

Mathematics and Future Opportunities

The Importance of Mathematics for College Entrance

Students who take rigorous mathematics and science courses are much more likely to go to college than those who do not. Data from a longitudinal survey of students who were in the 8th grade in 1988 (National Educational Longitudinal Study or NELS) reveal that 83 percent of students who took algebra I and geometry enrolled in college⁽¹⁾ within two years of their scheduled high school graduation. Only 36 percent of students who did not take algebra I and geometry went to college (Figure 1 -- 4,861 bytes). Similarly, students who take rigorous science courses in high school are much more likely to go to college. While nearly 89 percent of students who took chemistry entered college, only 43 percent who did not take chemistry went to college.

Students who take more rigorous mathematics courses also show higher gains in mathematics achievement (measured by the mathematics achievement test given as part of NELS) than students who take less challenging courses, even when controlling for initial achievement. For example, among students who initially began at the same level of mathematics proficiency in the 8th grade, students who had taken algebra II or geometry by the 10th grade experienced greater gains, on average, than students who had taken no algebra or only algebra I during that period.

Students of all income levels who take rigorous mathematics and science courses in high school are more likely to go to college, and among low-income students (students in the bottom third of the income distribution)⁽²⁾, the difference is particularly dramatic. Students from low-income families who took algebra I and geometry were almost three times as likely to attend college as those who did not. While 71 percent of low-income students who took algebra I and geometry went to college, only 27 percent of low-income students who did not take algebra I and geometry went on to college. The differences are also dramatic among students from middle- and high-income families: 94 percent of students from high-income families, and 84 percent of students from middle-income families who took algebra I and geometry went on to college, while 60 percent of students from high-income families and 44 percent of students from middle-income families who did not take geometry still went on to college (Figure 2 -- 4,752 bytes).

Unfortunately, many students, in particular low-income students, do not take these rigorous mathematics and science courses. According to NELS, 63 percent of all students took algebra I and geometry and 50 percent took chemistry. Students from low-income families, however, were far less likely than their more advantaged peers to take these rigorous courses. Among students in the bottom third of the income distribution, 46 percent took algebra I and geometry and only 33 percent took chemistry. By way of comparison, fully 81 percent of students in the top third of the income distribution took algebra I and geometry, and 72 percent took chemistry. The differences are similar for other rigorous mathematics courses (Table 1).

Table 1: Course-Taking Patterns of NELS Students

	Percent of Students Taking Course			
	All	Bottom Income	Middle Income	Top Income
Algebra I and Geometry	63	46	68	81
Trigonometry	18	10	19	30
Chemistry	50	33	52	72

Accounting for course-taking patterns dramatically reduces the difference in the rate of college-going between low- and high-income students. Students from high-income families are almost twice as likely to attend college as students from low-income families (86 percent compared to 44 percent) when course-taking patterns are not accounted for. However, comparing only students who have taken rigorous courses to one another, students from low-income families go to college at rates much more similar to students from middle- and high-income families (Table 2). For example, among students who took chemistry in high school, 95 percent of high-income students, 89 percent of middle-income students, and 79 percent of low-income students went to college. When low-income students take rigorous courses, income effects on college entrance rates diminish greatly, although they do not disappear.

Table 2: College Attendance by High School Course-Taking Patterns of NELS Students

		Percent of Students Attending Postsecondary Education			
		All	Bottom Income	Middle Income	Top Income
	All	63	44	69	86
Algebra I and Geometry	Yes	83	71	84	94
	No	36	27	44	60
Trigonometry	Yes	94	90	92	98
	No	59	42	66	83
Chemistry	Yes	89	79	89	95
	No	43	31	50	68

Public Versus Private Achievement Depends on Course-Taking, Not the Type of School

In general, the mathematics courses students take in high school determine achievement more than the type of school they attend. While recognizing that a great deal of diversity exists in public and private schools, it is useful to note that when

both categories of school is very similar. Public and private (Footnote: Private schools include non-religious, Catholic, and other private schools.) school students who took the same mathematics courses were almost equally likely to score at the highest level on the NELS 12th grade mathematics achievement test. This was also true for low-income public and private school students. Additionally, among both public and private school students of all incomes, students who had taken more rigorous mathematics courses were much more likely to score at the highest achievement level (Figure 3 -- 8,073 bytes).

Mathematics in College, the Workplace, and the 21st Century

The benefits of taking rigorous mathematics and science courses extend to students heading into the job market and to both two- and four-year colleges. As technology becomes prevalent in the workplace, more and more workers will find they need to have strong backgrounds in mathematics and science--backgrounds which will have begun to form even before high school. Rigorous mathematics and science preparation is also important to students intending to go to a two- or four-year college or university. The level and number of mathematics courses that a student needs to take before and during college depend on the college and the major that the student wants to pursue. Mathematics- and science-related disciplines typically require that students have taken rigorous mathematics courses. Many other popular courses of study require advanced mathematics as well.

Two-year colleges often require all students to gain an understanding of intermediate algebra prior to graduation, regardless of their course of study. Many two-year colleges require all degree-seeking students to take mathematics placement exams prior to enrollment. High scorers may be exempt from taking certain mathematics courses, while low scorers may have to take remedial mathematics courses. Many of the most popular majors at two-year colleges--including Business, Nursing, and Computer Science--require more rigorous mathematics course work, such as statistics.

Four-year colleges and universities typically require more high school mathematics preparation for admission. Typical state four-year colleges and universities recommend, and in some cases require, that all students take at least three, and sometimes four, years of mathematics in high school. Data collected by the College Board reveal that in 1997, 68 percent of incoming freshmen at four-year colleges and universities had taken four years of mathematics in high school. Furthermore, almost all of these students had taken algebra and geometry, and more than half had taken trigonometry. Most state colleges require students to take mathematics placement exams upon enrollment. Colleges look favorably on Advanced Placement courses and often place students who have taken them out of introductory mathematics courses. While graduation requirements differ depending on the students' major, many popular majors, such as Business and Psychology, require students to take several more rigorous courses in mathematics or science.

In the job market, workers who have strong mathematics and science backgrounds are more likely to be employed and generally earn more than workers with lower achievement, even if

they have not gone on to college. A national survey found that by age 30, high school graduates who had not furthered their education but had scored in the top quartile on the mathematics portion of the Armed Services Vocational Aptitude Battery (ASVAB--administered to civilians for study purposes) earned, on average, 38 percent more per hour than high school graduates who had not gone to college and had scored in the bottom quartile of the mathematics portion of the ASVAB. Similarly, the unemployment rate among high school graduates who scored in the top quartile of the mathematics test was only 4.4 percent. The unemployment rate was 10.3 percent among high school graduates who scored in the lowest quartile. Workers who scored in the top quartile of the science section of the ASVAB also earned more, on average, and were less likely to be unemployed.

Mathematics ability will be even more important for well-paying jobs in the future. Some major firms already require job applicants to pass standardized mathematics and reading tests. For example, Diamond-Star Motors, a joint venture of Chrysler and Mitsubishi, tests all applicants for production and maintenance positions on their ability to do high school level mathematics. Authors Richard Murnane and Frank Levy have identified a set of "New Basic Skills," in their book of the same name, that non-college-bound high school graduates should master in order to get well-paying jobs in the modern labor market. The "New Basic Skills" that workers will need in order to earn a good wage include the ability to use mathematics skills and concepts **at least** at the 9th grade level.

Shortages in workers skilled in mathematics and science could affect U.S. performance in global markets. According to a recent report, *America's New Deficit: The Shortage of Information Technology Workers*, from the Office of Technology Policy at the U.S. Department of Commerce, as computer and data processing become more important to the economy, more and more workers skilled in mathematics- and science-related disciplines will be needed to maintain the U.S.'s international competitiveness. The report cites a survey by the Information Technology Association of America indicating that 50 percent of company executives in information technology report a lack of skilled workers as "the most significant barrier" to their companies' growth during the next year. However, the number of bachelor level computer science degrees awarded by U.S. colleges and universities declined more than 40 percent between 1986 and 1994, indicating that these problems are likely to persist.

Mathematics and Science in the Modern Job Market

Many jobs in today's labor market require a mathematics or science background. A number of these are among the fastest growing occupations nationally, and are not ones ordinarily thought of as "technical." Projections from the Bureau of Labor Statistics' (BLS) Occupational Outlook Handbook indicate that between 1994 to 2005, jobs requiring the most education and training will be the fastest growing and highest paying. BLS predicts that occupations requiring a bachelor's degree or higher will average 23 percent growth, almost double the 12 percent growth rate projected for occupations that require less education and training.

skills in algebra, geometry, measurement, probability, and statistics. According to an industry-wide standard, an entry level automobile worker needs to be able to apply formulas from algebra and physics to properly wire the electrical circuits of any car. The National Coalition for Advanced Manufacturing has defined 25 specific standards of mathematics and measurement among their national skill standards for what a competent worker should know and be able to do.

Several of the fastest growing job areas will reflect growth in computer technology and health services--fields that can require substantial mathematics and science preparation. Generally speaking, fields requiring a strong science base also require substantial mathematics preparation, as most academic science programs build upon a strong background in mathematics. Below are some of the jobs which BLS indicates require a mathematics or science background; while many of these jobs require mathematics or science course work beyond the high school level, all require at least a high school level background. The occupations that BLS projects will be among the fastest growing during the period from 1994 to 2005 are noted with a star (*).

Computer Scientists (*) Surgical Technologists Systems Analysts (*)
Dietitians and Nutritionists Occupational Therapy
Optometrists Assistants and Aides (*) Chemical Engineers
Physical Therapists (*) Civil Engineers Roofers Aerospace
Engineers Tool and Die Makers Medical Assistants (*)
Photographers Dentists and Dental Hygienists Financial Managers
Surveyors Budget Analysts

Foot Notes:

1. Throughout this report, the term "college" is used to refer to any postsecondary education taken at a public, private not-for-profit, or private for-profit institution.
2. Income data are based on total family income reported by parents. Low, middle, and high income groups each contain approximately one-third of the sample. The "all" category includes additional observations with missing income data.