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# Social Background Differences in High School Mathematics and Science Coursetaking and Achievement

**Contact:**
Peggy Quinn
202–219–1743

**Authors:**
Thomas B. Hoffer
Kenneth A. Rasinski
Whitney Moore
NORC

Since the publication of *A Nation at Risk* (U.S. National Commission on Excellence in Education, 1983), several state and local educational authorities have increased the number of mathematics and science courses required for high school graduation. While research has shown that students who take more mathematics and science courses score higher on standardized achievement tests (Gamoran, 1987; Jones, et al., 1992), many have questioned the effectiveness of higher requirements. Some have expressed concern that the new courses will be undemanding, since they are designed to accommodate students who would rather not take them (see Clune and White, 1992 for an initial assessment). Others have predicted that weaker students will find the higher standards unattainable, and will drop out of high school (McDill, Natriello, and Pallas, 1986). The record shows, however, that dropout rates have actually declined over the past decade (McMillen, Kaufman, and Whitener, 1994). While dropout rates have been declining, the average numbers of mathematics and science courses completed by high school graduates have in fact increased dramatically (Smith, et al., 1994, pp. 76 - 77). Data from the National Assessment of Educational Progress show small improvements in the average mathematics and science achievement levels of 17-year-olds from 1982 to 1990 (Smith, et al., 1994, pp. 54 - 57). However, the links between the coursetaking and achievement trends need to be analyzed in more detail before causal claims are made.

As a step in that direction, this report examines the relationships between the numbers of courses in mathematics and science that high school students complete and their achievement on standardized tests. Three questions are addressed: (a) To what extent do students from different social backgrounds differ in the numbers of courses they complete during high school?; (b) To what extent do students from different social backgrounds differ in their final levels of academic achievement?; and (c) Does additional coursework have comparable relationships with measured achievement gains during the high school years for students from different backgrounds? Our major findings include:

- Males and females do not significantly differ in the numbers of science and mathematics courses they complete.
- Students from higher socioeconomic-status families complete more courses in these subjects.

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- Asians complete more courses in math and science than whites, and whites complete more courses than blacks and Hispanics.

- Among students with comparable SES, the differences in the number of courses completed between whites, blacks, and Hispanics are insignificant.

- Test score increases from the end of 8th grade to the end of grade 12 are strongly related to the number of math and science courses students complete in high school.

- Students who complete more math and science courses show greater achievement score gains during high school, regardless of gender, race-ethnicity, and socioeconomic class.

The data analyzed are from the second (1992) follow-up survey of the National Education Longitudinal Study of 1988 (NELS:88). All of the students represented here were 8th-graders in 1988. Most (85 percent) of the students in the study were high school seniors when the data were collected; 12 percent had dropped out, and 3 percent were in grade 11. We examine high school students' coursetaking and achievement in mathematics and science by using new data from the NELS:88 second follow-up Transcript Survey. It is important to emphasize that this report uses only a small segment of the information on students' coursetaking and achievement available in the NELS:88 database. Further analyses could usefully examine the effects of different *kinds* of mathematics and science courses, in addition to the present focus on the *number* of courses. And in addition to the focus here on *overall achievement* levels, further work could analyze the effects of coursework on the students' proficiencies in *particular skill areas* within the domains of science and mathematics. The appendix amplifies on these suggestions and gives details on the NELS:88 survey and the sample and variables used here.

## Coursetaking

Virtually all high schools in the United States count courses toward graduation in terms of Carnegie units. A Carnegie unit or fraction thereof is assigned strictly on the basis of how long a course meets, and does not depend on the course content. One Carnegie unit is earned for every course that meets for five 50-55 minute periods per week for an entire school year. In 1992, 10 states required 3 Carnegie units in mathematics for graduation, 30 states required 2 units, 3 required 2 units plus an additional unit of either science or math, and 7 states left the policy decision up to their local districts. In science, only 3 states required 3 units for graduation, while 36 required 2, 3 required 2 units of science and 1 additional unit of science or math, 2 required only 1 unit, and 7 states left it up to the local districts to decide (Blank and Gruebel, 1993).

While several states thus set a lower bound of two courses in both subjects for high school graduation, there is still considerable room for differences among students to arise. The overall distributions for mathematics and science are shown in table 1. The median number of courses completed in both subjects is three. About 37 percent of the students complete four or more mathematics courses, and about 23 percent of the students complete four or more science courses. At the other end of the distributions, about 5 percent complete no math or science courses, presumably because they fail to pass any courses in these subjects while in high school.

What accounts for the differences shown in table 1? Individual motivation, ability, and parental guidance are surely important factors leading to different outcomes. But opportunities may also vary, leading to different results for equally motivated and able students. Some students, for example, may attend schools with sharply limited opportunities for advanced coursework in science and mathematics; others may have an interest but be excluded because of school tracking patterns or inappropriate guidance. Historically, some of the largest fault lines in student participation coincided with social background differences, and these often had little to do with ability or motivation to succeed. Low-income students, for example, faced extremely unfavorable odds for attending college prior to the 1960s and would have had little to gain from a college-preparatory sequence in science or math. Sex differences in college attendance declined sharply after World War II, but science and mathematics were largely defined as masculine fields.

**Table 1**
**Percentage of Students Completing Various Numbers of Mathematics and Science Courses During High School: 1992**

| Number of Carnegie units earned:[a] | Mathematics | Science |
|---|---|---|
| Total | 100.0 | 100.0 |
| 0 | 5.4 | 4.5 |
| 1 | 9.5 | 10.3 |
| 2 | 18.4 | 31.7 |
| 3 | 29.7 | 30.0 |
| 4 | 30.6 | 17.8 |
| 5 or more | 6.5 | 5.6 |
| | | |
| mean | 2.8 | 2.6 |
| standard deviation | 1.3 | 1.2 |
| unweighted sample size | 14,283 | 14,283 |

[a] **One Carnegie unit is earned for every course that meets for five 50 - 55 minute periods per week for an entire school year. Carnegie units are rounded to the nearest integer for the categorical breakdowns, but are not rounded for the means and standard deviations. Students completing .5 course were rounded to 0, 1.5 to 2.0, 2.5 to 2.0, 3.5 to 4.0, and 4.5 to 4.0.**

**SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: High School Transcript Study.**

How does social background affect participation in science and mathematics in the 1990s? The average numbers of Carnegie units students completed in mathematics and science are broken down in table 2 by sex, race-ethnicity, and socioeconomic status (SES) quartile membership. These figures show that males and females completed almost identical numbers of courses in both subject areas.[1] Asians completed the most science and mathematics courses. Hispanics and blacks completed about a third of a course less than whites in both subjects. The differences between students in the lowest and highest SES quartiles are about one and one-third Carnegie units.

The racial and ethnic groups differ in their average socioeconomic levels. Since the socioeconomic status of the students' families is also associated with the numbers of courses students complete, it is important to see whether the overall race and ethnicity differences are found among students from the same SES levels. To assess this, the average numbers of math and science courses completed by the race and ethnic groups are calculated separately for the SES groups. To simplify the presentation, we collapsed the middle two SES quartiles into a single "middle" category.

The SES breakdowns in figure 1 indicate that the white-black and white-Hispanic differences in both subjects are in fact largely reflections of SES-related differences. Within SES groups, blacks and whites do not significantly differ in the numbers of math and science courses they

**Table 2**
**Average Number of Math and Science Courses**
**Completed in High School, by Sex, Race-ethnicity, and SES: 1992**

| Student characteristic | Mathematics | | | Science | | |
|---|---|---|---|---|---|---|
| | Mean | SE | Unw N | Mean | SE | Unw N |
| **All Students** | 2.81 | .03 | 14,283 | 2.58 | .03 | 14,283 |
| **Sex** | | | | | | |
| Male | 2.81 | .05 | 7,113 | 2.57 | .04 | 7,113 |
| Female | 2.81 | .03 | 7,170 | 2.58 | .03 | 7,170 |
| **Race-Ethnicity** | | | | | | |
| Asian | 3.25 | .07 | 885 | 3.04 | .10 | 885 |
| Hispanic | 2.51 | .08 | 1,689 | 2.15 | .05 | 1,689 |
| Black | 2.57 | .09 | 1,315 | 2.35 | .09 | 1,315 |
| White | 2.89 | .04 | 10,241 | 2.66 | .03 | 10,241 |
| American Indian | 1.95 | .22 | 134 | 2.13 | .15 | 134 |
| **SES Quartile** | | | | | | |
| Lowest | 2.13 | .05 | 3,017 | 1.94 | .05 | 3,017 |
| Second | 2.62 | .04 | 3,440 | 2.35 | .04 | 3,440 |
| Third | 2.97 | .04 | 3,532 | 2.74 | .04 | 3,532 |
| Highest | 3.46 | .05 | 4,293 | 3.21 | .04 | 4,293 |

**SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Survey and High School Transcript Study.**

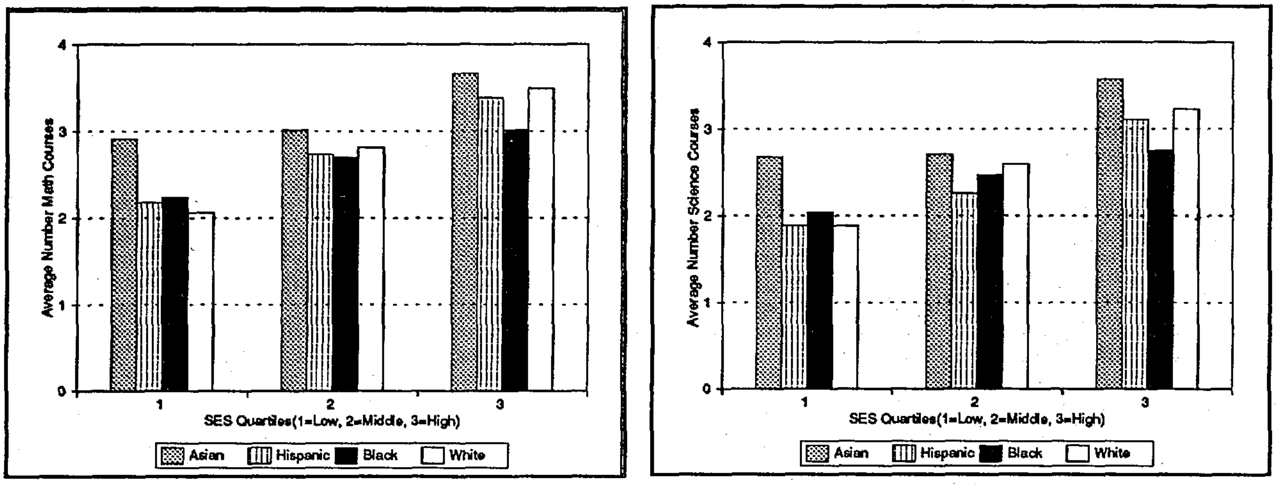
complete. Hispanics and whites show no significant differences in mathematics, but middle-SES whites complete more science courses than middle-SES Hispanics.

The Asian advantage in course completions turns out to be especially large in the low-SES population. High-SES Asians also complete more science courses than whites. The main points from figure 1 are that (a) black and Hispanic students who come from the same socioeconomic background as white students complete about the same number of math and science courses; and (b) among low-SES students, Asians complete substantially more math and science courses than whites.

## Achievement

How does the academic achievement of the different subpopulations compare by the end of high school? If achievement differences primarily reflect differences in the numbers of courses students complete, then test scores would show no gender gap, minimal race-ethnicity differences within SES levels, and relatively large SES differences. To measure academic achievement in science and mathematics, the NELS:88 survey

**Figure 1.-- Average number of mathematics and science courses completed during high school, by student socioeconomic status and race-ethnicity: 1992**

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**NOTE: American Indian and Alaskan Native students are excluded due to small sample size (n=96).**

**SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.**

administered tests to respondents during the spring term of 1988, 1990, and 1992. The scale used here is the number of items a student answered correctly on the mathematics and science cognitive tests that were administered to students in the spring 1992 survey, when most of the students were seniors (see the Appendix for details on the NELS:88 tests). The sample standard deviation of the tests are 14.1 for mathematics and 6.0 for science.

The average grade 12 achievement levels and standard errors broken down by subgroup are shown in table 3. The total male-female difference in mathematics is only 1.15 items and is not statistically significant at the conventional p=.05 level. A significant difference is evident in science, with males scoring higher than females. The differences between the race-ethnicity groups are much larger than the sex differences. Asians score higher in mathematics than whites. Whites (and Asians) score higher than blacks and Hispanics in both math and science. Hispanics score somewhat higher than blacks in both mathematics and science. As was true for the coursework comparisons, the SES differences in achievement are large. The results in tables 2 and 3 indicate that the achievement score differences among the different subpopulations tend to be larger than the differences in the numbers of courses completed.

## Coursetaking and Achievement Gains

To what extent do the coursetaking differences shown in table 2 account for the achievement differences in table 3? Are additional courses in mathematics and science equally beneficial to the achievement of students from different subpopulations? To answer these questions, we take advantage of the longitudinal design of the NELS:88 study to estimate the "value-added" of additional coursework. While the achievement scores presented in table 3 give an indication of how much students had learned by the end of high school, those scores alone do not indicate how much students learned *while* in high school. For that purpose, the focus must shift from the endpoints to change. NELS:88 administered math, science, reading comprehension, and social studies achievement tests at three time points: 1988, 1990, and 1992. For present purposes, we measure change during high school by calculating the difference between the 1992 and 1988 scores for each student. The average gains broken down by the number of Carnegie units earned and the social background variables are presented in table

**Table 3**
**Average 12th-Grade Achievement Test Scores in Mathematics and Science, by Student Social Background.**

| | Mathematics achievement | | | Science achievement | | |
|---|---|---|---|---|---|---|
| | Mean | SE | Unw. N | Mean | SE | Unw. N |
| **All Students** | 47.66 | .33 | 11,695 | 23.22 | .14 | 11,626 |
| **Sex** | | | | | | |
| Male | 48.23 | .47 | 5,812 | 24.16 | .18 | 5,777 |
| Female | 47.08 | .37 | 5,883 | 22.26 | .17 | 5,850 |
| **Race-Ethnicity** | | | | | | |
| Asian | 53.36 | 1.09 | 714 | 24.54 | .40 | 710 |
| Hispanic | 41.69 | .68 | 1,319 | 20.42 | .28 | 1,310 |
| Black | 39.23 | .77 | 1,049 | 18.79 | .30 | 1,038 |
| White | 49.84 | .37 | 8,502 | 24.38 | .14 | 8,457 |
| American Indian | 39.25 | 1.76 | 96 | 19.88 | 1.09 | 96 |
| **SES** | | | | | | |
| Lowest | 38.88 | .45 | 2,319 | 19.70 | .20 | 2,304 |
| Second | 44.69 | .44 | 2,830 | 22.14 | .21 | 2,807 |
| Third | 49.07 | .43 | 2,931 | 23.82 | .19 | 2,917 |
| Highest | 55.83 | .65 | 3,615 | 26.35 | .25 | 3,598 |

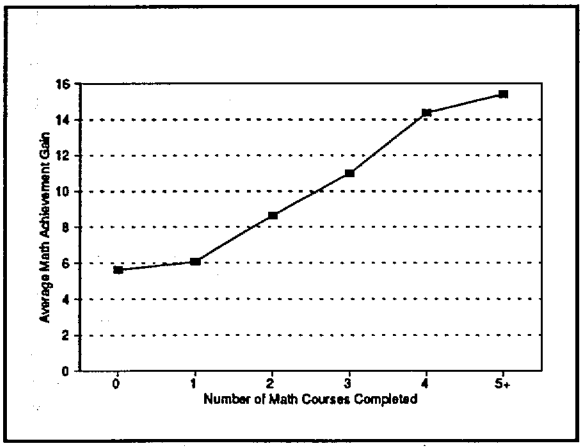
**SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component.**

4 at the end of the report. The standard deviations of the gain scores are 7.8 for math and 4.7 for science.

The overall average gain scores for students grouped according to the number of mathematics and science credits they earned in high school are plotted in figures 2 and 3. The positive slopes in these graphs clearly indicate that students who completed more courses showed greater improvement from the end of 8th grade to the end of 12th grade. The average gain in mathematics amounts to about 2.4 additional items correct for each additional course, and in science the average gain per additional course is about .8 of an item.[3]

**Sex differences.** The average gain scores by numbers of courses completed for males and females in mathematics are shown in figure 4; the results for science are presented in figure 5. The positive slopes mean that both males' and females' average test score gains from grade 8 to grade 12 are greater, the more courses the students complete. The slopes of the male and female lines in both figure 4 and 5 are roughly parallel, and thus show that both males and females benefit about equally from additional coursework. The vertical gap between the lines indicates the size of the sex difference in learning for students who completed the same numbers of math and science courses during high school. Even though the

**Figure 2.-- Average mathematics test score gain from 8th- to 12th-grade, by number of mathematics courses completed during high school: 1992**

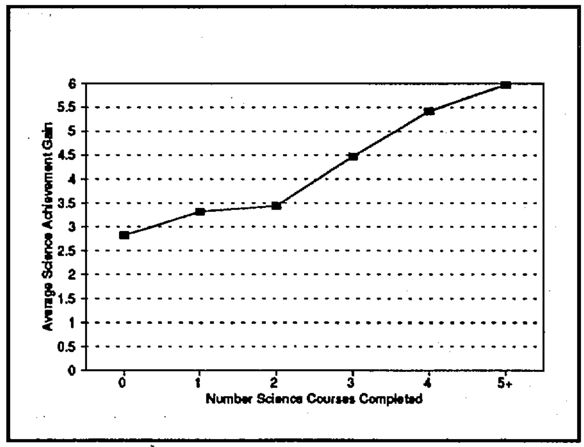



SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student and Transcript Components.

overall sex difference in grade 8 to grade 12 math gains is significant (table 4), the convergence of the graphs indicates that gaps are not consistent when students are grouped by the numbers of math courses they complete.

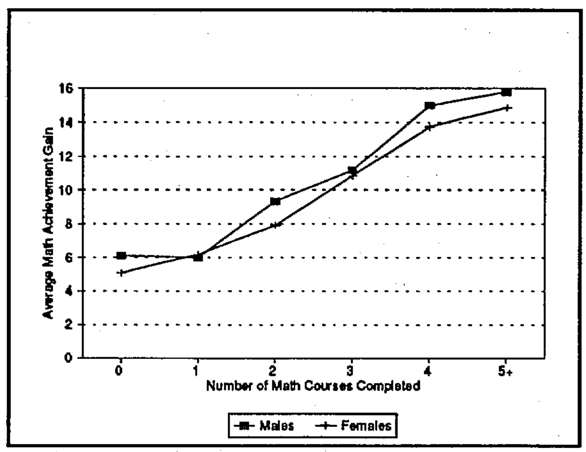
In science, males finish high school significantly ahead of females (table 3). The overall gains in table 4 also show significant advantages for males. Figure 5 shows that advantage reflects a pattern of greater gains for males than females among students completing the same numbers of high school science classes. The sex gap at most levels of course completions is about one item, which is also about what students gain on average from completing an additional science course.[4]

**Figure 3.-- Average science test score gain from 8th- to 12th-grade, by number of science courses completed during high school: 1992**



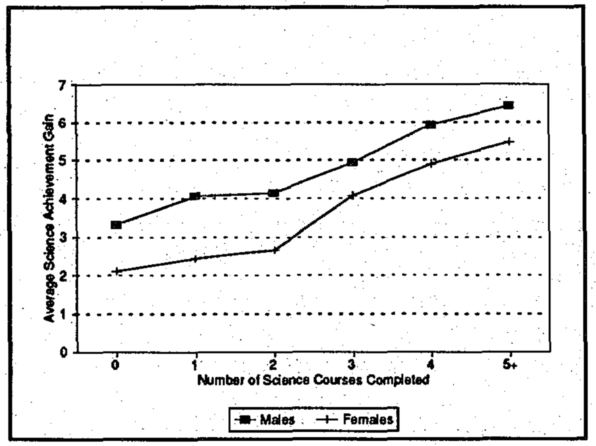

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student and Transcript Components.

**Figure 4.-- Average mathematics test score gain from 8th- to 12th-grade, by number of mathematics courses completed during high school and student sex: 1992**




SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.

**Figure 5.--** **Average science test score gain from 8th- to 12th-grade, by number of science courses completed during high school and student sex: 1992**




**SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.**

**Race-ethnic differences.** The returns to additional coursework are broken down by race-ethnicity in figures 6 and 7. Despite some irregularities, the slopes of the lines are generally positive, indicating that all groups benefit from more coursework. The slopes of the lines are also roughly equivalent. This equivalence means that all students benefit about the same from completing additional courses in mathematics and science.

The gaps between the lines at each level of courses completed indicate the race and ethnic growth differences. In mathematics, the overall differences in 8th- to 12th-grade gains (table 4) show that blacks learn less than whites during high school, Hispanics and whites do not significantly differ, and Asians learn more than whites on average. When blacks and whites who complete the same numbers of math courses are compared (figure 6), the learning gaps generally are smaller and none are statistically significant. The Asian-white achievement gain differences are also generally reduced among students completing the same numbers of math courses. The only exception is that the Asian advantage over whites among students completing four courses is about the same as the overall gain differential.

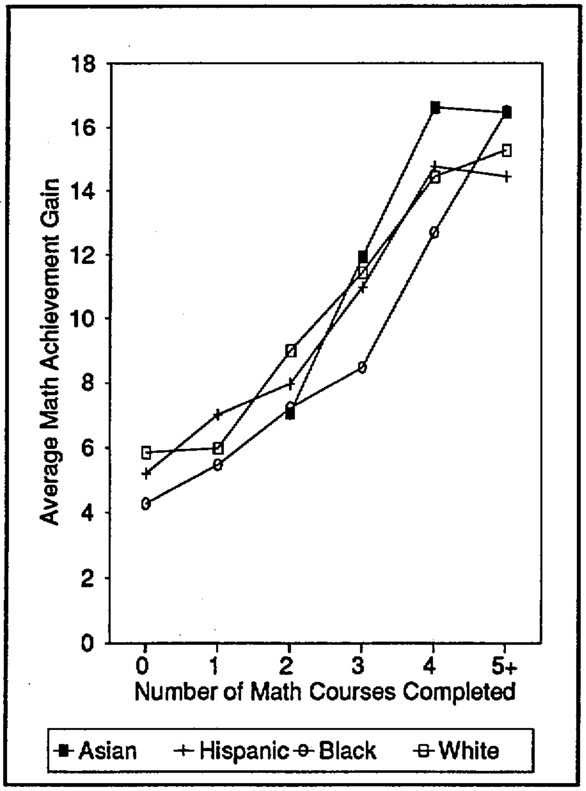
In science, whites show significantly greater achievement growth than blacks and Hispanics from 8th- to 12th-grade, but Asians do not gain significantly more than whites. As figure 7 shows, the gap between the average gains for blacks and the average gains for whites ranges from about 1.5 to 2.2 items. Since the average additional gain that students realize from taking an additional science course is about .7 items, the black-white gaps amount to an equivalence of over two courses across the high school years. The white-Hispanic gap, in contrast, tends to be slightly smaller and statistically insignificant among students completing the same numbers of courses.

**SES differences.** The relationships of gain scores with the numbers of courses completed are broken down by student socioeconomic background in figures 8 and 9. The positive slopes for all SES groups in both subjects indicate that all SES groups benefit from additional courses completed. Additional math and science coursework also pays off about equally for students in the three SES groups. Again, we find that the lines are roughly parallel in both mathematics and science.

The gaps between the lines represent the effect of SES differences among students completing the same numbers of courses. While SES background is strongly associated with the overall achievement gains (table 4), the achievement growth differences among high- and low-SES students completing the same numbers of courses are smaller. This is particularly true in mathematics, where none of the SES comparisons show significant differences among students taking the same numbers of courses. This means that much of the SES differences in math achievement gains over the high school grades are the result of the different numbers of math courses that high- and low-SES students complete during high school.

In contrast to the pattern in mathematics, the high-SES students generally gain significantly more on the science test among students completing comparable numbers of courses. This pattern suggests that the quality of the courses completed by high- and low-SES students differs more in science than in mathematics.

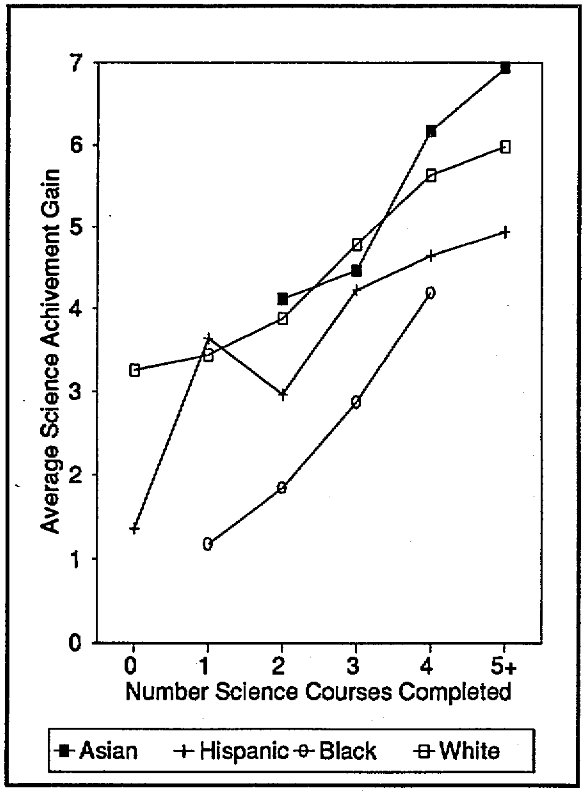
**Figure 6.-- Average mathematics test score gain from 8th- to 12th-grade, by number of mathematics courses completed during high school and student race-ethnicity: 1992**




NOTE: American Indian and Alaskan Native students are excluded due to small sample size (n=96).

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.

**Figure 7.-- Average science test score gain from 8th- to 12th-grade, by number of science courses completed during high school and student race-ethnicity: 1992**



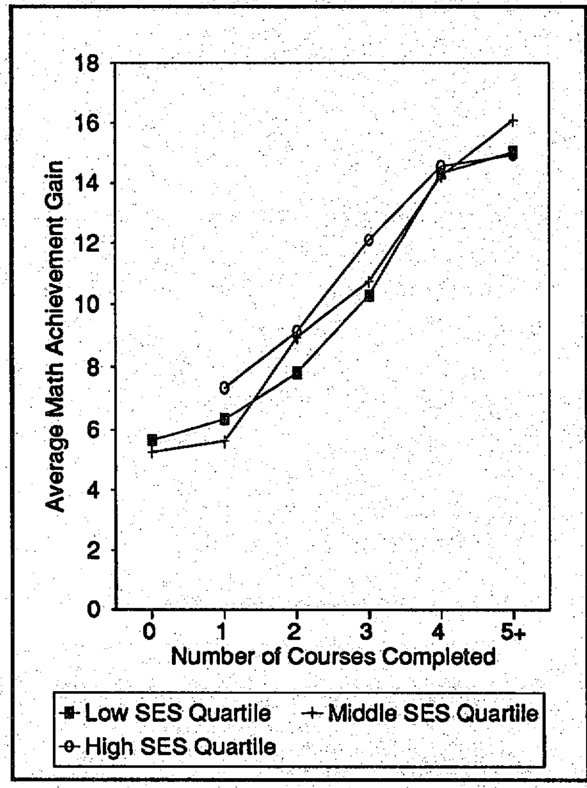

NOTE: American Indian and Alaskan Native students are excluded due to small sample size (n=96).

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.

## Summary

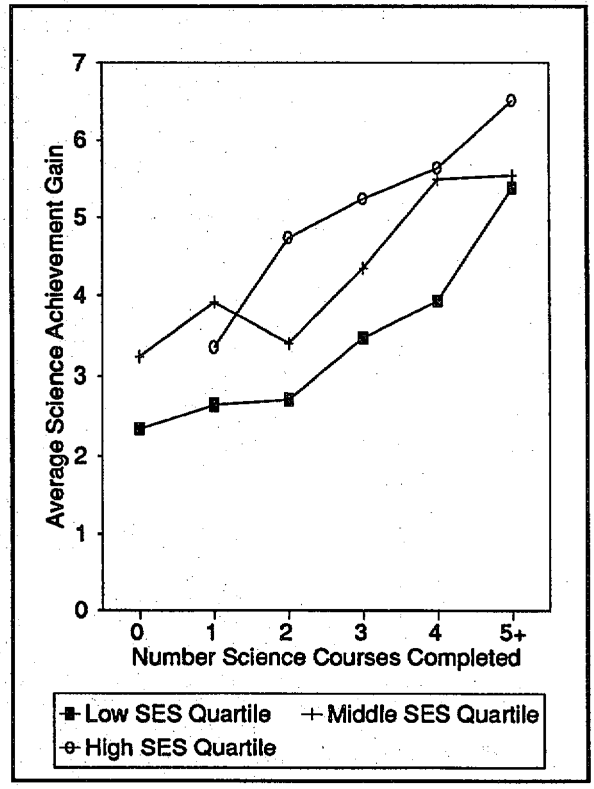
**Course completion.** Despite the recent efforts of many states and local districts to require more coursework in science and mathematics, wide variations in numbers of courses high school students complete are still found. Of the social background factors examined here, socioeconomic class differences among students are the strongest correlate of persistence in these curricula. Blacks and Hispanics complete fewer courses than whites and Asians, but these differences largely vanish once socioeconomic status differences between racial-ethnic groups are taken into account. Sex differences, in contrast, are small and generally insignificant in both subjects.

Figure 8.-- Average mathematics test score gain from 8th- to 12th-grade, by number of mathematics courses completed during high school and student socioeconomic status: 1992




SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.

Figure 9.-- Average science test score gain from 8th- to 12th-grade, by number of science courses completed during high school and student socio-economic status: 1992




SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Component and Transcript Study.

**Tested achievement.** Twelfth-grade achievement test scores in science and mathematics are also strongly correlated with SES, but are also related to sex and race-ethnicity. Females score slightly lower than males, and Asian youth score higher than others. Black and Hispanic youth finish high school with lower test scores than non-Hispanic whites.

**Coursetaking and achievement gains.** Test score increases from the end of 8th grade to the end of grade 12 are strongly related to the number of math and science courses students complete in high school. Additional coursework pays off about equally for all students, regardless of sex, race-ethnicity, and socioeconomic class.

These results suggest that if high school students complete more academic coursework in mathematics and science, their test scores in those subjects will increase. Further analyses of the NELS:88 data are needed to identify possible inducements to greater coursetaking, including higher graduation requirements. Research could usefully examine, for example, whether benefits of completing additional courses are found in states and schools that have actually implemented higher standards. Further research is also needed on the *types* of mathematics and science courses students complete, and whether differences there can account for the sex, race-ethnicity, and SES differences in test score gains documented here.

## References


Blank, R. K. & Gruebel, D. (1993). *State Indicators of Science and Mathematics Education, 1993*. Washington, D.C.: Council of Chief State School Officers.

Clune, W.H. and White, P.A. (1992). Education reform in the trenches: Increased academic coursetaking in high schools with lower achieving students in states with higher graduation requirements. *Educational Evaluation and Policy Analysis, 14,* 2-20.

Gamoran, A. (1987). The stratification of high school learning opportunities. *Sociology of Education, 60,* 135-155.

Green, P.J., Dugoni, B.L., and Ingels, S.J. (1995). *Trends Among High School Seniors, 1972-1992.* NCES 94-380.

Ingels, S.J., Dowd, K.L., Taylor, J.R., Bartot, V.H., and Frankel, M.R. (1995). *NELS:88 Second Follow-Up: Transcript Component Data File User's Manual.* NCES 94-377.

Jones, L.R., Mullis, I.V.S., Raizen, S.A., Weiss, I.R., and Weston, E.A. (1992). *The 1990 Science Report Card.* NCES 92-064.

Madigan, T.J. (forthcoming, 1995). Changes in science proficiency between 8th and 12th grades. NCES.

McDill, E.L., Natriello, G., and Pallas, A.M. (1986). A population at risk: Potential consequences of tougher school standards for student dropouts. *American Journal of Education, 94,* 135-181.

McMillen, M.M., Kaufman, P., and Whitener, S.D. (1994). *Dropout Rates in the United States: 1993.* NCES 94-669.

Rasinski, K.A., Ingels, S.J., Rock, D.A., and Pollack, J. (1993). *America's High School Sophomores: A Ten Year Comparison, 1980 - 1990.* NCES 93-087.

Rock, D.A., Owings, J.A., and Lee, R. (1994). *Changes in Math Proficiency Between Eighth and Tenth Grades.* NCES 93-455.

Rock, D.A., and Pollack, J.M. (1995a). *The Relationship Between Gains in Achievement in Mathematics and Selected Coursetaking Behaviors.* NCES 95-714.

Rock, D.A., and Pollack, J.M. (1995b). *Base Year to Second Follow-Up Psychometric Report.* NCES 94-382.

Scott, L.A., Rock, D.A., Pollack, J.M., and Ingels, S.J. (1994). *Two Years Later: Cognitive Gains and School Transitions of NELS:88 Eighth Graders.* NCES 94-436.

Smith, T.M., Rogers, G.T., Alsalam, N., Perie, M., Mahoney, R.P., and Martin, V. (1994). *The Condition of Education 1994.* NCES 94-149.

U.S. National Commission on Excellence in Education, (1983). *A Nation at Risk.* Washington, D.C.: Government Printing Office.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## Endnotes

1 All differences mentioned in this report are statistically significant at p=.05 or lower, based on t-tests using standard errors adjusted for the NELS:88 cluster sampling, and using Bonferroni adjustments for multiple comparisons. Additional breakdowns not presented here show that gender differences in the numbers of courses completed are also negligible within SES and race-ethnic groups.

2 Additional breakdowns not presented here show that gender differences in achievement within the race-ethnicity and SES quartile groups are generally consistent with the overall pattern. The only exception in mathematics is that Hispanic males score significantly higher

than Hispanic females. The exceptions in science are that significant by sex differences are *not* found for blacks or Asians.

3 Some potential problems with these comparisons are discussed in the Appendix on "Gain Score Comparisons." The gains per additional course shown here may misrepresent the true relationships because (a) students who take more courses are higher achievers to begin with, and (b) higher levels of initial achievement are correlated with lower gains. To assess this possibility, we estimated an ordinary least squares regression of 12th-grade math achievement on the number of math courses completed, plus controls for 8th-grade achievement scores in math, science, and reading. This gives an estimated effect of taking an additional math course of 2.8 items, compared to the 2.4 item estimate without the controls. Comparable regression results for science yielded estimates of 0.7 items per additional course, which is almost identical to the unadjusted estimate of 0.8 items.

4 The results presented in figures 2 through 9 can be represented as ordinary least squares regression equations. While a linear regression may oversimplify the patterns shown in the figures, it does provide a compact summary of group differences in gains, the effects of coursetaking on gains, and whether the slopes significantly differ among groups. We estimated regressions of gain scores on 8th-grade levels of achievement in math, science, and reading; social background indicators (sex, race-ethnicity, and SES); numbers of courses completed; and interaction terms representing social background differences in the effects of the number of courses completed on gains. The results of the regressions including all of the listed independent variables show significant effects of additional course completions on gains in math (b=2.89, t=14.4) and in science (b=0.70, t=8.3). In mathematics, the only other significant effect on gains is the advantage of males (b=1.67, t=2.2). In science, significant effects on gains are found for males (b=1.98, t=6.3), blacks (b=-2.59, t=-3.7), and SES (measured here as a continuous variable with a mean of 0 and a standard deviation of .75) (b=0.42, t=2.4). The effects of course completions on gains are not significantly different for any of the social-background groups examined in this report. This supports the claim that all groups benefit about equally from taking additional math and science courses in high school.

## Appendix: Technical Notes for NELS:88

The National Education Longitudinal Study of 1988, or NELS:88, is a 10-year data collection project sponsored by the National Center for Education Statistics (NCES) of the U.S. Department of Education. The aim of the study is to collect comprehensive information on the family, school, and community experiences of a national cohort of 1988 eighth-graders. The study began with a national probability sample of more than 1,000 eighth-grade schools and more than 24,000 eighth-grade students. Data were collected from the students, their parents, and their teachers and school administrators in 1988. A nationally representative subsample of the original students was resurveyed in 1990, 1992, and 1994; individuals were included regardless of whether they were still enrolled, graduated, or dropped out. Additional data were collected from teachers and school administrators in 1990 and 1992; parents were resurveyed in 1992. The students were administered achievement tests in mathematics, science, reading, and social studies. Students and dropouts were interviewed and tested again in 1990 and 1992. Transcript data spanning the years of high school were collected for both high school students and dropouts in the NELS:88 Second Follow-up Survey. Transcripts were collected for 17,100 individuals out of a target number of 21,188.

The NELS:88 achievement test and coursework data can be analyzed in many different ways, depending on the purpose of the analysis. Various reports have been prepared or commissioned by NCES that illustrate different approaches to measuring achievement gain over time. This particular report is concerned with the amount of coursetaking and its relationship to achievement gain measured by (IRT-estimated) number-right scores. The NELS:88 database, however, also reports criterion-referenced mastery levels for mathematics and science (as well as reading), in the form of *proficiency scores*. Proficiency scores show *what kinds* of skills are being learned. In addition, the NELS:88 database permits coursetaking to be viewed not just from the quantitative perspective of how many units of a given subject have been successfully completed, but also from the more qualitative point of view of what *types of courses* were completed (e.g., algebra 1, geometry, trigonometry, or calculus). In contrast to the approach of this report, which looks at number of course units completed and number-right scores, Rock, Owings, and Lee (1994) illustrate achievement gain analysis using mathematics *dichotomous proficiency scores* in conjunction with information on whether a student completed higher level math course sequences. Madigan (forthcoming) presents a similar analysis for science proficiency. Scott, Rock, Pollack and Ingels (1994) and Rock and Pollack (1995a) illustrate achievement gain analysis in math using the continuous *probability of proficiency scores* in conjunction with information on specific coursetaking sequences. In addition to the longitudinal use of the NELS:88 test data, other NCES reports (Rasinski, Ingels, Rock and Pollack, 1993; Green, Dugoni and Ingels, 1995) illustrate the use of NELS:88 cross-sectional results for measuring achievement trends over time through comparisons with earlier NCES longitudinal cohorts (NLS-72, and HS&B).

## Analysis Sample

The population to which the results presented here generalize is the eighth-grade class of 1988. The sample used in this report consists of the 14,283 students who participated in the 1988 and 1992 surveys and for whom transcript data were collected. These students are identified in the public-use data files with the flag variable named **F2TRP1FL**. They include all students, whether they had graduated, were delayed, or dropped out by the time the transcripts were collected in the fall of 1993. The analyses of 1988 to 1992 achievement test score gains included 11,264 individuals for whom both math achievement test scores are available and 11,192 individuals with both science test scores. In most of the racial-ethnic breakdowns, the Native Americans are excluded because the sample sizes are too small to yield reliable estimates.

## Variables Used in the Analysis

The variables used in this report are all included in the NELS:88 second follow-up public-use data files. The *coursework variables* were constructed by counting up the Carnegie units each student earned in mathematics and science as recorded on the transcripts. These counts were merged to the student data records and are named **F2RHMA_C** (number of math credits) and **F2RHSC_C** (number of science credits). Since courses differ in the length of time they convene, Carnegie unit assignments were based on a prior standardization of all course records to ensure comparability between, for example, semester versus quarter courses, and half-year versus full-year courses.

The *achievement test scores* used here are composite scores that summarize each student's performance across the various content and skill domains of science and mathematics. The names of the public-use variables are **BY2XMIRR** (base year mathematics), **F22XMIRR** (second follow-up mathematics), **BY2XSIRR** (base year science), and **F22XSIRR** (second follow-up science). The math and science tests consisted of 40 and 25 multiple-choice items, respectively, in each of the three survey cycles. The NELS:88 testing program used grade-adapted science tests in 1988, 1990, and 1992, and 38 different items were used across the three forms. The difficulty levels of the first and second follow-up mathematics tests were adapted to the students' performance levels in the previous administration. A total of 81 different math items were used in all of the forms. IRT methods were used for both the math and science tests to equate the different forms so that the results from different forms could be expressed on the same metric. Units on these tests refer to the number of items answered correctly, after the IRT procedures were used to score the tests and to locate all students on the same scale. The metric is thus the "estimated number of items correctly answered." The NELS:88 tests were designed to measure both low-level and higher-level skills at all three data points - 1988, 1990, and 1992 - and to minimize "floor" and "ceiling" effects. As such, gains can be detected both for students who are learning advanced concepts and for students who are still learning very basic concepts. The math tests did not include, however, items requiring knowledge of calculus. An assessment of the degree to which the tests have been successful in achieving their psychometric aims can be found in Rock and Pollack, 1995b.

The measures of *student social background* include **F2SEX** (student sex), **F2RACE1** (student race-ethnicity), and **F2SES1Q** (family socio-economic status quartile). These are composite measures constructed from all available information collected in the first three waves of NELS:88. The SES measure was constructed as an equally weighted composite of parental education, occupation, income, and household possessions. Parent responses to questions about their education, occupation, and income were used for all students whose parents were surveyed in the base year and answered the requisite questions; information on household possessions was collected from the students in the base year and first follow-up survey. The components were standardized to means of zero and standard deviations of one, and the nonmissing components averaged to create the SES measure. The quartiles were defined after weighting the cases to match their representation of the population.

## Sampling Errors

Sampling errors refer to the chance discrepancies between the population and a sample drawn from it. The size of the errors are inversely related to the sample size, but determining the proper degrees of freedom is complicated when surveys use complex sample designs. The NELS:88 sampling procedures were designed to produce a sample that would be broadly representative of students across the country from public and private schools, and from many different types of social background. This required a complex classification of all schools and further subclassifications of students within selected schools. Students from the different cells defined by the classification scheme were sampled with different probabilities of inclusion. In order to obtain accurate estimates of population values, analysts must thus use sampling weights which adjust the contributions of each case according to the number of other individuals in the sampled population who he or she represents. All numbers presented in this report are calculated using the NELS:88 public-use design weight named **F2TRP1WT**. This weights the sampled individuals according to the number of individuals in the original population sampled by NELS:88 (the eighth-grade class of 1988) that each sampled member represents. The subset of cases for whom this weight was defined consisted of the 14,283 students who participated in the 1988 and 1992 surveys and for whom transcript data were collected.

The clustering and stratification used in the NELS:88 sampling design also results in larger uncertainty of population values than would an equal-sized simple random sample. All estimates, standard errors, and significance tests reported were thus calculated taking into account the sample design. The SUDAAN statistical analysis program was used to estimate the standard errors taking into account the complex survey design. The program uses a Taylor Series estimator for the variance calculations.

## Gain Score Comparisons

The group comparisons of achievement growth presented in this report do not include any statistical adjustments for the effects of initial achievement differences on achievement growth. As is true for all two-time-point, "pretest-posttest" comparisons of the type used here, *gains are negatively correlated with initial level.* This reflects "regression to the mean," and is usually attributable to some combination of measurement error and ceiling effects. As a result, the eighth- to twelfth-grade gains reported here may be overestimates for groups that scored lower than average as eighth-graders and underestimates for groups that scored higher than average in grade 8.

To check whether the simple comparisons reported here yield different results, we also estimated all of the reported relationships with a variety of multivariate regression models that included statistical adjustments for the effects of initial achievement differences. The regression results show that the relationships of math and science coursework with achievement gains are statistically significant when controls for initial achievement level are included, and that the relationship between coursework and gains does not significantly differ by gender, race, or SES (see endnote 4). The unadjusted estimates are used here to simplify the exposition.

**Table 4**
**1988 to 1992 achievement gain in mathematics and science by number of courses completed and sex, race-ethnicity, and socioeconomic status**

| Student characteristics | Number of courses completed | Mathematics | | | Science | | |
|---|---|---|---|---|---|---|---|
| | | Gain | SE | Unw N | Gain | SE | Unw N |
| **All Students** | Overall | 11.6 | .172 | 11,279 | 4.3 | .080 | 11,207 |
| | 0 | 5.6 | .658 | 254 | 2.8 | .393 | 170 |
| | 1 | 6.1 | .492 | 515 | 3.3 | .281 | 638 |
| | 2 | 8.6 | .303 | 1,847 | 3.4 | .141 | 3,289 |
| | 3 | 11.0 | .309 | 3,506 | 4.5 | .147 | 3,732 |
| | 4 | 14.4 | .284 | 4,263 | 5.4 | .141 | 2,577 |
| | 5+ | 15.4 | .488 | 894 | 6.0 | .290 | 801 |
| **Sex** | | | | | | | |
| **Males** | Overall | 12.0 | .271 | 5,607 | 4.9 | .108 | 5,569 |
| | 0 | 6.1 | 1.052 | 140 | 3.3 | .594 | 99 |
| | 1 | 6.0 | .702 | 280 | 4.0 | .451 | 341 |
| | 2 | 9.3 | .477 | 932 | 4.1 | .230 | 1,636 |
| | 3 | 11.2 | .585 | 1,649 | 4.9 | .147 | 1,743 |
| | 4 | 15.0 | .356 | 2,120 | 5.9 | .178 | 1,305 |
| | 5+ | 15.8 | .561 | 486 | 6.4 | .272 | 445 |
| **Females** | Overall | 11.1 | .189 | 5,672 | 3.7 | .114 | 5,638 |
| | 0 | 5.1 | .614 | 114 | 2.1 | .409 | 71 |
| | 1 | 6.2 | .633 | 235 | 2.4 | .324 | 297 |
| | 2 | 7.9 | .309 | 915 | 2.6 | .141 | 1,653 |
| | 3 | 10.8 | .259 | 1,857 | 4.1 | .244 | 1,989 |
| | 4 | 13.7 | .413 | 2,143 | 4.9 | .212 | 1,272 |
| | 5+ | 14.9 | .924 | 408 | 5.5 | .446 | 356 |

## Table 4 (cont'd)
## 1988 to 1992 achievement gain in mathematics and science by number of courses completed and sex, race-ethnicity, and socioeconomic status

| Student characteristics | Number of courses completed | Mathematics | | | Science | | |
|---|---|---|---|---|---|---|---|
| | | Gain | SE | Unw N | Gain | SE | Unw N |
| **Race-ethnicity** | | | | | | | |
| **Asian** | Overall | 13.8 | .683 | 685 | 5.3 | .323 | 682 |
| | 0 | -- | -- | 3 | -- | -- | 1 |
| | 1 | -- | -- | 13 | -- | -- | 14 |
| | 2 | 7.1 | 1.833 | 61 | 4.1 | .867 | 138 |
| | 3 | 11.9 | 1.099 | 152 | 4.5 | .522 | 204 |
| | 4 | 16.6 | .625 | 354 | 6.2 | .300 | 226 |
| | 5+ | 16.4 | .817 | 102 | 6.9 | .395 | 99 |
| **Hispanic** | Overall | 11.1 | .437 | 1.253 | 3.6 | .191 | 1,240 |
| | 0 | 5.2 | .981 | 49 | 1.4 | .674 | 31 |
| | 1 | 7.0 | 1.102 | 93 | 3.6 | .597 | 91 |
| | 2 | 7.9 | .740 | 228 | 3.0 | .395 | 522 |
| | 3 | 11.0 | .581 | 436 | 4.2 | .230 | 368 |
| | 4 | 14.8 | .927 | 368 | 4.6 | .356 | 193 |
| | 5+ | 14.4 | 1.775 | 79 | 4.9 | 1.024 | 35 |
| **Black** | Overall | 9.6 | .697 | 1,002 | 2.6 | .238 | 988 |
| | 0 | 4.2 | .731 | 52 | -- | -- | 23 |
| | 1 | 5.5 | .968 | 71 | 1.2 | .551 | 68 |
| | 2 | 7.2 | .668 | 184 | 1.8 | .342 | 356 |
| | 3 | 8.5 | 1.634 | 328 | 2.9 | .282 | 335 |
| | 4 | 12.7 | .723 | 316 | 4.2 | .677 | 180 |
| | 5+ | 16.5 | 2.025 | 51 | -- | -- | 26 |
| **White** | Overall | 11.9 | .189 | 8,229 | 4.7 | .091 | 8,187 |
| | 0 | 5.8 | 1.016 | 144 | 3.2 | .423 | 112 |
| | 1 | 6.0 | .642 | 328 | 3.4 | .349 | 453 |
| | 2 | 9.0 | .364 | 1,353 | 3.9 | .149 | 2,227 |
| | 3 | 11.4 | .248 | 2,543 | 4.8 | .173 | 2,799 |
| | 4 | 14.4 | .335 | 3,203 | 5.6 | .148 | 1,961 |
| | 5+ | 15.3 | .476 | 658 | 6.0 | .330 | 635 |

**Table 4 (cont'd)**
**1988 to 1992 achievement gain in mathematics and science by number of courses completed and sex, race-ethnicity, and socioeconomic status**

| Student characteristics | Number of courses completed | Mathematics | | | Science | | |
|---|---|---|---|---|---|---|---|
| | | Gain | SE | Unw N | Gain | SE | Unw N |
| **SES Quartiles** | | | | | | | |
| **Low Quartile** | Overall | 9.7 | .399 | 2,206 | 3.1 | .119 | 2,192 |
| | 0 | 5.7 | .923 | 129 | 2.3 | .543 | 89 |
| | 1 | 6.3 | .851 | 225 | 2.6 | .322 | 248 |
| | 2 | 7.8 | .383 | 575 | 2.7 | .197 | 958 |
| | 3 | 10.3 | .485 | 738 | 3.5 | .193 | 606 |
| | 4 | 14.3 | 1.127 | 454 | 3.9 | .434 | 232 |
| | 5+ | 15.0 | .996 | 85 | 5.4 | .852 | 59 |
| **Middle Quartiles** | Overall | 11.4 | .222 | 5,553 | 4.2 | .101 | 5,516 |
| | 0 | 5.3 | .849 | 114 | 3.2 | .536 | 73 |
| | 1 | 5.6 | .557 | 250 | 3.9 | .427 | 331 |
| | 2 | 8.9 | .432 | 1,040 | 3.4 | .197 | 1,780 |
| | 3 | 10.7 | .485 | 1,858 | 4.3 | .152 | 1,890 |
| | 4 | 14.2 | .276 | 1,920 | 5.5 | .213 | 1,112 |
| | 5+ | 16.1 | .861 | 371 | 5.5 | .520 | 330 |
| **High Quartile** | Overall | 13.4 | .288 | 3,520 | 5.4 | .148 | 3,499 |
| | 0 | -- | -- | 11 | -- | -- | 8 |
| | 1 | 7.3 | 1.376 | 40 | 3.4 | .821 | 59 |
| | 2 | 9.1 | .648 | 232 | 4.7 | .296 | 551 |
| | 3 | 12.1 | .381 | 910 | 5.2 | .345 | 1,236 |
| | 4 | 14.6 | .532 | 1,889 | 5.6 | .190 | 1,233 |
| | 5+ | 14.9 | .604 | 438 | 6.5 | .276 | 412 |

NOTE: Empty cells indicate groups with 30 or fewer sampled students.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Second Follow-Up Student Survey and High School Transcript Study.