DO ENTRY-LEVEL MATH SKILLS PREDICT SUCCESS IN PRINCIPLES OF ECONOMICS?

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ABSTRACT

Principles of economics relies on a rudimentary knowledge of mathematics, whether it is algebra or the use and understanding of graphs. The math skills that students bring into the principles course may greatly affect their eventual performance. In this paper, we show that outcomes on a math pre-test provide instructors with an early-warning signal of potential difficulty in principles of economics. Our statistical analysis indicates that, holding constant a variety of other factors, performance on the math pre-test and final grades are positively and significantly related. One implication of this result is that instructors armed with the results of the pre-test may be able to intervene, enhance at-risk students' math skills and improve student performance in principles of economics.

INTRODUCTION

Using mathematics to explain economics, while second nature to most instructors, often leaves students bewildered. And by mathematics we do not mean the specialized mathematical skills discussed in Becker (1998). Rather, we refer to a rudimentary understanding of algebra and arithmetic that are needed in a principles course to calculate index numbers, percentages and averages, and a fundamental grasp of graphs and charts that are predominant in principles of economics texts. To determine just how resources should be allocated to bring students' math skills up to a level that enhances success in a principles of economics class, it is essential to gauge the students' math skills early in the course. Few instructors assess their students' math capabilities before they delve into economic discussions that require some math knowledge. If a basic level of math skill is essential for understanding (and success in) principles of economics,

some front-end analysis may help alleviate student anxiety and lackluster performance in economics.

In this paper we assess the relationship between students' entry-level math skills and their performance in principles of economics. To gauge the student's basic math knowledge, we conduct a short pre-test is given in the first week of the semester. The results reported in this paper are based on data taken from several of our sections of principles taught at in the fall semester of 1997. Does a student's score in the math pretest provide a significant indicator of performance in principles of economics? Looking ahead, we find that, after holding a number of other factors constant, the answer to that question is yes.

DESCRIPTION OF THE EXPERIMENT

The experimental design is similar to the analyses of Evensky, et al. (1997), Anderson, Benjamin and Fuss (1994), Simkins and Allen (1997), and Dale and Crawford (2000), among others. (Siegfried and Walstad (1998) and Becker (1997) provide discussions of related studies.) In the Evensky study, for example, students in the introductory economics course at Syracuse University were given a 22-question quiz to assess their ability to interpret graphs. While graphical skills are important, so too is a basic knowledge of algebra and arithmetic. With that in mind, the math pretest we have constructed and use consists of 15 questions covering a broad range of math skills, including calculating the slope of an equation, determining a percentage change, plotting the relationship between two variables, and calculating an average. (A copy of the pretest is available on request.) This test is administered in class during the first week of the semester. Scores on this test are used to determine if performance on the math pretest, ceteris paribus, predict performance in principles of economics.

To determine the usefulness of the math pre-test score as an indicator of success in principles, a number of conditioning variables were collected for the statistical analysis. Previous work has found that the most important variable is the student's GPA. This measure serves as a portmanteau variable which captures the students' overall academic ability and, a priori, should be positively related to the final grade in principles of economics. Indeed, numerous studies have found that the GPA is the most important variable when included in a regression to explain student performance. Simkins and Allen (1997), for example, report that GPA is the dominant variable, eclipsing even SAT scores.

Siegfried and Walstad (1998) survey other studies that find the GPA to be significant.

TABLE 1
Student Characteristics (N = 271)

Characteristic	Percent of Sample
Age	
17-21	77
22-26	18
27-31	3
32+	2
Race	
Asian	4
Black	9
Hispanic	2
White	83
Other	2
Gender	
Female	40
Male	60
Hours Worked	
0	16
0<H<10	10
10<H<20	26
20<H<30	27
30<H<40	13
H>40	7
Living Arrangements	
Home	42
Campus	36
Off-campus, not home	21
Prior Math	
High School Algebra	21
College Math[1]	79
Prior Statistics	
Yes[2]	28
No	72
Prior Economics	
Yes[3]	27

	No	73
1	Includes college algebra and calculus.	
2	Includes business statistics or math statistics.	
3	Includes micro, macro or high school economics.	

A number of demographic variables also were collected to account for differences in living conditions--home versus on-campus--age, hours worked, etc. The data for these measures are based on responses to a questionnaire that was administered at the same time as the pretest. (A copy of the questionnaire is available on request.) The demographic variables used and the summary results of the questionnaire are reported in Table 1. Based on the responses to the questionnaire, the "average" student in our sample is a white male, aged 17-21, who works part-time, lives away from home, has had some college math, no statistics and no economics, prior to completing the test and the questionnaire.

To test the importance of scores on the math pretest as an indicator of success in principles of macroeconomics, we estimated the regression

$$(1) \quad FINAL_i = a_0 + b_1 MATH_i + b_2 GPA_i + c_{ij} TRAIT_{ij} + e_i$$

where FINAL represents the ith student's grade in the course (expressed as a percent of total possible points), MATH is the percentage correct on the pretest, GPA is the student's grade point average, and TRAIT is a catch-all variable that includes the j characteristics listed in Table 1. The terms a, b_i $(i=1,2)$ and c_{ij} are parameters to be estimated, and e is an error term. To account for the demographic characteristics, each trait is measured as a (0,1) variable depending on the response. We expect the signs on b_1 and b_2 to be positive.

In addition to the demographic characteristics included under TRAIT, an additional variable was used to capture any differential effects between instructors. This variable is labeled INSTRUCTOR. It is important to recognize that the INSTRUCTOR variable actually may reflect several factors at work. One is the fact that the instructors are of different gender. Another is that some instructors approach economics in a more math-intensive manner than others. Butler, et al. (1994), for example, found that whether math matters was a function of the instructor. This variable also may reflect institutional differences; for

instance, in our test one school is a liberal arts institution while the other is a more comprehensive university. It may be, therefore, that these commingled traits explain differences in estimated MATH coefficients. We address this issue below when we discuss the statistical results.

EMPIRICAL RESULTS

The data were obtained from sections of our principles of economics at Lindenwood University and at SIUE in the fall semester of 1997. Our sample, totaling 271 students, includes those students who took the math pretest and completed the course. Theoretically, selection bias caused by students dropping the course may affect the results. The small number of students included in this group--less than 10 percent of the total--and the fact the previous studies in which OLS results are compared with more sophisticated estimation techniques finds little difference suggests that the marginal return of not using OLS is minimal.

The results of estimating equation (1) are found in Table 2. It is worthwhile to briefly discuss the results for the TRAIT variables first, primarily because of the vast amount of previous work. For example, the results indicate that maturity (AGE) produces no statistically significant advantage. This outcome is similar to the findings reported by Siegfried and Fels (1979) and Dale and Crawford (2000). It differs from other analyses discussed in Siegfried and Walstad (1998) where older students are found to perform better than younger students. One explanation for this difference may be the fact that our age measure uses fairly wide ranges and may not be able to capture slight differences in effect from changes in age. (Combining age groups into broader ranges does not alter our finding.) We also find that gender does not account for any statistically different result in the final grade. It appears that ceteris paribus gender does not explain differences in final grades in principles. Finally, based on our sample, race, the number of hours worked and living conditions are not statistically related to performance.

The two trait measures that do achieve statistical significance are INSTRUCTOR and STATISTICS. As mentioned earlier the INSTRUCTOR variable may reflect a number of differences between the principals of this experiment. To test whether INSTRUCTOR accounts for the importance of MATH, equation (1) also was estimated with an interaction term between INSTRUCTOR and MATH to test whether there is any slope change. Specifically, the estimated coefficient on the interaction term is -0.06 with a

t-statistic of -0.99. The estimated coefficient on the MATH variable is unaffected. The results indicate that there is no such effect.

What is striking is that while STATISTICS is positively and significantly associated with a higher final grade, the same is not true for having had economics and college mathematics: for these two variables, neither is significantly related to the final grade in principles.

TABLE 2
REGRESSION RESULTS

Variable	Coefficient	t-Statistic
Constant	30.21	9.85
Math	0.15	5.44
GPA	10.29	11.96
INSTRUCTOR	6.55	3.97
AGE		
22-26	2.45	1.49
27-31	1.66	0.48
32+	-3.31	-0.81
RACE		
Asian	0.08	0.03
Black	-2.61	-1.20
Hispanic	3.69	0.78
Other	-2.93	-0.70
GENDER		
Male	-0.30	-0.25
WORK		
0-10	2.50	1.14
10-20	-1.61	-0.94
20-30	1.43	0.83
30-40	1.99	0.98
40+	-3.49	-1.53
LIVING ARRANGEMENTS		
On-campus	-1.16	-0.76
Off-campus, not home	1.21	0.77

PRIOR MATH	1.09	0.75
STATISTICS (yes)	3.10	2.32
ECONOMICS (yes)	0.96	0.82
N = 271 Adj-R^2 = 0.56 SEE = 9.03 F = 17.25		

The significance of STATISTICS may reflect the different skills taught in these courses. For example, statistics courses may provide a firmer foundation in the kind of reasoning that is useful in economics. The failure of prior economics to explain performance in principles, while disconcerting, actually is consistent with the Simkins and Allen (1997) and Dale and Crawford (2000) studies, both of which found that students did not retain basic economic skills.

Turning now to the variables of interest, the results indicate that the score on the math pretest (MATH) and the GPA are positively and significantly related to students' final grade in principles of economics. Specifically, we find that for every 1 grade-point level increase in the student's GPA there is an associated 10 percentage point increase in the student's final grade in the principles course. The result for GPA is consistent with expectations and most experiences: better students are likely to do better in class.

The results also indicate that the score on the math pretest is significantly related (t=5.44) to student performance in principles of economics. The estimated coefficient indicates that an increase in the math pretest score of 10 percentage points (effectively 1.5 questions) is associated with an increase in the final course grade of 1.5 percentage points. This finding suggests that the results from this pretest, administered early in the semester, can provide instructors with useful information regarding their students' math skills. More importantly, this information that may help isolate at-risk students who, without intervention, are likely do poorly in the course.

Several specification tests were conducted to determine the joint statistical significance of variables included in the regression. For example, using an F-test we were able to reject the hypothesis that the variables included under the heading TRAIT were jointly insignificant. The F-statistic from this test is 57.47, significant at the 1 percent level. Similarly, testing for the joint significance of the MATH and GPA variables yields an F-statistic of 187.94, also significant at the 1 percent level.

We also experimented with several alternative specifications to gauge the robustness of the results reported in Table 2. For example, since only the INSTRUCTOR and STATISTICS variables are individually significant at the 5 percent level, what would be the effect of omitting the other trait measures? We addressed that question using an F-test based on omitting the rest of the trait measures. This test yields an F- statistic of 24.67, which is significant at only the 10 percent level. This outcome suggests that a more parsimonious specification is one that includes only the trait variables INSTRUCTOR and STATISTICS. Equation (1) was re-estimated including only these two trait measures along with the math and GPA variables. The result of estimating this pared down specification is (t-statistics in parentheses):

(2) FINAL=30.81 + 0.17 MATH + 10.26 GPA + 6.44 INSTRUCTOR + 3.05 STATISTICS
(13.54) (6.50) (2.32) (4.29)
(2.37)

Adj-R2 = 0.55 SEE = 9.14 F = 82.56

Even in this more compact model, it remains true that the estimated coefficients on the math pretest score and GPA are positive and statistically significant.

CONCLUSIONS

Are a student's entry-level math skills an important indicator of performance in principles of economics? Based on a sample of 271 students, we find that after accounting for the demographic characteristics, GPA, and previous courses in economics, math and statistics, the answer is yes. The results reported in this study have several important implications for economics instructors. One is that we probably should pay more attention testing and enhancing our students' math skills. While there has been increased emphasis on learning-by-writing approaches to economics and other disciplines, our results suggest that pursuing this pedagogy in lieu of improving or reinforcing students' math skills may produce students who do poorer in principles of economics.

Another implication is that instructors have at their disposal a relatively low marginal cost process to identify students for whom a math review would be highly advantageous to their understanding of economics. By assessing students' math skills early in the course, the instructor has an early-warning signal of

potential at-risk students. This information allows instructors to intervene, to provide remedial math instruction or to alter the content of the course.

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