Math Matters: The Links Between High School Curriculum, College Graduation, and Earnings

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Foreword

In an effort to address the poor performance of students graduating from California schools, the public policy debate has focused on more spending, smaller class sizes, teacher hiring, and a more equitable allocation of resources. For some reason, it seems that school curriculum has received less attention. Yet, as important as other concerns are, student outcomes will always be related to the type and quality of the available curriculum. In this study, Heather Rose and Julian Betts focus on the relationship between the math courses students take in high school, whether they graduate from college, and their earnings in the labor force 10 years after graduating from high school.

The authors' conclusions are encouraging. Math curriculum—especially advanced courses such as algebra and geometry—has a positive effect on college graduation and on earnings later in life. Although these are findings that might seem obvious to some, and explained by privileged backgrounds for others, this study finds that the effect of math courses on later earnings does not appear to vary much with respect to student or school characteristics and that a rigorous math curriculum at any school can benefit students of any type. Another important finding of this study is that not all math courses are equal. To quote the authors, "It is not simply the number of math courses that matters; what matters more is the extent to which students take more demanding courses such as algebra and geometry."

The findings of this study underscore the importance of local school districts' meeting the challenge by recruiting qualified teachers trained in mathematics and by offering all students the opportunity to take a full range of advanced math courses in high school. The authors note that schools should not suddenly *require* that all students take advanced math courses, but they should encourage and prepare them to do so.

This study is one of a series of projects under way at PPIC on education policy for the state of California. Future reports will include contributions to the new master plan for California's system of public education; an analysis of student achievement in San Diego; an examination of the relationship between teacher quality and the achievement of minority and low-income students; and a study to determine how the educational needs of new immigrants might be better met. *Math Matters* is the first step in our effort to look carefully at what schools are offering to students and how those offerings affect their long-term economic and social well-being.

David W. Lyon
President and CEO
Public Policy Institute of California

Summary

A recurrent concern in the debate over education reform is that schools are not doing a good job in preparing students, especially minority and disadvantaged students, to excel in school and to be successful in the labor market. This concern has led to a variety of government responses over the years, some of which have focused on curriculum. In 1983, the National Commission on Excellence in Education recommended a more rigorous high school curriculum. It outlined a "New Basics" curriculum that included, among other things, four years of English and three years of math. Many states have since upgraded their graduation requirements. California, which has traditionally granted districts some autonomy in setting curriculum, has adopted statewide content standards in a number of subjects over the last few years. Most recently, on September 30, 2000, California Governor Gray Davis approved a bill making algebra a requirement for high school graduation.

Considerable evidence suggests that differences in years of schooling explain a large portion of the income gap in the nation and in California. Many have inferred that the growing income gap can be narrowed by better educating people at the lower end of the income distribution, especially minority students.

It stands to reason that it is not just years of education, but the type of education—the courses taken during school—that affects the earnings of high school students years later. There is some limited evidence that students who take more math in high school are more likely to pursue postsecondary education and to have higher earnings in the future. However, it has not been established how strong these relationships are, for what groups they exist, and what else might explain the apparent effect of curriculum on postsecondary education and future earnings.

Despite the belief that an enhanced curriculum is one way to improve students' college attendance rates and earnings, the few studies

that do include curriculum in estimates of these long-run student outcomes generally find minimal effects. The notion that the actual courses that students take in high school do not matter raises serious questions about the effectiveness of the American public school system's curriculum. Therefore, it is essential to investigate further.

The purpose of this report is to answer a series of broad questions:

1. What kind of math courses do which students take? Is there a link between the type of math courses that students take, the probability that students earn a college degree, and their future earnings?
2. If there is a link, does it reflect the effect that math courses have on students' productivity and therefore earnings, or does it merely reflect other underlying factors, such as a student's ability and motivation? (These other factors may determine both the level of math courses that a student takes and his or her future earnings.)
3. What are the policy implications of the study's findings?

This report focuses on the relationship between mathematics curriculum and earnings because a student's earnings are arguably the ultimate measure of how well schools prepare students for the labor market, and because recent evidence indicates that math achievement is more strongly correlated with labor market success than other measures of student achievement. Despite the importance of math courses, we extend the analysis to other subjects as well.

From a policy perspective, a clear understanding of the effects of math courses is extremely important. This is especially true for California where, after considerable debate, Governor Gray Davis and the State Board of Education have decided to include algebra in high school graduation requirements and a new high school "exit" exam. Understanding the economic value of such a course would be useful in justifying or modifying such policies.

There are also more general reasons why it is important to understand the effects of mathematics curriculum. First, to intervene in education effectively, we must understand whether students' destinies have been determined by the time they reach high school or whether a rigorous high school curriculum can alter students' paths. If it turns out that high school has little influence over student outcomes, intervention is necessary at an earlier stage. On the other hand, if high school curriculum does affect educational and labor market outcomes, policies aimed at encouraging students to take a more advanced curriculum may be a way of increasing the flow into college and increasing student earnings later in life.

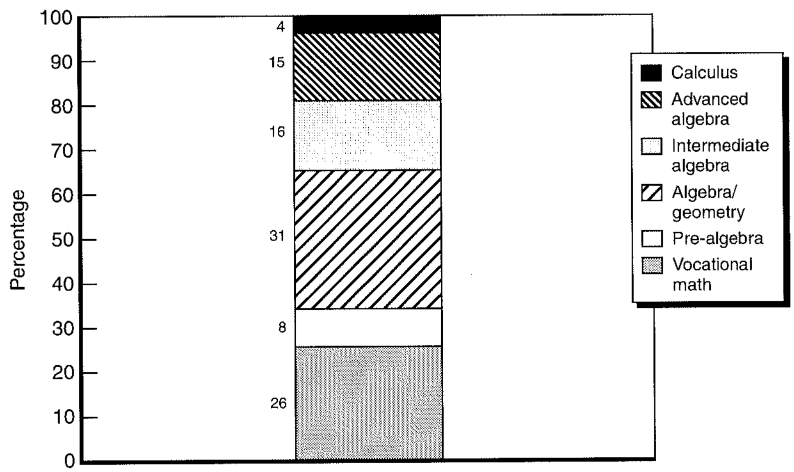
Second, with the recent elimination of affirmative action programs in California and some other states, there is fear that minority access to postsecondary education has suffered. As the returns to a college education continue to rise, such limited access would have severe implications for income equality between different ethnic groups. In light of the disappearance of race-based admissions policies, encouraging minority students to take more math, and improving their educational foundations so that they can do so, may help to increase their enrollment in college.

Finally, if we can establish that a more rigorous curriculum indeed affects the probability of going on to college and having higher future earnings, there will be many implications for how school resources are allocated. Perhaps more money should be spent on improving curriculum options, as opposed to spending designed to reduce class sizes. In sum, a clear understanding of the effects of curriculum and of possible variations in these effects related to student and school characteristics will guide policymakers about how best to equip students with the skills and education necessary to be successful once they leave school.

To answer the questions set forth in this report, we use the longitudinal data collected in the High School and Beyond survey of a representative national sample of students who were in grade 10 in 1980. This survey includes detailed data from the students' high school transcripts, information about the highest educational degree the student attained, and information about earnings nearly 10 years after students should have graduated from high school. The rich demographic data, as well as information about the student's family and high school, permit us to account for many noncurriculum factors that may also be related to college graduation and earnings. Because the survey data do not contain enough California students to estimate separate statistical models for California, most of the analysis proceeds at the national level. Nonetheless, we have enough California data to perform some checks that indicate that the predictions from the national models apply to California.

Mathematics Course-Taking Behavior of the 1982 Senior High School Class

There was a great deal of variation in the course-taking behavior of students in the early 1980s. Figure S.1 shows the proportion of students who completed at least one semester of the given level of mathematics course, as their highest course, by the time they graduated (or dropped out) from high school. A staggering 26 percent of students completed



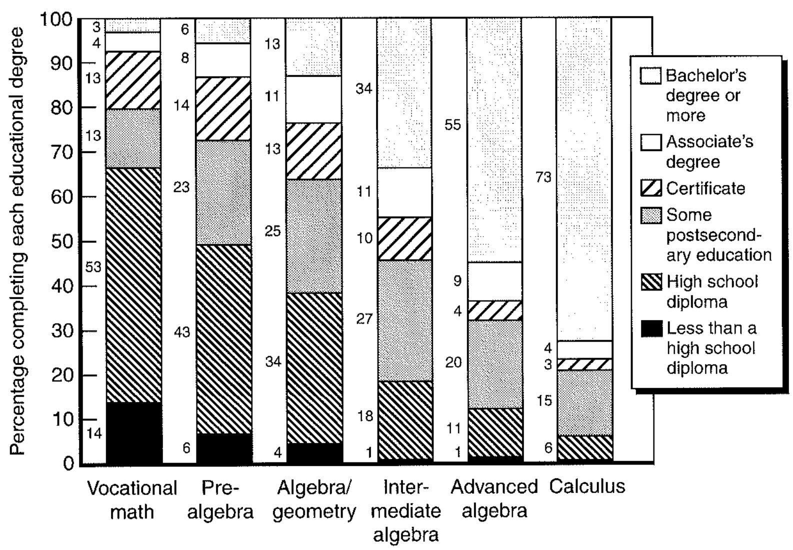
SOURCE: HSB sophomore cohort.

NOTES: Sample includes public school students who have completed at least one semester in at least one math course and are not missing any pertinent math transcript data. The highest math course is considered to be that in which the student completed at least one semester. The number of observations included is 10,073. The frequencies are weighted by the HSB transcript weight. Unweighted, the values are 26 percent, 9 percent, 30 percent, 16 percent, 16 percent, and 4 percent, respectively.

Figure S.1—Highest Math Course Taken

only vocational math courses and nothing more before leaving high school.[1] Another 8 percent stopped taking math courses after completing pre-algebra. Thirty-one percent took at least an algebra or geometry course, but nothing beyond; and a roughly equal percentage took an even more advanced math course. Only 4 percent of students completed a calculus course.[2]

This variation in course-taking had long-term implications for the welfare of these students. Figures S.2 and S.3 reveal that the point where students ended their math taking is related to how much education these



NOTES: See Figure 2.1 for the data source, sample criteria, and weighting. The sample size is only 8,850 because of missing data on educational attainment.

Figure S.2—Highest Degree Earned by 1992 Related to Highest Math Course Taken in High School

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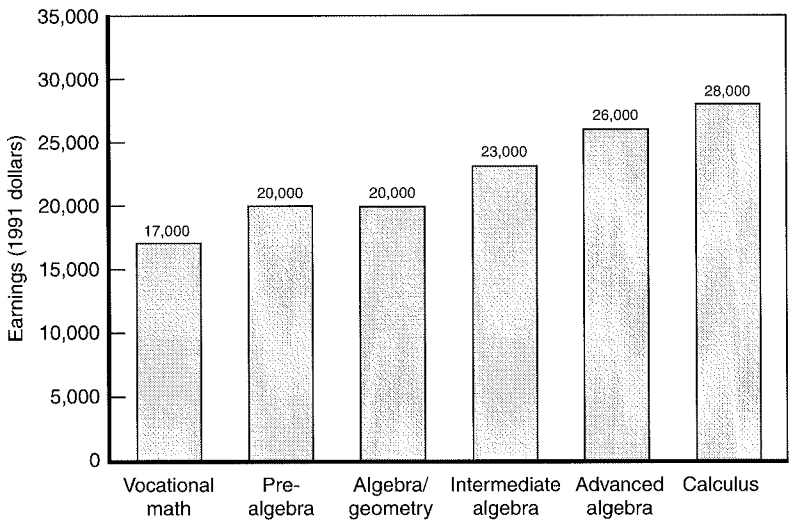
[1]Vocational math courses include courses described as vocational math, general math, basic math, consumer math, and math review.

[2]We consider the highest course to be the highest-level course in which the student completed at least one semester. However, in our more detailed models of earnings, we consider a course to be a year-long course.

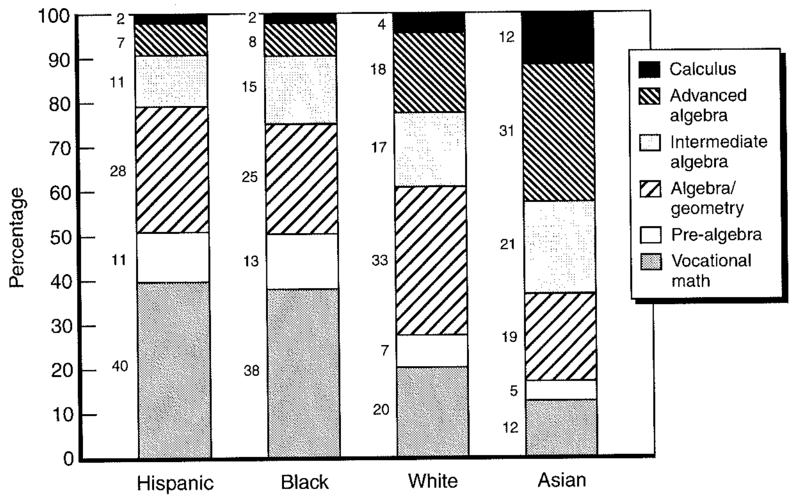


NOTES: The sample includes public school students who have completed at least one semester in at least one math course, are not missing any pertinent math transcript data, have annual earnings between $2,000 and $75,000, and are not enrolled in any postsecondary education program. The number of observations included is 5,891. The medians are weighted by the HSB fourth follow-up weights. In 1999 dollars, the above earnings are vocational math, $20,794; pre-algebra, $24,464; algebra/geometry, $28,134; advanced algebra, $31,803; and calculus, $34,250.

Figure S.3—Median 1991 Annual Earnings, by Highest Math Course Taken

students obtained overall and to how much they eventually earned. Students who took more-advanced math courses during high school tended to obtain markedly higher levels of education, and a decade after graduation, they earned significantly more than those who took only lower-level courses.

Given the stark differences in long-term outcomes for students, the fact that a high percentage completed only vocational math is troubling. Even more troublesome is the ethnic composition of these students. Black and Hispanic students were about twice as likely as whites and three times as likely as Asians to cease their math career at this low level. Similarly, students of extremely low-income families were much less likely to take any academic math courses. Figures S.4 and S.5 show the

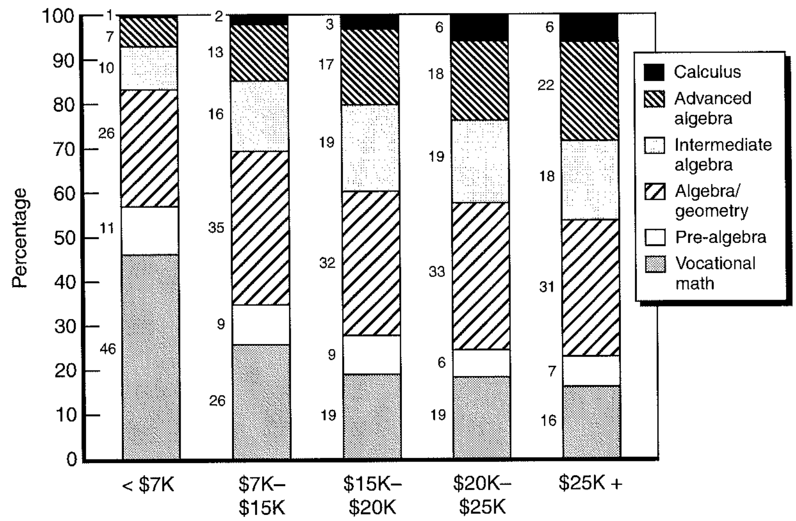


NOTES: See Figure 2.1 for the data source, sample criteria, weighting, and sample size. When these course completion rates are computed without weights, they are broadly similar to the ones above. The biggest difference is in the number of Hispanic and black students who take vocational math. In these two cases, the unweighted values are 5 percentage points lower than the weighted case, with the slack being taken up in the higher-level courses. The sample sizes for the ethnic groups are 2,221, 1,320, 5,855, and 345 for Hispanic, black, white, and Asian, respectively.

Figure S.4—Highest Math Course Taken, by Ethnicity

math courses taken by each ethnic group and parental income group. The minority students and students from low-income families who disproportionately stopped taking math at early stages also tended to be the students who did not progress very far through the school system and who tended to be at the low end of the income distribution later on in life.

Although the level of math course a student takes is correlated with college graduation rates and earnings, the correlations do not necessarily imply causation. There may be some underlying student characteristic that causes students to take a more rigorous curriculum and earn higher wages in the future. Nonetheless, the correlations do raise a red flag indicating the need for more in-depth analysis. When we conducted this analysis and estimated the effect that math courses have on our two



NOTES: See Figure 2.1 for the data source, sample criteria, weighting, and sample size. The sample sizes for the income groups are 916, 2,833, 1,751, 1,503, and 2,258, respectively, from the lowest to the highest income category. The income categories are in 1980 dollars. The 1999 dollar equivalents are roughly double the 1980 values.

Figure S.5—Highest Math Course Taken, by Parental Income

outcomes of interest (college graduation and earnings), we took into account as many of these underlying factors as we could to net out the true curriculum effects. Figure S.6 provides a sketch of the relationship that we model in this report. The student's demographic characteristics include ethnicity and gender; family background characteristics include parental education and income; and high school inputs and resources include things such as school size, teacher's education level, and the percentage of students at the school who are disadvantaged. We expect all of these factors to influence both the type of math courses students take and their educational attainment and earnings. The effect that math courses have on earnings operates through two channels, as shown in the figure: through some cognitive effect that makes students more productive and through an educational attainment effect that makes

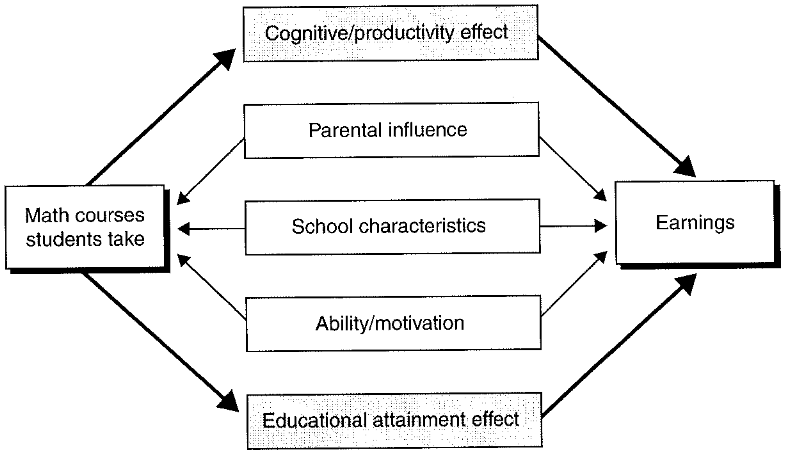


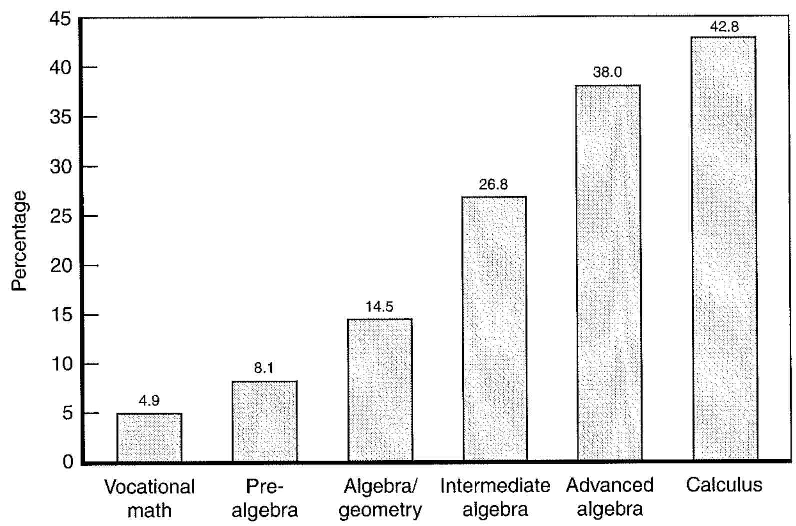
Figure S.6—The Pathways Through Which Curriculum Affects Earnings (and potentially confounding factors)

students more likely to pursue higher education. We estimated these two pieces of the overall earnings effect.

The Effects of Math Courses on the Likelihood of College Graduation

A large part of a math course's effect on earnings can be explained by its effect on the student's ultimate level of education. Different types of mathematics courses have different effects on the predicted probability of graduating from college, even after controlling for the student's demographic traits, family and school characteristics, and measures of ability. For example, as Figure S.7 shows, whereas the overall probability that an average student[3] whose highest math course is algebra/geometry will graduate is almost 15 percent, the probability that a student who takes intermediate algebra will graduate is nearly 27 percent. And an average student who takes advanced algebra is over 10 percentage points

[3]An average student is considered to be a student with the mean values for all of the explanatory factors in the graduation model.



NOTES: When estimating the math effects, we control for the student's demographic, family, and school characteristics as well as the student's ability as measured by his or her math GPA and math test score. The highest completed math course is the highest-level course in which the student completed at least one semester.

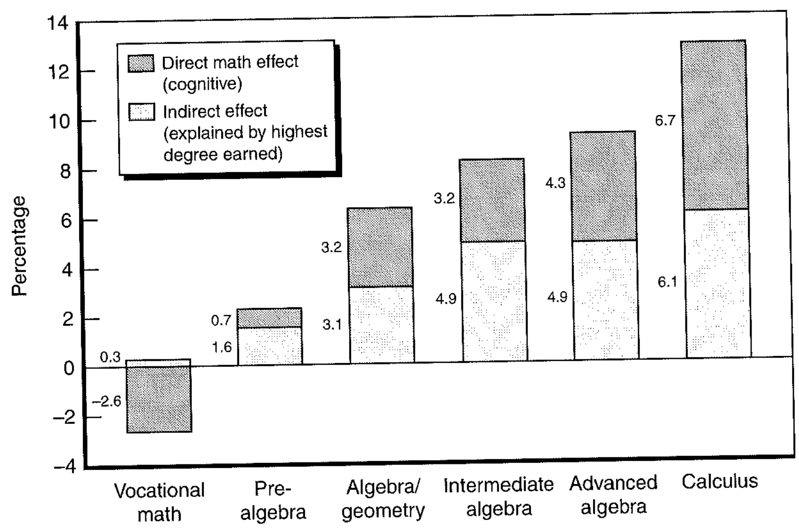
Figure S.7—Predicted Percentage of Students Graduating from College Given Their Highest Completed Math Course

more likely to graduate from college than is a student who completes only intermediate algebra.[4]

The Effects of Math Courses on Earnings

The effect that an additional mathematics course has on earnings is quite strong, and it varies by the level of the mathematics course even after accounting for the student's demographic traits, family background characteristics, and high school inputs and resources. As shown in Figure S.8, an additional algebra or geometry course is associated with over 6

[4]The highest math course is the highest-level math course in which the student completed at least one semester.



NOTES: When estimating the math effects, we control for the student's demographic, family, and school characteristics. An additional math course refers to an additional year-long course.

Figure S.8—Predicted Percentage Increase in Earnings Resulting from an Additional Math Course (direct and indirect effects)

percent higher earnings, holding all other factors constant.[5] The predicted effect of an additional calculus course is double that. The vocational math effect is somewhat more complicated to interpret. It has a negative sign, implying that students who take one more vocational math course than the average student does have lower earnings than the average student.

The student's ultimate level of educational attainment accounts for half of the academic math course effects, indicating that a large part of the pathway through which mathematics may affect earnings is by increasing the likelihood that students will seek higher education. Figure S.8 shows the predicted percentage difference in earnings resulting from

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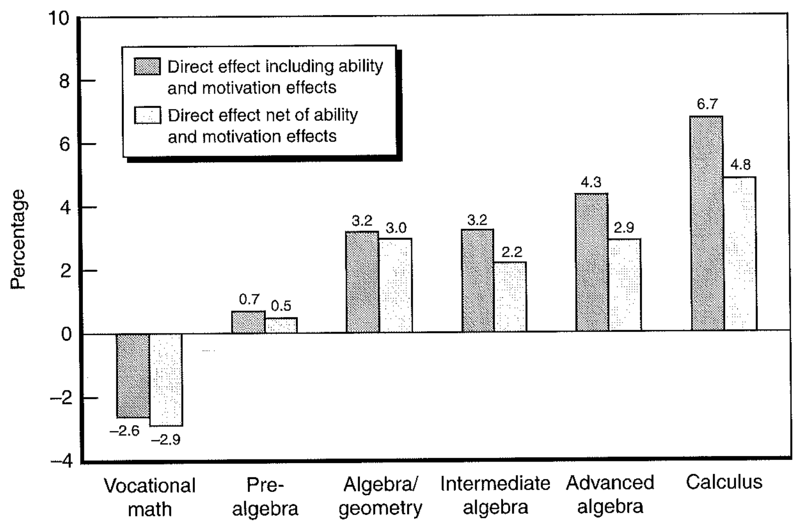
[5]In this section, we consider a course to last a year. In other words, we report the predicted effects of an additional 1.0 Carnegie unit (or credit) in the course.

an additional math course as well as the portion of that math effect that can be explained by the ultimate level of education that a student obtains. The light and dark bars in the figure show how the total effect of a math class can be broken down into the direct cognitive effect on earnings and the indirect effect on earnings that works by enabling the student to obtain more education. For instance, consider two students who have similar background characteristics and the same ultimate level of education. If one student takes an algebra/geometry course in high school and the other takes, in addition to algebra/geometry, intermediate and advanced algebra, the latter student is predicted to earn 7.5 percent more than the former (intermediate algebra is predicted to increase earnings 3.2 percent and advanced algebra is predicted to increase earnings another 4.3 percent). These are the *direct effects* on earnings. But in addition, as shown by the lighter bars in the figure, the student who takes the additional two courses is also likely to obtain more postsecondary education, boosting his or her earnings another 9.8 percent (4.9 percent for each class). The total combined effect is a predicted earnings gain of 17.3 percent. This is the sum of the two effects of curriculum outlined in Figure S.6, the direct cognitive and the indirect educational attainment effects.

As the diagram in Figure S.6 shows, in addition to accounting for demographic, family, and school characteristics, it is also important to account for other factors, including the student's ability and motivation, to net out the true cognitive/productivity math effects. Accounting for such factors using the students' mathematics grade point average (GPA) explains a portion of the cognitive math effect on earnings.[6] Figure S.9 shows the *direct* math effects that include ability effects and the direct math effects net of ability effects. Controlling for ability and motivation diminishes the *direct* effect of mathematics, and it appears to explain a larger portion of the more advanced math course effects (intermediate algebra and higher) than it does of the algebra/geometry and vocational effects. Nonetheless, once we account for ability, the courses at or above

[6]In the main text and Appendix C of this report, we present results from other ways of controlling for ability and motivation. Regardless of the exact control, the tenor of the results does not change.



NOTES: When estimating the math effects, we control for the student's demographic, family, and school characteristics. To estimate the effects net of ability and motivation, we also control for the student's math GPA. An additional math course refers to an additional year-long course.

Figure S.9—Predicted Percentage Increase in Earnings Resulting from an Additional Math Course (direct effects with and without ability and motivation)

the algebra level are still associated with much higher earnings than are vocational math and pre-algebra courses. The magnitude of the academic math course effects still differs depending on the course, i.e., calculus has a stronger effect than algebra, but the differences are not as great once we account for ability.

We also examined whether the effect of curriculum on earnings depended significantly on certain characteristics of the schools that students attend, or on the demographic characteristics of the students themselves. This is a crucial concern for policymakers, who will want to know whether, for instance, the math curriculum offered at affluent schools with many resources and largely upper-income white students will prove as effective in a different school and socioeconomic environment. Similarly, we need to know whether curriculum works differently among men and women.

Math curriculum is predicted to affect earnings significantly for both men and women. However, for men, unlike women, most of the influence of curriculum appears to work through the effect that high school math courses have on the student's ultimate level of educational attainment. For women, the direct cognitive/productivity effect is stronger than it is for men.

Similarly, we sought to examine whether the effect of math courses on earnings varied with respect to other student characteristics, characteristics of the student body at the high school, and measures of school resources. We did not find strong evidence that the effect of curriculum changed with respect to any of these variables. If anything, we found weak evidence that taking more math courses might have larger beneficial effects for students from relatively disadvantaged backgrounds. However, we do not find our evidence in this regard decisive.

Finally, although these results are estimated using national data, statistical tests suggest that they apply to California students as well.

The Effects of Math Courses on the Earnings Gap

Considering the important role that math curriculum plays in predicting earnings, it is important to ask a follow-up question: Can math explain the earnings gap between students of different ethnicity or the gap between students from different socioeconomic backgrounds? For the 1980 sophomore cohort, the gap in 1991 earnings between white and black and between white and Hispanic students can be almost entirely explained by demographic, family, and school characteristics, with parental income levels and parental education levels playing a substantial explanatory role.

In turn, curriculum does explain about one-quarter of the earnings gap between the students from the lowest-income families and students from middle-income families. Even more striking, it explains almost the entire gap between the students from the next-to-lowest parental income category and students from middle-income families. So, it appears that curriculum directly explains a portion of the earnings gap based on students' family income level when they are in high school. And, because

Hispanic and black students tend to be overrepresented in the lowest two income groups (in other words, ethnicity and family income level are quite related for these student groups), curriculum indirectly explains part of the ethnic earnings gap as well.

Conclusions

The main message of this report is that math matters. For the 1980 cohort of high school sophomores, math curriculum is strongly related to student outcomes more than 10 years later. Math curriculum has a strong effect on the probability of graduating from college. High school math courses also appear to influence earnings. Roughly half of the predicted effect of math courses on earnings works indirectly through enabling students to obtain more postsecondary education, and the other half appears to work through a direct effect on earnings, independent of how much education the student ultimately obtains.

Although this report focuses on math, we devote a section to the effects of courses in other academic subjects as well. As with math, different types of courses within a certain subject area affect earnings differently. Taking an above-level English course is predicted to increase earnings by more than taking average-level English courses. More interesting, math courses still seem to matter once we account for the courses a student takes in other subjects. It appears that taking an advanced-level English course increases earnings by more than an additional course in algebra/geometry, or intermediate algebra, but by less than the more advanced math courses do. However, all of the math courses at or above the algebra/geometry level are predicted to increase earnings by more than an average-level English course.

A notable finding of the report for policymakers is that the observed correlation between math courses and earnings appears to be at least partly causal. That is, in spite of our extensive efforts to take into account confounding factors, including the student's innate ability and motivation, the relationship between curriculum and earnings still appears strong. Perhaps the most important message of this report is that not all math courses are equal. More-advanced math courses have a much larger effect on college graduation rates and earnings than do less-advanced courses. The biggest difference is between courses at or above the algebra/geometry level and courses below the algebra/geometry level. This finding implies that all students should have access to the full range of demanding math courses and that they should be strongly encouraged, motivated, and prepared to take them. Again, it is not simply the number of math courses that matters; what matters more is the extent to which students take the more demanding courses, such as algebra/geometry.

Although the results of this inquiry show that students who take more-advanced math courses benefit from them, it is important to note one limitation of this finding. These results do not speak to the consequences of policies requiring that all students take a specific math course for graduation. Policies that force certain math courses on students could have negative consequences, such as high student dropout rates and a watering down of the work required to complete those courses. This report does not analyze such consequences. Any policymakers considering sweeping curriculum reform would be well advised to initiate small-scale demonstrations of the reforms to test for such negative side-effects before implementing them widely.

We conclude by noting that in California, perhaps even more so than in other states, public attention continues to focus on such issues as class size, school spending, and teacher quality. Although such public attention is welcome, this report shows that it is crucial to remember that quite independent of the level of resources at a given school, curriculum appears to matter tremendously for long-term student outcomes. Put differently, we must not lose focus on the heart of the matter: what students actually learn in school.