CENTER FOR ANALYSIS OF POSTSECONDARY EDUCATION AND EMPLOYMENT

The Labor Market Returns to Math in Community College: Evidence Using the Education Longitudinal Study of 2002

A CAPSEE Working Paper

Clive Belfield
Queens College, City University of New York

October 2015

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305C110011 to Teachers College, Columbia University. The opinions expressed are those of the author and do not represent views of the Institute or the U.S. Department of Education. This paper uses restricted-use data from the Education Longitudinal Study of 2002.

Abstract

This paper examines the returns to math courses relative to those in courses in other subjects for students who started their postsecondary education at community college. The limited available evidence presumes that college-level math is valuable in the labor market relative to other coursework. Using data on college transcript and earnings from the Education Longitudinal Study of 2002, I estimate the relative effects of college-level math on attainment and earnings in early adulthood. I find clear attainment effects: college-level math is more strongly associated with receiving a college award than is college-level coursework in other disciplines. However, when controlling for attainment, there is little evidence that math courses are associated with increased earnings. The overall effect of math coursework on earnings is therefore modestly positive or close to zero. I also find that high school math and college-level math are positively correlated: failure to control for college-level math leads to an upward bias in estimating the effects of high school math on earnings. Finally, it is worth noting that, given high student transfer rates, it is important to have transcript information for all colleges attended by a given student when conducting this kind of analysis. The amount of college-level math coursework completed by community college students is almost doubled in the current study when accounting for math courses at all colleges attended by each student.

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1. Introduction

Prior evidence has found math skills to be especially valuable in boosting attainment and earnings (Duncan et al., 2007; Jamison, Jamison, & Hanushek, 2007; Rose & Betts, 2004). Math skills may help students progress through high school and college; with more attainment or credentials, students may then earn more in the labor market (Aughinbaugh, 2012). More directly, math skills may boost earnings if they are relatively valuable in the labor market or lead to occupations that are high-paying. From a policy perspective, these arguments have led to significant pressure for programs to improve students' math skills at all levels of education (Hodara, 2013).

However, little research attention has been paid to college-level math; almost all the research to date has studied high school math. Thus far, the limited evidence does not show clear benefits from college-level math. In a recent paper, Belfield and Liu (2015) examined the relative effects of math and other subjects on the attainment and earnings of a large sample of community college students. They found that college-level math coursework does increase award completion more than accumulated coursework in other subjects. However, they found mixed evidence on the direct effect of enhanced math skills on earnings over other college-level skills. Overall, the combined direct plus indirect effects appear to be adverse on earnings. The combined effect is modest, sensitive to modeling, and heterogeneous by gender, race/ethnicity, and ability. These results do not indicate a clear priority for taking math courses over other courses in other disciplines in community college.

In this paper, I estimate the labor market returns to college math for community college students using a similar approach to Belfield and Liu (2015). After a brief review of the evidence on the presumed importance of math skills, I estimate the effects of college-level math on both attainment and earnings using restricted-use data from the Education Longitudinal Study of 2002 (ELS:2002), a nationally representative sample of over 16,000 youth who were in 10th grade in 2002 and who were most recently surveyed in 2012. Following Belfield and Liu (2015), I focus on students who started their postsecondary education at community college and estimate overall and subgroup effects. As a new comparison, I perform a parallel analysis for students who started at a four-year college; I also consider the extent of omitted variable bias from looking only at high school math performance. In the conclusion, I discuss the implications of the study's findings on the importance of enhancing math skills in college.

2. The Economic Value of Math Skills

Math Skills in High School and College

A substantial body of research highlights the importance of math course-taking for completing high school (Bozick & Lauff, 2007; Lee & Burkam, 2003; Zvoch, 2006). In turn, high school math affects college attendance and placement into developmental courses (sometimes called remedial courses) (Aughinbaugh, 2012; Cortes, Goodman, & Nomi, 2013; Long, Iatarola, & Conger, 2009). Hence, more high school math should improve labor market outcomes if only because it is associated with greater human capital attainment. Indeed, most evidence has found that math skills—measured during high school—have a powerful effect on earnings (see Altonji, Blom, & Meghir, 2012, Table 2; summary in Belfield & Liu, 2015, pp. 2–4). The associations do however vary by gender, race/ethnicity, and ability.[1]

In contrast, the research on the value of college math is sparse. Some attention has been paid to developmental math, which has not been found to be unambiguously beneficial (Bailey, Jeong & Cho, 2010; Hodara & Xu, 2014; Martorell & McFarlin, 2011). The implications of this for college-level math are unclear. Using the National Education Longitudinal Study of 1988, Adelman (2006) did find some—but not consistent—evidence that college-level math courses are important for bachelor's degree receipt. At the four-year college level, majoring in math yields high labor market returns (Melguizo & Wolniak, 2012; Olitsky, 2012; Thomas & Zhang, 2005), and at the community college level, more quantitative majors are associated with higher earnings (Belfield & Bailey, 2011). Again, it is not clear what this implies for the majority of students who are taking math requirements.

The focus of this paper is on the returns to general math skills across the population of community college students. Few of these students are math majors, and many who begin as math majors either transfer to a four-year institution, do not complete, or switch majors. Rather, most community college math courses are for non-math majors who typically struggle to complete their college-level math courses even as these are either required or at least strongly recommended. It is these courses—mainly for students who are struggling at math—that are the subject of reform initiatives (Hodara, 2013). At issue is whether these courses are in fact more valuable than other, non-math courses.

In addition, the current analysis is relevant for the large evidence base on high school math. That evidence base often does not distinguish between the direct and indirect effects of high school math. It is possible that high school math boosts attainment, which is then associated with higher earnings, and that math skills *per se* are not relatively beneficial in the labor market. More importantly, students who do well in math in high school take more (advanced) math in college, so the high school math effect might partially be attributable to enhanced college math

[1] These studies include Blackburn (2004); Gaertner, Kim, DesJardins, and McClarty (2014); Goodman (2012); Hanushek (2006); Koedel and Tyhurst (2012); Rose (2006); Rose and Betts (2004).

skills. High school math might prepare students for their college math requirements: these students might more easily pass their college math requirements or avoid developmental math and so advance more quickly toward completion (Rose & Betts, 2004, p. 503). If college math affects earnings, then the role of high school math—insofar as it is correlated with college math—needs to be reinterpreted. Earnings equations that include only high school math variables—but not college-level math—may suffer from omitted variable bias.

Finally, few studies directly compare math course-taking patterns with other patterns. Even if math is beneficial, other courses—or course sequences—may be equally or more beneficial. If more students are required to take math, then the pool of math students will include those with little aptitude for or interest in math; these students may accumulate less human capital from a math course than from a course for which they were prepared or which they had chosen voluntarily; or, they may impose negative peer externalities (e.g., if material is simplified to accommodate those with fewer math skills). Also, these college-level math courses may be the terminal levels of math students take or may be unrelated to subsequent coursework; as such, they will not serve as useful preparation for future courses. Finally, if the job tasks performed by community college students do not require math skills (e.g., if computerization has reduced the need for general numeracy skills), these courses are unlikely to increase productivity. Of course, if colleges require (or strongly encourage) math coursework, then there will still be an attainment effect. Nevertheless, math may have a negative direct effect on earnings, which may partially offset or even dominate any positive attainment effect.

Extending Prior Analysis

These issues are addressed in part by Belfield and Liu (2015). For a large sample of community college students, the authors found mixed evidence overall. Relative to other coursework, credits in math are associated with higher probabilities of award receipt, although a non-trivial proportion of students take no math in college. The association between math coursework and earnings is inconclusive. Relative to other credits or pathways, there is sparse evidence that math has a strong impact on earnings and some evidence that it has a weak one. One inference is that the positive attainment effect is offset by a negative direct effect: math helps students graduate, but the specific math skills acquired in community college are not especially valuable in the labor market. The results should be interpreted cautiously because of the heterogeneity by gender, race/ethnicity, and (college-level) ability. Yet, Belfield and Liu did not have measures of high school ability in their dataset and so were unable to test for the importance of omitted variable bias. As well, their transcript data did not include information on courses taken at colleges other than the initial community college. Information was therefore not available on math courses taken by students who transferred to other colleges.

These findings suggest that further research is needed. This paper begins by following the analytical approach used in Belfield and Liu (2015). I test to see if their pattern of results can be replicated using alternative data: that of ELS:2002. The ELS:2002 dataset has detailed information on both high school and college-level math coursework, including courses taken at every postsecondary institution attended by the student, and it has data on earnings (at age 26). I am able to derive results using a similar specification to Belfield and Liu (2015). As a further comparison I look at the effects of math on students who started at four-year colleges. This group may too experience a positive attainment effect but an unknown direct effect of math coursework. I test for these associations using information on math at the first college attended as well as math at all colleges attended. Finally, by linking high school and college transcripts, I am able to look at high school math and test for omitted variable bias in earnings equations.

3. Model for Estimating Returns to Math Courses

The modeling approach used in this paper follows Belfield and Liu (2015). I look at both the direct and indirect effects of college-level math courses and compare these with the direct and indirect effects of coursework in all other subjects.

The first estimation is of the indirect effect (i.e., the association between math and completion of a college award). I estimate a logistic regression of the following form:

$$\text{Prob}(AWARD) = \alpha + \beta_A MATH_{CL} + \theta_A NONMATH_{CL} + \zeta_A MATH_{HS} + \xi_A READ_{HS} + \gamma \mathbf{X} \quad (1)$$

For community college students, *AWARD* includes any credential earned either at the community college (diploma, certificate, or associate degree) or at a subsequent transfer college (bachelor's degree) by age 26. For students who started at a four-year college, *AWARD* measures bachelor's degree receipt by age 26. The $MATH_{CL}$ variable is measured based on math credits reported on all college transcripts, with a distinction made between math at the initial college and math at subsequent colleges.[2] The residual category of $NONMATH_{CL}$ captures all college-level coursework other than math (again divided across the initial college and all colleges). Using high school information, I control for 10th grade math and reading scores ($MATH_{HS}$ and $READ_{HS}$). Finally, equation (1) includes a detailed set of individual demographics and family background characteristics (given as the vector $\boldsymbol{X}$).[3]

[2] Students may accumulate math skills in non-math courses. I assume that this accumulation is relatively small compared with math skills acquired in math courses. Also, I interpret recent reforms as attempts to increase math skills in math courses and encourage more math coursework, rather than augment non-math courses with more quantitative skills.
[3] Many community college students do not have college-ready skills, particularly in math, and require developmental coursework. Therefore, I control for developmental credits in all specifications. Otherwise, I do not control for other college characteristics.

Straightforwardly, the β_A coefficient on $MATH_{CL}$ should be positive—more coursework must almost automatically increase the probability of award receipt. Of interest here is the relative effect of $MATH_{CL}$ compared with other coursework, that is, whether the β_A coefficient on $MATH_{CL}$ is positive and greater than the θ_A coefficient for $NONMATH_{CL}$. I expect $\beta_A > \theta_A > 0$. In addition, differential effectiveness—heterogeneity in earnings gaps across gender, race/ethnicity, and initial college performance—is expected. High school influences are also important. Given the substantial evidence, high school math should be more valuable than high school reading: $\zeta_A > \xi_A > 0$. Of key interest is whether performance in high school subjects is valuable after controlling for college credit accumulation.

To estimate the effect of math on earnings, I apply a conventional (Mincerian) earnings equation:

$$Y = \alpha + \beta_{Y1} MATH_{CL} + \theta_{Y1} NONMATH_{CL} + \psi AWARD + \gamma \mathbf{X} \quad (2)$$

$$Y = \alpha + \beta_{Y2} MATH_{CL} + \theta_{Y2} NONMATH_{CL} + \gamma \mathbf{X} \quad (3)$$

Earnings Y are measured in dollars at age 26 for all persons no longer in college (but including those with zero earnings). Given the potential for both direct and indirect effects, I anticipate the coefficient on $MATH_{CL}$ to be positive and to exceed that for $NONMATH_{CL}$ ($\beta_Y > \theta_Y > 0$). In addition, I expect math to be differentially effective across subgroups and to have stronger impacts for more advanced math at four-year colleges. Equation (2) includes the award earned by the student. Conditional on their award, differences in the returns to math credits therefore reflect course mix rather than attainment (see Flores-Lagunes & Light, 2010). So the coursework coefficients represent only the indirect effect: controlling for award, math credits are expected to have the stronger effect ($\beta_{Y1} > \theta_{Y1} > 0$). Equation (3) excludes award and therefore identifies the direct and indirect effects combined. The expectation is that the overall effect will be greater for math coursework ($\beta_{Y2} > \theta_{Y2} > 0$). In addition, I estimate equation (3) with the sample divided according to final award status (including no award). These estimations show the overall effect of math credits.

Finally, I estimate a series of earnings equations that include high school math and reading scores:

$$Y = \alpha + \zeta_Y MATH_{HS} + \xi_Y READ_{HS} + \gamma \mathbf{X} \quad (4)$$

Initially, I estimate equation (4) to assess the effect of math and reading scores in 10th grade. Given the evidence base, I expect $\zeta_Y > \xi_Y > 0$. In stepwise form I then introduce variables for credits and awards to equation (4) to see how the coefficients for math and reading scores are attenuated. As these coefficients change one can see to what extent the high school coefficients in equation (4) suffer from omitted variable bias.

The main concern with these identification strategies is selection bias. Only students who expect math to be beneficial will take math coursework. However, if college-level math is required for completing an award, then this positive selection bias may be small. Controlling for a detailed array of observable characteristics prior to taking math—especially high school test scores—will partly mitigate this bias. Also, in equation (2) I control for award receipt.

4. Dataset

I use data from ELS:2002, which is a nationally representative survey of students who were in 10th grade in 2002. These students were followed up with additional survey waves in 2004 (for most, their final year of high school), and the sample was freshened to be representative of students enrolled in 12th grade in the spring of 2004. Additional follow-ups were in 2006 (when most were in college for some period) and in 2012 (by which time many had terminated their postsecondary education). The initial sample is 16,700 students, of which over 11,000 had attended a postsecondary institution for some period before 2012.[4]

ELS:2002 includes detailed information on high school performance prior to college enrollment. Over the college years there is detailed information both from self-reports and from direct analysis of college transcripts (including all colleges attended). There is also information on earnings and other labor market activities. This information is extended through to 2012, when the respondents were aged 26.

These data allow the linking of high school and college math to attainment and earnings for a large sample of students who undertake heterogeneous pathways through college. Also, because they are taken from transcripts, the data on college enrollment are not biased due to imputation, self-reporting, or non-response. The main deficiency is that the sample sizes used in this study are quite small, particularly for subgroup analysis. Also, the earnings measure is only calculated through to age 26; this may be insufficient time for significant earnings gains by education level to accumulate.

[4] The ELS:2002 dataset is representative of a cohort of high school students, not a cohort of college students. Hence, this dataset is representative of students aged 16 to 18 in 2002 who were deciding on which college to attend (or whether to attend college at all) and so allows for comparisons of individuals who were in the same situation before application or enrollment.

5. Results

Math Coursework in College

Table 1 shows descriptive frequencies for the study sample, divided according to whether the student started at community college or a four-year college.

Notably, beginning community college students took very little formal math: the students in this dataset accumulated, on average, less than one three-credit math course; they accumulated 10 three-credit courses in other fields. Many students—including a non-trivial proportion with awards—took no math course in college (these figures include students who are math majors).[5] Students who started at four-year colleges took more math, although still less than two three-credit courses, on average. In fact, the group with the lowest math concentration was female students at four-year colleges (with only 5 percent of all their coursework in math).

Many students attended more than one college. Of all individuals who started at community college or a four-year college, the mean number of colleges attended is 1.7 and 1.6, respectively. Therefore, as shown in Table 1, credit accumulation is significantly higher when all college enrollment is included. Math coursework rises to four credits and six credits, respectively, for community college and four-year students. But so does non-math coursework; consequently, math concentration actually falls across all groups of students as they attend more colleges.

Table 1 shows high school math and reading scores across the sample. These scores are standardized across all 10th grade students (regardless of college enrollment). Unsurprisingly, students who started at four-year colleges had significantly higher test scores; community college students had scores that are close to the mean. The spread of scores for math is wider than for reading.

[5] For community college students (and some students at four-year colleges), math does not appear to be compulsory: indeed, many of the completers in the sample did not have any math credits. Some students can select into (or out of) math courses. Thus, the pool of math-taking students is unlikely to be dominated by students with low aptitude in, or weak preference for, math.

Table 1: Credit Accumulation: Math and All Other Subjects

	Started at Community College				Started at Four-Year College			
	Female		Male		Female		Male	
Math credits (first college)	2.58	[3.71]	2.46	[3.94]	4.42	[5.43]	5.60	[6.94]
Math credits (all colleges)	4.19	[5.33]	4.04	[5.94]	5.50	[6.14]	6.58	[7.39]
Non-math credits (first college)	32.83	[29.38]	29.24	[27.13]	80.55	[50.79]	76.88	[50.02]
Non-math credits (all colleges)	70.61	[55.51]	57.22	[51.65]	103.00	[46.49]	94.41	[47.7]
10th grade HS math score (std.)	–0.15	[0.88]	–0.02	[0.90]	0.43	[0.82]	0.60	[0.85]
10th grade HS reading score (std.)	–0.04	[0.91]	–0.08	[0.89]	0.38	[0.81]	0.46	[0.88]
N	*1410*		*1370*		*2370*		*2260*	

Note. Table adapted from ELS:2002, Course Transcript file. Credits are college-level only. Tenth grade high school scores standardized across the whole ELS:2002 sample. Unweighted samples. Excludes persons still in college. Standard deviations in brackets.

College Math and Award Receipt

Based on equation (1), Table 2 shows the association between award receipt and course-taking (see table notes for covariates). The left-hand panel shows results for students who started at community college and are predicted to receive any award. The right-hand panel shows results for students who started at a four-year college and are predicted to receive a bachelor's degree. Specifications are separated for the number of credits at the first college and at all colleges.

As expected, the first two rows show that students are more likely to receive an award if they have more college-level credits ($\beta_A > 0$, $\theta_A > 0$). For community college students, the effect on completion is greater if these credits are in math ($\beta_A > \theta_A$). But this result does not hold for female students when all credits accumulated are considered. For four-year college students, the results are less conclusive: for two specifications math credits are more valuable; for one specification other credits are more valuable; and for one specification the coefficients are identical.

High school math test scores are influential for college award completion, even after controlling for college-level credits. However, the impacts are not always statistically significant; and the effects for reading are negative or insignificant (due to multicollinearity with 10th grade math scores).

Overall, there is evidence for the indirect effect of math on earnings. As found by Belfield and Liu (2015), taking more math courses relative to other courses is associated with a higher probability of award completion.

Table 2: Award Completion by Initial College: High School and College Math Effects

	Started at Community College: Any Award by Age 26				Started at Four-Year College: Bachelor's Degree by Age 26			
	Credits at 1st College		Credits at All Colleges		Credits at 1st College		Credits at All Colleges	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Math credits	0.038**	0.040**	0.023*	–0.001	0.024***	0.010	0.023***	0.013**
	(0.017)	(0.018)	(0.012)	(0.011)	(0.008)	(0.008)	(0.006)	(0.007)
Other credits	0.019***	0.020***	0.017***	0.014***	0.009***	0.007***	0.015***	0.013***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Math (10th grade)	0.165**	–0.027	0.027	–0.141*	0.188***	0.095	0.147**	0.037
	(0.083)	(0.083)	(0.084)	(0.084)	(0.068)	(0.067)	(0.072)	(0.068)
Reading (10th grade)	–0.166**	0.020	–0.221***	–0.079	–0.096	0.018	–0.140**	0.029
	(0.077)	(0.077)	(0.080)	(0.076)	(0.064)	(0.064)	(0.066)	(0.066)
N	*1,010*	*1,110*	*1,010*	*1,110*	*1,790*	*1,900*	*1,790*	*1,900*

Note. Table adapted from ELS:2002. Any award includes certificate, associate degree, or bachelor's degree or above. Credits are college-level only. Tenth grade high school scores standardized across the whole ELS sample. Weighted sample. Excludes persons still in college. Probit estimation. All models include: individual characteristics (race/ethnicity [3 groups], single parent, high school graduate, parent education [6 groups], family income). Robust standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

College Math and Earnings

Table 3 shows the associations between course credits and enrollment patterns with annual earnings measured at age 26 for the students who started at community college. The results are from estimation of equations (2) and (3), where the former includes all controls as well as the credential earned by the student and the latter excludes the credential earned and is estimated across the entire sample and for subgroups with different credentials. High school test scores are also included in these specifications. Results for equation (2) therefore identify the effect of incremental math coursework beyond that necessary to complete an award—the direct effect of math skills on earnings. Results for equation (3) identify the combined direct and indirect effect of math skills.

Panel A of Table 3 shows no clear association between earnings and credits when only credits from the first college are considered. These results also correspond to those from Belfield and Liu (2015). However, Panel B does show that earnings are positively associated with math credits when all math credits are considered. The association is not consistent when awards are included in the specification (column [1]) or when the samples are restricted to students with degree awards. But for students who do not receive an award, there is a clear positive effect of total math credits on earnings. In contrast, the effect of non-math credits is never positive on earnings. Overall, these results are consistent with a positive indirect effect and a weak (but possibly positive) direct effect of college-level math coursework. This is a similar conclusion to Belfield and Liu (2015), although they found fewer absolutely positive direct effects of math coursework and fewer positive effects relative to other coursework.

Table 4 shows the same specifications for the sample of students who began at a four-year college. For this group, there is no clear positive association between math credits and earnings. This null association holds both for the full sample (regardless of whether or not award receipt is controlled for) and for subsamples of persons with no award or bachelor's degree. Thus, these results are closer to Belfield and Liu (2015) in finding no clear direct effect of math coursework on earnings. For non-math credits, the effects on earnings are not consistent, with positive effects for female students and negative effects for male students.

Table 3: Annual Earnings Gains of Students Starting at Community College: Math and Other Subjects

	Female					Male				
	[1] Net of Award	[2] By Award Status				[1] Net of Award	[2] By Award Status			
Effect on Annual Earnings ($):	**All**	**All**	**No Award**	**Assoc. Degree**	**Bachel. Degree**	**All**	**All**	**No Award**	**Assoc. Degree**	**Bachel. Degree**
Panel A. Credits at 1st community college:										
Math credits (β_Y)	572	618	1,991	–163	–22	–3	77	868	–1,567**	123
	(533)	(503)	(1,489)	(548)	(313)	(241)	(231)	(544)	(680)	(303)
Non-math credits (θ_Y)	–58	–51	–133	3	–30	–94**	–20	–177***	152*	–149**
	(39)	(42)	(108)	(50)	(50)	(38)	(35)	(59)	(91)	(66)
Panel B. Credits at any college:										
Math credits (β_Y)	672**	678**	1,128**	–313	218	160	266**	711*	–1,366**	58
	(290)	(290)	(547)	(436)	(254)	(135)	(133)	(419)	(588)	(153)
Non-math credits (θ_Y)	–32	–20	–32	–46	–52	–92***	–21	–119***	–11	–54
	(23)	(25)	(40)	(33)	(35)	(20)	(20)	(31)	(70)	(37)
R-squared	0.072	0.070	0.158	0.210	0.145	0.145	0.116	0.151	0.383	0.273
N	*1,060*	*1,060*	*440*	*170*	*310*	*940*	*940*	*470*	*140*	*230*

Note. Table adapted from ELS:2002, Course Transcript file. Average earnings in 2012 (expressed in 2012 dollars), persons with zero earnings included. Students starting at community college. Excludes persons still in college. All models include: individual characteristics (race/ethnicity [3 groups], single parent, high school graduate, parent education [6 groups], family income). Developmental credits included. Model [1] includes highest credential earned (certificate, associate degree, or bachelor's degree or above). Robust standard errors in brackets.

*** $p < .01$. ** $p < .05$. * $p < .1$.

Table 4: Annual Earnings Gains of Students Starting at Four-Year Colleges: Math and Other Subjects

	Female				Male			
	[1] Net of Award	[2] By Award Status			[1] Net of Award	[2] By Award Status		
Effect on Annual Earnings ($):	**All**	**All**	**No Award**	**Bachelor Degree**	**All**	**All**	**No Award**	**Bachelor Degree**
Panel A. Credits at 1st community college:								
Math credits (β_Y)	41	53	126	33	125	181*	246	127
	(85)	(87)	(132)	(112)	(102)	(102)	(156)	(136)
Non-math credits (θ_Y)	16	27***	47***	–5	–26	14	–56***	–18
	(10)	(10)	(17)	(14)	(19)	(22)	(19)	(29)
Panel B. Credits at any college:								
Math credits (β_Y)	22	33	175	–30	90	132	225*	95
	(75)	(75)	(127)	(96)	(82)	(82)	(124)	(109)
Non-math credits (θ_Y)	–5	14	25	–47*	–77***	–16	–72***	–124***
	(12)	(11)	(17)	(26)	(17)	(18)	(17)	(36)
R-squared	0.123	0.113	0.122	0.097	0.094	0.065	0.101	0.086
N	*2,530*	*2,530*	*1,020*	*1,230*	*2,360*	*2,360*	*950*	*1,200*

Note. Adapted from ELS:2002, Course Transcript file. Average earnings in 2012 (expressed in 2012 dollars), persons with zero earnings included. Students starting at four-year college. Excludes persons still in college. All models include: individual characteristics (race/ethnicity [3 groups], single parent, high school graduate, parent education [6 groups], family income. Developmental credits included. Model [1] includes highest credential earned (certificate, associate degree, or bachelor's degree or above). Robust standard errors in brackets.

*** $p < .01$. ** $p < .05$. * $p < .1$.

Differential Effects on Award Receipt and Earnings

Prior literature has found differences in math effects by race/ethnicity and ability. Looking at attainment, Belfield and Liu (2015) found effects that are greater for male students than female students and greater for high-GPA than low-GPA students; math effects are greater for racial/ethnic minority students.

Table 2 shows stronger effects of math for male students than female students. However, other results do not correspond to Belfield and Liu (2015). In Appendix Table A.1 I report estimates of equation (1) for subsamples of community college and four-year college students. These results can be compared with those in Table 2. For all students, the attainment effects of math are greater for students with below-average high school GPA, but they are weaker for ethnic/racial minority students. However, the effects of non-math coursework are stronger for students with low GPA and for ethnic/racial minority students. These results are the same whether one looks at first-college credits or all-college credits.

Similar results are found for subgroup analysis of coursework on earnings (Appendix Table A.2). As for attainment, there is no clear evidence that math coursework has a stronger effect on earnings for ethnic/racial minority students or those with low GPAs.

High School Math and Earnings: Omitted Variable Bias

As discussed above, there is a sizeable literature on the positive impact of high school math on earnings; and as shown in Table 2, I find a strong effect on award completion independent of college credit accumulation. At issue is to what extent effects attributable to high school math are driven by omitted variable bias from college math.

Table 5 shows coefficients for 10th grade test scores on earnings for a series of stepwise estimations. Panel A shows the effects without controlling for college credits or awards. Higher math scores lead to substantially higher earnings at age 26. Again, reading scores do not. However, these gains are substantially reduced when controlling for subsequent attainment (Panel B), for credits (Panels C and D), and for both simultaneously (Panels E and F). Math test scores are no longer statistically significant at the 1 percent level.

To illustrate the extent of omitted variable bias, I look at male students who started at a four-year college. (The results for female students are similar, although the results for male community college students are never statistically significant.) For this group, a one-standard deviation increase in math scores yields earnings gains of +$4,139. When controlling for awards, the effect falls to +$2,842 (by 31 percent). When controlling for math (and other) credits, the gain is +$3,414 (or +$3,472), a decline of 17 percent. Finally, when controlling for both awards (and math credits), the earnings gain from math in high school is +$2,582 (or +$2,706); this is 38 percent (35 percent) lower than the unadjusted estimate. Although high school math skills are still influential for earnings, the extent of omitted variable bias is non-trivial.

Table 5: Annual Earnings Gains at Age 26: High School Math Effects

	Started at Community College		Started at Four-Year College	
	Male	**Female**	**Male**	**Female**
Panel A. Not controlling for credits or awards:				
Math (10th grade)	608	3,257**	4,139***	3,351***
	(1,418)	(1,392)	(1,207)	(938)
Reading (10th grade)	–1,273	–190	–1,652	372
	(1,303)	(938)	(1,341)	(959)
Panel B. Including awards:				
Math (10th grade)	32	3,203**	2,842**	3,021***
	(1,451)	(1,326)	(1,202)	(934)
Reading (10th grade)	–704	–274	–1,069	301
	(1,333)	(938)	(1,317)	(957)
Panel C. Including first college credits:				
Math (10th grade)	577	2,885**	3,414***	2,948***
	(1,441)	(1,232)	(1,249)	(971)
Reading (10th grade)	–1,274	–81	–1,410	456
	(1,309)	(901)	(1,335)	(963)
Panel D. Including all college credits:				
Math (10th grade)	328	2,446*	3,472***	2,940***
	(1,453)	(1,345)	(1,275)	(971)
Reading (10th grade)	–1,148	–22	–1,395	500
	(1,292)	(871)	(1,331)	(959)
Panel E. Including awards and first college credits:				
Math (10th grade)	46	2,890**	2,582**	2,751***
	(1,440)	(1,167)	(1,192)	(963)
Reading (10th grade)	–653	–154	–919	426
	(1,331)	(886)	(1,302)	(966)
Panel F. Including awards and all college credits:				
Math (10th grade)	228	2,583**	2,706**	2,873***
	(1,440)	(1,251)	(1,214)	(968)
Reading (10th grade)	–444	–36	–659	444
	(1,315)	(886)	(1,304)	(963)
N	*940*	*1,060*	*1,720*	*1,840*

Note. Table adapted from ELS:2002. Models as per Table 3. Average earnings in 2012 (expressed in 2012 dollars), persons with zero earnings included. Excludes persons still in college. Awards include certificate, associate degree, or bachelor's degree or above. Robust standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

6. Conclusion

Based on the evidence from studies of high school math, there is a compelling case for encouraging high school students to study math more intensively. But for several reasons this evidence should not be over-interpreted. First, in the current analysis I find that the impact of high school math on earnings is significantly attenuated when controlling for college-level math. Although high school math is presumably a prerequisite for college math, it bears emphasis that expected gains from high school math should be expressed as conditional on also taking college math. Second, the evidence for high school math should be only cautiously applied to students in college. With the exception of those who major in math, there has been limited inquiry as to the relative benefits of college-level math.

Overall, taken in conjunction with similar results from Belfield and Liu (2015), the evidence on the value of college-level math is not conclusive. Community college students and students who start at four-year colleges take little math in college. On average, college students take less than one three-credit course when considering coursework at their first college and less than two courses across their entire college enrollment. For the average student, math coursework is only 5–10 percent of his or her overall load, and many students take no math in college. Interestingly, I find that—given the high transfer rates of students across colleges—it is important to collect information on college transcripts to get an accurate picture of college coursework.

Nevertheless, findings from the current study show that math coursework is—relative to other courses—more clearly associated with award receipt. In this respect, it should lead to higher earnings indirectly. However, the results for the association between math coursework and earnings lead to a more cautionary conclusion. Relative to other credits or pathways, there is sparse evidence that math has a strong impact on earnings. This conclusion is consistent with a positive attainment effect but a null direct effect: math helps students graduate, but the specific math skills acquired in college are not especially valuable in the labor market. As in Belfield and Liu (2015), I do find differential effects by gender, race/ethnicity, and ability. Moreover, I do not find that math coursework is differentially helpful for ethnic/racial minority students or those with lower pre-college skills.

This analysis extends that of Belfield and Liu (2015) by including both community college students and those who started at a four-year institution. These findings apply to both groups and so do not reflect the particular level of academic preparedness of community college students. Instead, it seems more likely that the focus should be on the content or delivery of college-level math courses. Possibly, reform strategies should be aimed at boosting the quality of math instruction or curriculum standards; alternatively, it may be more effective to replace dedicated math courses with more general quantitative courses or to introduce more quantitative skills into non-math courses. It may be appropriate to see whether math courses are well integrated into students' programs of study or whether they are simply a hurdle to overcome. More emphatically, this growing evidence suggests that—before promoting further math in college—more attention needs to be paid to how math coursework fosters productivity and hence yields earnings gains for students.

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Appendix

Appendix Table A.1: Award Completion by Initial College: College Math Effects by Subgroup

	Started at Community College: Any Award by Age 26				Started at Four-Year College: Bachelor's Degree by Age 26			
	Credits at 1st College		Credits at All Colleges		Credits at 1st College		Credits at All Colleges	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Ethnic/racial minority student:								
Math credits	0.004	0.013	–0.031	–0.037*	0.036*	0.013	0.019	0.020**
	(0.037)	(0.035)	(0.030)	(0.019)	(0.019)	(0.014)	(0.015)	(0.010)
Non-math credits	0.029***	0.021***	0.027***	0.017***	0.011***	0.010***	0.016***	0.025***
	(0.006)	(0.005)	(0.004)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
Low HS GPA:								
Math credits	0.043*	0.073**	–0.019	0.041	0.042***	0.001	0.035***	0.014
	(0.023)	(0.031)	(0.020)	(0.029)	(0.013)	(0.018)	(0.010)	(0.014)
Non-math credits	0.021***	0.023***	0.022***	0.020***	0.013***	0.011***	0.020***	0.021***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)	(0.003)
N	*240*	*280*	*550*	*450*	*310*	*380*	*890*	*660*

Note. Table adapted from ELS:2002. Any award includes certificate, associate degree, or bachelor's degree or above. Credits are college-level only. Excludes persons still in college. Model as per Table 2. Low HS GPA is < 2.7 for community college students and < 3.1 for four-year college students. Robust standard errors in parentheses.

*** $p < .01$. ** $p < .05$. * $p < .1$.

Appendix Table A.2: Annual Earnings Gains: Math and Other Subjects by Subgroup

	Started at Community College				Started at Four-Year College			
	Credits at 1st College		Credits at All Colleges		Credits at 1st College		Credits at All Colleges	
	Male	Female	Male	Female	Male	Female	Male	Female
Students of color:								
Math credits	–229	1,664	203	824	2	–1	–41	90
	(419)	(1,376)	(408)	(518)	(193)	(183)	(165)	(155)
Non-math credits	–1	–132	–21	–57	1	10	–4	24
	(65)	(121)	(45)	(53)	(28)	(23)	(26)	(26)
Low HS GPA:								
Math credits	–556*	1,543	–219	1,610	132	123	129	–65
	(335)	(1,698)	(285)	(1,557)	(301)	(176)	(293)	(112)
Non-math credits	9	–118	–30	–91	27	55***	0	59***
	(52)	(117)	(29)	(92)	(55)	(20)	(37)	(19)
N	*210*	*270*	*510*	*430*	*300*	*360*	*850*	*630*

Note. Table adapted from ELS:2002. Average earnings in 2012 (expressed in 2012 dollars), persons with zero earnings included. Low HS GPA is < 2.7 for community college students and < 3.1 for four-year college students. Excludes persons still in college. Robust standard errors in parentheses.

*** $p < .01$. ** $p < .05$, * $p < .1$.