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ABSTRACT

The benefits of mathematics and science courses in high school were studied using information from the High School and Beyond (HS&B) data set, a study that began with more than 30,000 high school sophomores in 1980. The analysis focuses on approximately 7,000 students who finished their schooling by 1988 and for whom there were valid test scores, transcripts, and data from the 12-year followup survey. Findings provide no direct evidence that taking mathematics and science courses affects earnings. Analysis results do show some indirect effects, in that there is evidence that taking relevant courses improves later skills as measured by test scores. Recent evidence from other sources suggests that skills are an increasingly important determinant of earnings. Mathematics skills do have an effect on learning, and high school courses do have an effect on mathematics skills. (SLD)

Raising Standards:

The Effects of High School Math and Science Courses on Future Earnings

by

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INTRODUCTION

During the 1980s, the earnings of 25 to 34 year-old high school-only graduates fell while those of college graduates rose. The earnings premium for finishing college versus high school nearly doubled between 1978 and 1987.[1] Well-educated people with high academic test scores are prospering more than ever, while those with less marketable skills, in particular non-college-going youth, continue falling further behind.[2]

Tests have long been used to encourage greater skill accumulation in high school. Evidence of falling high school test scores during the 1960s and 1970s and international comparisons showing the U.S. trailing behind many industrialized countries heightened national interest in increasing the academic skills of youth.[3] More recently, it appears that youth have been responding positively to high and increasing marketplace returns to education and skills. Data from the National Center for Education Statistics ("NCES") show rising math and science test scores during the 1980s and 1990s.[4] Similarly, college enrollment among recent high school graduates increased from about fifty percent to over sixty percent between 1977 and 1992.[5] During the 1980s, high school musical activities, hobby clubs, and vocational program participation all decreased substantially, while college preparatory program placement and

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[1] Gary T. Burtless et al., The Urban Institute, Widening Earnings Inequality: Why and Why Now, 30 (1994).
[2] Richard J. Murnane et al., The Growing Importance of Cognitive Skills in Wage Determination, 82 Rev. Econ. & Stat. 251, 253 (1995); Ronald F. Ferguson, New Evidence on the Growing Value of Skill and Consequences for Racial Disparity and Returns to Schooling, (Malcom Weiner Center for Social Policy, John F. Kennedy School of Government, Harvard University Working Paper No. H-93-10) 1 (1993).
[3] Robert H. Meyer, Applied versus Traditional Mathematics: New Evidence on the Production of High School Mathematics Skills, Irving B. Harris Graduate School of Public Policy Studies, University of Chicago, 1 (1994).
[4] National Center for Education Statistics, U.S. Dept. of Ed., The Condition of Education, 1997, NCES No. 97-388, 86 (1997) <http://nces.ed.gov/pubs/ce/97388.pdf> (hereinafter "NCES").
[5] Id. at 62.

advanced math and science course enrollment increased.[6]

As youth devote an increasing amount of effort towards developing their human capital, it becomes even more important to make sure that schools make optimal use of the time that they have with students. This article analyzes the benefits of two important subjects taught in high school: math and science. These findings and those of previous research suggest that more math courses increase math test scores and that increased math test scores increase future earnings. The results for science courses are less clear.

The rest of this article is divided into five sections. The first section describes the data used in this study. The second section describes the methodology used to analyze this data. In the third section, I summarize the direct evidence concerning whether high school courses affect earnings, both from previous literature and from my own estimates. These results provide no direct evidence that the number of courses a student takes affects earnings. The fourth section, however, provides indirect evidence that courses do affect earnings: more math courses increase test scores, and increased math test scores improve earnings. Finally, in the fifth section, I discuss the policy implications of these results for standards-based reforms. The results of this study indicate that students on average will experience greater earnings in the marketplace when held to higher math standards. The effect of science standards is less certain.

I. Description of the Data

The data used in this study is derived from the High School and Beyond ("HS&B") data set. HS&B began with over 30,000 high school sophomores in the base year of 1980 and was designed to be comparable in many ways to the National Longitudinal Survey of the High

[6] Kenneth A. Rasinski et al., National Center for Education Statistics, NCES No. 93-087, America's High School Sophomores: A Ten Year Comparison, 1980-1990, iii-iv (1993) <http://nces.ed.gov/pubs93/93087.pdf>; NCES,

School Class of 1972 ("NLS72") used by Joseph G. Altonji.[7] In 1982, high school transcripts were collected for more than half of these youth (about 18,400), and in 1980 and 1982, the youth were given a set of standardized tests in math, science (chemistry, physics, and biology), writing, reading, vocabulary, and civics. I limit the analysis to the approximately 7000 students from public high schools who finished their schooling by 1988 and who had valid test score data, complete transcript information for all four years of high school, and data from the twelve-year follow-up survey. I define non-college-going youth as those who by 1992 had attended no post-secondary education.[8]

II. METHODOLOGY

I begin my study by estimating course effects on earnings directly, as has been done in most previous studies.[9] As explained above, however, direct estimates of the effects of courses[10] on earnings are very imprecise. Therefore, much of this article focuses on estimating the indirect effect of high school courses on earnings six to nine years after high school via math and science skills[11] measured at the end of high school.

To estimate the effects directly, I regress earnings[12] on courses in eleventh and twelfth grade, controlling for a number of background factors, as discussed below. I then proceed to

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supra note 4, at 98.

[7] Joseph G. Altonji, The Effects of High School Curriculum on Education and Labor Market Outcomes, 30 Journal of Human Resources 409, 414 (1995).

[8] A more detailed description of the data and the variables used in this analysis can be found in Duncan Chaplin, The Earnings Benefits of Math and Science Courses in High School, Paper presented at the annual meetings of the American Education Research Association, Chicago, March, 1997, tbl.1 (1998).

[9] See Altonji, supra note 7 at 410-11; see also Gary Natriello et al., Post-High School Employment and Schooling Patterns of Non-College-Bound Youth, Institute on Education and the Economy Brief (March 1992) <http://www.tc.columbia.edu/~iee/BRIEFS/Brief03.htm>.

[10] Courses are measured in Carnegie credits, where one credit represents a one-year course that meets five days a week for fifty to fifty-five minutes. One semester courses normally earn one-half credit.

[11] Skills are represented by the test scores of the youths as seniors in high school.

[12] Earnings are measured as the logarithm of monthly earnings between 1989 and 1991. The logarithm of earnings is used to allow for increasing returns to scale and is common in labor economics. See, e.g., Murnane, supra note 2, at

estimate the effects of courses on earnings indirectly, via test scores. These effects are estimated in two stages. First, I estimate the effects of courses in eleventh and twelfth grade on twelfth grade test scores, controlling for the tenth grade test scores and courses taken in ninth and tenth grade. Second, I estimate the effects of twelfth grade test scores on later earnings.

In all my regression models, I include controls for factors that are likely to affect skills, course work, and later earnings. At the individual level, I control for ethnicity, gender, religious beliefs, if the student has been held back, if the student is college bound, the student's disability status, parent income, and parent education. I also estimate models with school dummy variables that control for all factors at the high school level.

III. Direct Evidence: Do Courses Improve Earnings?

A number of scholars have previously attempted to ascertain the relationship between courses and earnings. The literature to date finds generally small and/or imprecisely estimated effects of high school coursework on later earnings.[13] For example, in a thorough study in this area, Altonji uses data on over 10,000 students from the National Longitudinal Survey of the High School Class of 1972 ("NLS72") to estimate the effects of high school curriculum on education and labor market outcomes up to ten years after graduation.[14] He finds non-significant and imprecise estimates of the effects of courses on later earnings and education for both the college- and non-college-bound youths, thus indicating that the directly estimated effects of taking more challenging classes are uncertain.[15]

I build on Altonji's findings in two ways. First, by using data from the High School and

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252-53.

[13] See, e.g., Neng-Tang Huang & Kenneth Gray, Sub-Baccalaureate Postsecondary Education: Does It Pay Off for Vocational Education Graduates?, 29 Journal of Indus. Tchr. Educ. 9 (1992); Natriello, et al., supra note 9.

[14] Altonji, supra note 7, at 410.

[15] Id. at 424, 430-31.

Beyond 1980 ("HS&B") survey, I have information for a more recent cohort of youth than the NLS72. Second, I estimate the effects of courses on earnings, both directly and indirectly, via skills, rather than only directly assessing the associations between high school courses and earnings.

Table 1 presents the directly estimated effects of courses on earnings. I control for tenth grade test scores in math, science, and writing, number of credits in basic (algebra and below) and advanced (above algebra) math courses in ninth and tenth grade, student and parent characteristics,[16] and missing value dummy variables. The point estimates suggest that an additional year of upper level math classes improves earnings by approximately 5% per year as compared to only 2.7% for the lower level courses, but the estimated effect of the lower level courses is very imprecise and is not statistically significant at the 0.10 level.[17] The coefficient estimate on upper level math is more precise (it is statistically significant at the 0.05 level), but when I allow for fixed school effects, the coefficient estimate becomes smaller and statistically insignificant at the 0.10 level.[18] Thus, I am left with weak support for the hypothesis that math courses improve earnings, be they upper or lower level courses. This is similar to the results found by Altonji, who also found imprecisely estimated effects of courses on later earnings.[19]

[16] These characteristics include the student's gender and race, the language spoken at home, whether the student was held back before tenth grade, whether the student is college bound or religious, any handicaps the student may have, and the parents' education and income. See Chaplin, supra note 8, tbl.1.
[17] A 0.05 confidence level indicates that the coefficient is relatively precise and is at least 1.96 times as large as the standard error. When the confidence level is greater than 0.05, the coefficient estimate is smaller than 1.69 times the standard error. Such an estimate is generally considered to be so imprecise that we cannot reasonably distinguish it from zero.
[18] Chaplin, supra note 8, tbl.2.
[19] Altonji, supra note 7, at 432-33.

Table 1
Which Courses Improve Earnings?

Outcome: Log of Monthly Earnings, 1988-1991

OLS Model
R-squared = 0.13

Variable	Coefficient	Standard Error	t-Ratio	Prob(t) =0	Mean	Standard Deviation
Courses						
MATH, Low, 11-12	0.0268	0.0184	1.46	0.15	0.25	0.47
MATH, High, 11-12	0.0467	0.0143	3.26	0.00	0.61	0.80
SCIENCE, 11-12	0.0081	0.0120	0.67	0.50	0.71	0.89

Controls for tenth grade test scores in math and science, ninth and tenth grade courses in math, student and parent characteristics, and missing value dummies.[20]

There are at least three explanations for imprecise estimates of the monetary returns from course work. First, the market may not be effectively rewarding the skills taught in these classes. Second, it is possible that young adults may be receiving large non-monetary returns from course work, such as higher social status, in place of monetary benefits. Third, it is quite likely that course work does improve earnings, but that the estimates are too imprecise to capture the effect directly.

IV. Indirect Evidence: Do Courses Affect Earnings?

Previous studies, as well as the results in this article, have demonstrated that it is difficult to directly estimate the effects of courses on earnings. Nevertheless, it is possible to estimate this relationship indirectly through test scores. There is a great deal of previous literature on the effects of courses on test scores, much of it demonstrating that more challenging course work has the greatest effect on test scores. For example, Julia B. Smith provides indirect evidence that taking harder math courses has a larger positive effect on later test scores than taking easier

[20] Chaplin, supra note 8, tbl. 1.

courses.[21] She shows that taking algebra before high school, as opposed to later, is associated with taking more higher level math courses and obtaining higher twelfth grade math test scores, even after controlling for tenth grade test scores and other observed characteristics. Part of the effect of taking algebra in eighth grade may have been captured by the tenth grade test scores, so larger effects might have been found if she had been able to control for test scores before eighth grade, when many youths take algebra.

More directly relevant research has been conducted by Robert H. Meyer,[22] Karl L. Alexander and Aaron M. Pallas,[23] and Wayne W. Welch, et al.[24] The last study found that upper level high school courses were associated with substantially higher standardized test scores, while lower level courses were not.[25] No control for prior achievement, however, was included in the study.[26] Pallas and Alexander do control for prior achievement and also find large, though smaller estimated, effects of upper level (above algebra) math courses on academic achievement and smaller, and in some cases negative, effects of lower-level courses.[27] Finally, Meyer also finds that upper level courses (algebra and above) have larger effects on senior year standardized test scores than other math courses, after controlling for prior achievement and correcting this control variable for measurement error.[28] Meyer also notes that many non-mathematics courses

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[21] Julia B. Smith, Does an Extra Year Make Any Difference? The Impact of Early Access to Algebra on Long-Term Gains in Mathematics Achievement, 18 Educ. Evaluation and Pol'y Analysis 141, 148 (1996).
[22] Meyer, supra note 3, at 1.
[23] Karl L. Alexander and Aaron M. Pallas, Curriculum Reform and School Performance: An Evaluation of the "New Basics," 92 Am. J. of Educ. 391, 391 (1984); Aaron M. Pallas and Karl L. Alexander, Sex Differences in Quantitative SAT Performance: New Evidence on the Differential Coursework Hypothesis, 20 Am. Educ. Res. J. 165, 165 (1983) (exploring impact of advanced math courses for female students on disparity between male and female SAT-M performance).
[24] Wayne W. Welch et al., The Effects of Schooling on Mathematics Achievement, 19 Am. Educ. Res. J. 145, 145 (1982).
[25] Id. at 149-50.
[26] See id. at 147-48.
[27] Pallas and Alexander, supra note 22, at 169, 179-80.
[28] Meyer, supra note 3, at [NEED PINPOINT].

are positively associated with higher math test scores, suggesting that students learn mathematical skills in a variety of settings.[29] More generally, these results suggest that when students are pushed to take more math, their test scores will, on average, improve.[30]

In Table 2, I present results suggesting that relevant courses improve later skills, as measured by test scores. In these regressions, I controlled for the 1980 test scores, school dummy variables, and the control variables used in Table 1. A comparison of the magnitude of the coefficients in Table 2, Panel 1, shows that the estimated effect of a credit in math is about twice as large as the estimated effect of a credit in science on 1982 math test scores. The results in Table 2, Panel 2, are symmetric; the estimated effect of science credits is about twice as large as the estimated effect of math credits on the science test scores. Both sets of coefficient estimates are statistically significant at the 0.05 confidence level. I found similar results using ordinary least squares models without the fixed effects and when I replaced the fixed school effects with random school effects.[31] These results suggest that twelfth grade test scores do measure learning that occurred in eleventh and twelfth grade, not merely skills learned before tenth grade or a single type of underlying ability.

[29] Id. [NEED PINPOINT].
[30] Probably some students will suffer a loss of self-esteem when pushed to take more math courses and will consequently achieve lower scores. The results in this paper suggest that this problem is more than offset by the students who gain from the greater challenges of additional math.
[31] Chaplin, supra note 8, tbl.3.

Table 2
Which Courses Improve Skills?

Outcome: 1982 MATH Test Score (Twelfth grade)
Fixed School Effects Models
R-Squared = 0.82 (0.78 without fixed school effects)

Variable	Coefficient	Standard Error	t-Ratio	Prob(t) =0	Mean	Standard Deviation
Courses, 11-12						
MATH	1.9832	0.0932	21.27	0.00	0.81	0.87
SCIENCE	0.8346	0.0904	9.23	0.00	0.67	0.88

Controls for tenth grade math test scores, student and parent characteristics, and missing value dummies. See Chaplin, supra note 8, tbl. 3, for details.

Outcome: 1982 SCIENCE Test Score (Twelfth grade)
R-squared=0.70 (0.65 without fixed school effects)

Variable	Coefficient	Standard Error	t-Ratio	Prob(t) =0	Mean	Standard Deviation
Courses, 11-12						
MATH	0.2669	0.0508	5.25	0.00	0.81	0.87
SCIENCE	0.5320	0.0497	10.70	0.00	0.67	0.88

Controls for tenth grade science test scores, student and parent characteristics, and missing value dummies. See Chaplin, supra note 8, tbl. 3, for details.

Recent evidence suggests that skills have become an increasingly important determinant of earnings. Increased returns to education in the marketplace are well documented, and Burtless et al. found that earnings disparities have also increased within education, industry, and age groups.[32] Burtless et al. suggest that changes in the demand for skills within these groups is a likely cause of within-group changes,[33] and their conclusion is supported by the results of Murnane, Willet, and Levy, and Ferguson, who find that the returns to basic skills rose during the 1980s.[34]

In Table 3, I present evidence that skills learned by twelfth grade improve earnings six to nine years later, based on a three-stage-least-squares (3SLS) model, which controls for

[32] Burtless et al., supra note 1, at 26.
[33] Id. at 30-31.
[34] Murnane et al., supra note 2, at 263-64; Ferguson, supra note 2, at 1.

measurement error in the test scores.[35] Only the math test score has a significant positive estimated effect on earnings, as indicated by the coefficients. These results suggest that a one point increase in the math test score is associated with 1.6% higher earnings. The coefficient for science is negative, and the standard error is small enough to allow us to say that it is very unlikely that a one unit increase in the science test score would increase earnings by even 0.8%.

Table 3
Which Skills Improve Earnings?

Outcome: Log of Monthly Earnings, 1988-1991

3SLS Estimator
R-squared = 0.13

Variable	Coefficient	Standard Error	t-Ratio	Prob(t) =0	Mean	Standard Deviation
Test Scores, 12						
MATH	0.0157	0.0028	5.53	0.00	15.22	10.68
SCIENCE	-0.0071	0.0071	-1.00	0.32	10.18	4.55

Controls for writing test score, student and parent characteristics, and missing value dummies. See Chaplin, supra note 8, tbl. 4, for details.

This evidence suggests that there is little monetary benefit, on the margin, to learning science skills tested in the HS&B tests during high school. This is particularly interesting in light of the fact that science test scores of seventeen year-olds in the National Assessment for Educational Progress actually improved by more points than did the math test scores between 1982 and 1992.[36]

The small and insignificant effects of science skills on later earnings can be explained in a number of ways. First, it is possible that the science information taught in these classes is not being rewarded monetarily by the market.[37] Indeed, it might be the case that students would

[35] The measurement error could be caused by luck factors affecting the test score, but not the individual's true underlying skills. This luck could be due to how well the test-taker was feeling on the day that he or she took the test. See also Chaplin, supra note 8, at 10-11.
[36] NCES, supra note 4, at 88.
[37] Math related science courses do appear to increase math skills. See Meyer, supra note 3, at 38. Math skills

receive larger monetary rewards from learning alternative skills. For instance, Alan B. Krueger provides evidence that the monetary returns to computer skills have been rising since the mid-1980s, suggesting that a shift from general science towards computer skills might benefit most students.[38] Second, it is possible that scientists receive relatively more non-monetary rewards than other workers. Finally, it may be that the HS&B science test is a poor measure of science skills learned in high school and/or used later in life. This would help to explain why the estimated effects of science courses on science tests are only about one quarter as large as the estimated effects of math courses on math tests.

While the Table 1 results do not indicate a statistically significant relationship between courses and earnings, the evidence presented in Table 2 and Table 3 indicates that courses do affect test scores and test scores affect earnings. One explanation for this anomaly, which would allow for a causal effect of courses on earnings, is related to the timing of the data. The courses-test score relationship may be relatively precise because, by controlling for tenth grade test scores, I focus the analysis on changes in test scores over the two-year period during which students are taking the courses. In contrast, the courses-earnings relationship is imprecise because earnings are measured several years later and are therefore likely to have been affected by many factors other than courses. The test score-earnings relationship is relatively precise because test scores reflect at least twelve years of accumulated learning of skills, as well as learning that occurs outside of school. The courses-earnings relationship is much less precise because the courses represent only two years of in-class learning. This would suggest that if I

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increase later earnings, which suggests that there are monetary benefits to teaching math skills in science courses, but not necessarily to teaching the science skills tested in the HS&B tests in science classes.

[38] Alan B. Krueger, How Computers Have Changed the Wage Structure: Evidence from Microdata, 1984-1989, Q. J. of Econ., Feb. 1993, at 33, 35.

had data on courses (and on-the-job training) taken up to the point at which the earnings are measured, I might obtain a more precise estimate of the courses-earnings relationship, comparable to those found for the courses-test scores and test scores-earnings relationships.

V. Policy Recommendations

Estimating the direct effect of high school course work on later earnings appears to be difficult, perhaps in part because of the timing of data used to estimate these relationships. I find statistically insignificant effects, similar to those found by other researchers. At the same time, however, I find that math skills have a large effect on later earnings and that high school math courses appear to increase math skills. Combined, these latter two results suggest that math courses do improve earnings in substantively important ways.

These findings support current education reforms aimed at increasing the degree to which youth are challenged to take more math courses. The results are less clear, however, with respect to science courses. Even for the math courses, it should be kept in mind that it is not obvious how to best implement these higher standards. Three problems come to mind. First, merely requiring schools to teach more math courses may simply result in course title inflation, in which the schools change the titles of currently taught courses, but do not teach their students more challenging materials.[39] Second, pushing teachers to teach more advanced math concepts may cause them to skip important intermediate material. The students should be pushed to learn the material more quickly, but they may not be able to learn at all if the concepts are not taught in the proper sequence. Finally, it is quite possible that students who take more math courses are learning more because teachers in their more advanced classes are better prepared. If this is the

[39] Thomas B. Hoffer, High School Graduation Requirements: Effects on Dropping Out and Student Achievement, 98 Teachers College Record 584, 584 (1998).

case, simply requiring the other teachers to challenge students more may not work. It may be necessary for some teachers to receive additional training. While the results of this study suggest that students will benefit from more of the types of challenges they currently receive in math courses, the remaining question is how to best ensure that all students are challenged in these ways.

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