using data from a sample of 1462 students who took the course in the Fall Semester of 1998 or 1999. We measure math skills by the student's score on a test of very elementary mathematical concepts, such as the ability to calculate the slope of a line, or to calculate the area of a triangle, or to divide by a fraction. We also measure math skills by the student's score on the math portion of the ACT test, by whether the student has taken a calculus course, and by whether the student has been required to take a remedial math course.

We draw several conclusions from these results. Our first conclusion is of practical interest. We ran one set of regressions using official data from administrative records, and another set using student-reported data. The results from these two sets of regressions are very similar. This point may be important for those who desire to conduct similar studies. At many colleges, it is difficult to acquire administrative records, and it

may be considerably easier to acquire self-reported data. Because the two data sets give similar results, a case can be made for going with the data that are easier to obtain.

Our second conclusion is that quantitative skills are very important to success in introductory economics. Our third conclusion is that quantitative skills are sufficiently multidimensional that no single variable is likely to represent them adequately. The multiple measures of math achievement are relatively independent and are all statistically significant.

Our fourth conclusion is that extremely basic quantitative skills are among the most important. Further, the math-quiz variable allows us to identify the students most in need of help in microeconomics. We find that students who scored 6 or less on the math quiz were significantly more likely to get a course grade of 2.0 or worse in the course than those who scored 7 or more, after controlling for the other explanatory variables. Moreover, the basic skills are the ones that can be addressed most easily in a course in principles of microeconomics.

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NOTES

¹ The math quiz was developed based on years of teaching introductory microeconomics; several trial runs were performed in previous semesters, resulting in the final quiz reported in Table 1. The particular math concepts covered by the quiz are similar to those reviewed in introductory economics textbooks. Tests of reliability indicate that none of the questions should be eliminated.

² On average, students over-report their ACT score by 0.42 points, and they over-report their GPA by 0.10 points. The correlation coefficient between actual and reported ACT is about 0.77, and the correlation coefficient between actual and reported GPA is about 0.91. The small size of the overstatements is partly caused by the fact that a large number of students report with precision. In our sample, 529 students reported their official ACT score exactly, and 193 students reported their university GPA accurately.

³ Regression results using student self-reported data are only slightly different from regressions using the official university data for ACT score and university GPA. For the math, GPA, and ACT variables, neither the sign nor the significance level is sensitive to the type of data used. For example, when we move from the administrative-records regression to the regression with self-reported data, the coefficient on the math-quiz variable increases very modestly, from 0.72 to 0.80, and the t statistic increases from 3.66 to 4.16. For the calculus variable, the coefficient increases from 2.83 to 3.24, and the t statistic increases from 3.99 to 4.66.

⁴ However, it appears that students are much more optimistic on subjective questions, such as self-reported motivation and expected grade. Our students' excessive optimism is

apparent in Table 2: Some 97 percent of the students who participated in our survey reported that they expect to receive a grade of 3.0 or better for the course.

⁵ The correlations reported in Table 3 are for the official data from university administrative records. However, because the errors in the self-reported data are small, we find similar correlations among these variables when we use self-reported data.

⁶ The variance inflation factor (VIF) for coefficient j is found as $\frac{1}{1-R_j^2}$, where R_j^2 is the R-squared from regressing the independent variable x_j on the other independent variables included in the regression reported in Table 4. If the VIF values are greater than 10, there may be cause for concern. (See Chatterjee, Hadi, and Price 2000.) We find no individual VIF greater than 10, the highest being 8.28 for the dummy variable indicating that a student was a sophomore. All of the math variables have a VIF of 2.03 or less. The mean VIF for all variables is 2.66, which suggests that there is no serious multicollinearity.

⁷ We are missing ACT scores for 106 students. This is because transfer students with over 28 credits were not required to provide an ACT score for admission to the university.

⁸ We find no significant coefficients on any combination of interaction terms. We include a math-quiz-squared term in these regressions, and the evidence from the regressions suggests that the relationship between student performance in the class and the math quiz is not expressed better as a quadratic.

⁹ Anderson, Benjamin, and Fuss (1994) find that males do significantly better than females, and they are also unable to explain this result by controlling for math

background, previous course work, or other student characteristics. Lumsden and Scott suggest that males may do better on multiple-choice exams, whereas females do better on essay exams (1987, 370).

¹⁰ In this specification, Asians perform slightly better than whites, all else equal, and blacks and Hispanics perform slightly less well. However, the effects fall far short of statistical significance. Our sample contains relatively few minority students, so the differences across race would have to be large to generate statistical significance. Blacks and Hispanics did not do significantly worse (or better) on the math quiz than their white counterparts, and they were no more or less likely to have taken calculus. However, blacks and Hispanics were more likely to have taken remedial math, and they did significantly worse on both the verbal and math portions of the ACT exam.

¹¹ Durden and Ellis (1995) and Brasfield, Harrison, and McCoy (1993) find a significant and positive relationship between previous course work in economics and student success in a college economics course. However, Palmer, Carliner, and Romer (1979) and Reid (1983) find that high-school economics has no impact, or a negative impact, on student success in introductory college economics courses.

¹² Note that the survey was given at the beginning of the class period. Thus, we were able to avoid a situation in which students would desire to rush through the survey, in order to get out of class more quickly.

¹³ In another investigation of the explanatory strength of the measures of quantitative skills, we normalize the math variables (by subtracting the mean value for the variable from each individual observation, and dividing by the standard deviation), and then run

the regression again. In this case, the coefficient on the ACT math score is the largest, followed by the coefficients for calculus and the math quiz.

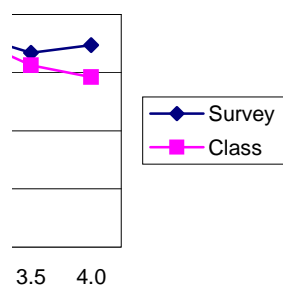
Course Grade	Survey Proportion	Class Proportion
0.0	0.0951	0.1089
1.0	0.0294	0.0316
1.5	0.0568	0.0702
2.0	0.1361	0.1389
2.5	0.1594	0.1644
3.0	0.1826	0.1796
3.5	0.1669	0.1562
4.0	0.1737	0.1461

Survey Percentage	Class Percentage	Course Grade
9.51	10.89	0.0
2.94	3.16	1.0
5.68	7.02	1.5
13.61	13.89	2.0
15.94	16.44	2.5
18.26	17.96	3.0
16.69	15.62	3.5
17.37	14.61	4.0

FIGURE 1. Grade Distribution



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TABLE 1

Math Quiz and Results

1. Solve the following system of equations for x:

$$x = y - 6$$

$$y = 10$$

(a) -60 (b) 10/6 (c) 3 (d) 4 (e) -4

97.81 percent of the class answered this question correctly as (d).

2. Solve the following system of equations for x:

$$y = 2x + 3$$

$$y = 3x$$

(a) 0 (b) 3 (c) 3/5 (d) -3/2 (e) none of the above

87.14 percent answered this question correctly as (b).

3. Suppose that $x = \frac{a}{b}$. Then if $a = 6$ and $b = 2$, solve for x.

(a) 12 (b) 8 (c) 3 (d) 4 (e) 1/3

98.29 percent answered correctly as (c).

4. Suppose that $x = \frac{a}{b}$. Then if $x = 4$ and $b = 2$, solve for a.

(a) 1/2 (b) 2 (c) 4 (d) 8 (e) 16

88.03 percent answered correctly as (d).

5. Suppose that $x = \frac{a}{b}$. Then if $x = 4$ and $a = 8$, solve for b.

(a) 1 (b) 2 (c) 32 (d) 4 (e) 1/2

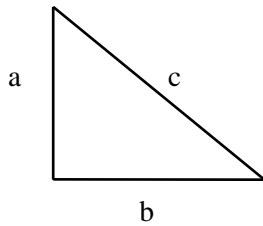
80.03 percent answered correctly as (b).

6. Perform the following division: $\frac{1/2}{2/3}$

(a) 3 (b) 3/2 (c) 3/4 (d) 4/3 (e) 1/3

71.48 percent answered correctly as (c).

7. Find the area of the right triangle drawn below.

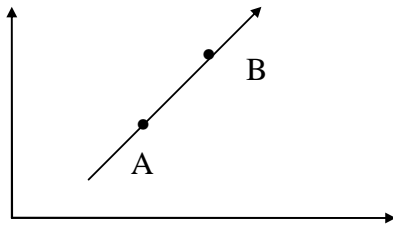


The length of side $a = 3$ and the length of side $b = 4$, and the length of side $c = 5$. The area of the triangle is:

- (a) 3 (b) 4 (c) 6 (d) 12 (e) 25

66.55 percent answered correctly as (c).

8.

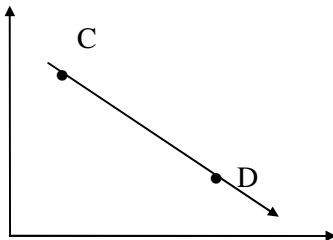


The coordinates of point A are (1,2) and the coordinates of point B are (2,4). Find the slope of the line.

- (a) $1/2$ (b) 1 (c) -1 (d) 2 (e) -2

76.13 percent answered correctly as (d).

9.



The coordinates of point C are (1,4) and the coordinates of point D are (5,2). Find the slope of the line.

- (a) $1/2$ (b) $-1/2$ (c) 2 (d) -2 (e) $5/4$

71.55 percent answered correctly as (b).

10. Suppose you want to carpet a rectangular room that is 6 feet by 12 feet. Carpet costs \$10 per square yard. Note that 1 yard = 3 feet. How much does it cost to carpet the room?

- (a) \$720 (b) \$2160 (c) \$240 (d) \$80 (e) \$8

40.15 percent answered correctly as (d).

TABLE 2
Description of the Variables

Variable	Number	Percentage	Mean	Standard Deviation
Age			19.65	2.30
18 or less	280	19.15		
19	627	42.89		
20	318	21.75		
21	125	8.55		
22 to 30	105	7.18		
31 and older	7	0.01		
Class				
Freshman	280	19.15		
Sophomore	798	54.58		
Junior	313	21.41		
Senior	59	4.04		
Other	12	0.82		
Gender				
Female	699	47.81		
Male	763	52.19		
Ethnicity				
White	1218	83.31		
Hispanic	25	1.71		
Black	84	5.75		
Asian	89	6.09		
Other	46	3.15		
College of Business Major				
Yes	596	40.77		
No	708	48.43		
Undecided	158	10.81		
Class Required for Major				
Yes	1128	77.15		
No	160	10.94		
Don't know	174	11.90		
English is Native Language				
Yes	1377	94.19		
No	85	5.81		
Economics in High School				
Yes	569	38.92		
No	893	61.08		
Economics at Another College				
Yes	165	11.29		
No	1297	88.71		
Previously Taken Micro				
Yes	57	3.90		
No	1405	96.10		

TABLE 2
Description of the Variables (Continued)

Variable	Number	Percent	Mean	Standard Deviation
Previously Taken Macro				
Yes	273	18.67		
Concurrently	128	8.76		
No	1061	72.57		
Weekly Hours Work for Pay			8.20	9.62
Weekly Hours in an Extracurricular Activity, Other than work for pay			7.09	6.76
Weekly Hours Study for All Courses			14.31	8.69
Motivation				
Very highly motivated	663	45.35		
Fairly highly motivated	689	47.13		
Somewhat motivated	100	6.84		
Not very motivated	6	0.41		
Very unmotivated	4	0.27		
Reported Absences				
Never miss class	579	39.60		
Fewer than 5 missed per semester	754	51.57		
Between 5 and 10 missed per Semester	122	8.34		
Attend infrequently	4	0.27		
Rarely attend	3	0.21		
Mother's Education				
Graduate or professional school	414	28.36		
Bachelor's degree	469	32.12		
Some college, no bachelor's degree	292	20.00		
High school diploma	244	16.71		
Did not complete high school	41	2.81		
Father's Education				
Graduate or professional school	307	21.01		
Bachelor's degree	431	29.50		
Some college, no bachelor's degree	387	26.49		
High school diploma	304	20.81		
Did not complete high school	32	2.19		

TABLE 2
Description of the Variables (Continued)

Variable	Number	Percent	Mean	Standard Deviation
College GPA*			2.80	0.53
4.0 to 3.5	238	16.28		
3.49 to 3.0	320	21.89		
2.99 to 2.50	367	25.10		
2.49 to 2.00	231	15.80		
1.99 or less	73	4.99		
First-semester freshman (No GPA)	233	15.94		
Math Score			7.77	1.81
10 Correct	239	16.35		
9	365	24.97		
8	320	21.89		
7	215	14.71		
6	147	10.05		
5	91	6.22		
4	52	3.56		
3	19	1.30		
2	8	0.55		
1	4	0.27		
0	2	0.14		
Actual Course Grade			2.61	1.16
4.0	254	17.37		
3.5	244	16.69		
3.0	267	18.26		
2.5	233	15.94		
2.0	199	13.61		
1.5	83	5.68		
1.0	43	2.94		
0.0	139	9.51		
Expected Grade				
4.0	332	22.71		
3.5	691	47.26		
3.0	403	27.56		
2.5	33	2.26		
2.0 or less	3	0.21		
ACT Score			23.09	3.35
Calculus				
Yes	882	60.33		
No	580	39.67		
Remedial Math				
Required	348	23.80		
Not required	1114	76.20		

* The mean is calculated excluding first-semester freshmen, who do not yet have a college GPA.

TABLE 3
Correlation Coefficients Among Selected Variables

	Math-Quiz Score	Calculus	Remedial-Math Course	ACT English Score	ACT Math Score	GPA	Course Grade*
Math-Quiz Score	1.00	0.37	-0.30	0.23	0.43	0.19	0.28
Calculus	0.37	1.00	-0.25	0.13	0.33	0.11	0.24
Remedial-Math Course	-0.30	-0.25	1.00	-0.19	-0.38	-0.17	-0.23
ACT English Score	0.23	0.13	-0.19	1.00	0.51	0.32	0.29
ACT Math Score	0.43	0.33	-0.38	0.51	1.00	0.31	0.42
GPA	0.19	0.11	-0.17	0.32	0.31	1.00	0.55
Course Grade*	0.28	0.24	-0.23	0.29	0.42	0.55	1.00

* Course Grade is the student's grade for the introductory microeconomics course as a whole, on a 4.0 scale. (See Figure 1 for the distribution of the course grades.)

TABLE 4
Regression Results (Dependent Variable = Percent Correct)

Variables	All Students		All But First-Semester Freshmen	
	Coefficient	t statistic ^a	Coefficient	t statistic
Male	1.76	2.77***	1.82	2.61***
Class ^b				
Sophomore	3.21	1.85*	3.12	1.78*
Junior	4.43	2.43**	4.30	2.32**
Senior	2.88	1.26	3.10	1.35
Other	15.41	4.07***	15.83	4.12***
Race ^c				
Hispanic	-0.41	-0.16	-0.87	-0.44
Black	-1.75	-0.98	1.13	0.38
Asian/Pacific Islander	1.17	0.90	1.74	1.16
Other	0.07	0.03	0.87	0.37
Hours worked at paid job per week	-0.10	-3.06***	-0.11	-3.05***
Hours in activities (incl. sports)	-0.08	-1.67*	-0.04	-0.80
Hours study per week	0.11	3.10***	0.09	2.03**
Economics in high school	-0.38	-0.62	-0.27	-0.38
Micro principles taken before	1.21	0.75	0.85	0.50
Taken macro principles	-0.91	-2.28**	-0.92	-2.22**
GPA ^d			3.75	12.33***
GPA 1.99 or less ^d	-11.08	-4.87***		
GPA 2.0-2.49 ^d	- 8.41	-4.23***		
GPA 2.5-2.99 ^d	- 3.55	-1.86*		
GPA 3.0-3.49 ^d	1.14	0.59		
GPA 3.5-4.0 ^d	2.22	1.13		
Required for major	0.11	0.23	0.22	0.38
Calculus taken	2.83	3.99***	3.08	3.95***
Remedial math course required	-1.59	-2.02**	-1.74	-2.05**
Math-quiz score	0.72	3.66***	0.63	2.95***
ACT math score	0.58	5.26***	0.51	4.17***
ACT English Score	0.26	3.04***	0.26	2.45***
Took course in 1999	0.86	1.41	1.00	1.64*
Constant	40.89		23.81	
R-squared	0.2919		0.2905	

^a Significance levels are indicated as: *=10%, **=5%, and *** =1%.

^b In the regressions for all students (on the left side of the table), the reference category is freshmen (who do not yet have a college GPA). In the nonfreshman sample, the reference category is second-semester freshmen (who have a college GPA).

^c The reference category is “white.”

^d In the regressions for nonfreshmen (on the right side of the table), every student has a value for GPA. However, in the regressions for all students (on the left side of the table), a substantial number are first-semester freshmen, who do not yet have a GPA. Therefore, in these regressions, we employ a set of dummy variables, in which the excluded category is first-semester freshmen.

TABLE 5
Sensitivity Results (Dependent Variable = Percent Correct)

Variables	Dropped Those Where Quiz is Inconsistent with Final Grade ^e		Dropped Those Where Quiz is Inconsistent with Math ACT Score ^f		Dropped Those Where Quiz is Inconsistent with Math Placement Exam ^g	
	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic
Male	1.67	2.59***	1.48	2.27**	1.75	2.67***
Class ^b						
Sophomore	2.32	1.29	2.51	1.41	2.04	1.15
Junior	3.09	1.63*	3.49	1.86*	2.96	1.58
Senior	1.82	0.77	2.46	1.04	1.92	0.81
Other	14.02	3.72***	14.15	3.75***	14.24	3.63***
Race ^c						
Hispanic	-2.45	-1.35	-2.98	-1.62*	-3.07	-1.66*
Black	-0.53	-0.21	-1.34	-0.51	-1.37	-0.52
Asian/Pac. Is.	0.76	0.57	0.28	0.20	0.24	0.18
Other	-0.22	-0.10	-0.04	-0.02	-0.51	-0.23
Hours paid work	-0.10	-2.86***	-0.10	-2.94***	-0.10	-2.89***
Hours in activities	-0.76	-1.63*	-0.05	-1.03	-0.06	-1.35
Hours study/week	0.11	3.05***	0.11	2.89***	0.11	2.94***
Econ. in high sch.	-0.55	-0.87	-0.35	-0.54	-0.41	-0.65
Taken micro before	2.89	1.70*	3.45	2.00**	2.94	1.73*
Taken macro	-0.91	-2.26**	-0.96	-2.35**	-0.98	-2.39**
GPA ^d						
GPA 1.99 or less ^d	-10.17	-4.38***	-10.36	-4.45***	-9.64	-4.14***
GPA 2.0-2.49 ^d	-7.01	-3.42***	-7.41	-3.63***	-6.85	-3.36***
GPA 2.5-2.99 ^d	-2.93	-1.48	-3.07	-1.56	-2.16	-1.10
GPA 3.0-3.49 ^d	2.20	1.10	1.96	0.99	2.87	1.45
GPA 3.5-4.0 ^d	3.42	1.70*	3.35	1.67*	3.92	1.95**
Required for major	-0.11	-0.23	-0.06	-0.13	0.03	0.06
Calculus taken	2.35	3.25***	2.64	3.64***	2.53	3.46***
Remedial math course required	-1.47	-1.83*	-1.44	-1.76*	-1.63	-1.99**
Math-quiz score	1.23	5.67***	0.84	3.75***	0.81	3.69***
ACT math score	0.53	4.69***	0.56	4.87***	0.57	5.04***
ACT English score	0.28	2.85***	0.29	2.92***	0.25	2.54***
Took in 1999	1.24	2.02**	1.03	1.66*	1.05	1.68*
Constant	35.11		36.92		38.02	
R-squared, N	0.31, 1381		0.30, 1362		0.30, 1360	

^a Significance levels are indicated as: *=10%, **=5%, and *** =1%.

^b The reference category is freshmen (who do not yet have a college GPA).

^c The reference category is "white."

^d The reference category is first-semester freshmen.

^e Students whose math-quiz score was less than or equal to 5, and whose overall grade in the course was 3.0 or higher are dropped.

^f Students whose math-quiz score was less than or equal to 5, and whose Math ACT score was greater than 22 (the mean score) are dropped.

^g Students whose math-quiz score was less than or equal to 5, and whose university math-placement exam score was higher than 12 (no need for remedial math) are dropped.