NATIONAL CENTER FOR EDUCATION STATISTICS

Research and Development Report August 2000

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U. S. Department of Education
Office of Educational Research and Improvement NCES 2000–601

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Synectics for Management Decisions, Inc.

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U. S. Department of Education
Office of Educational Research and Improvement **NCES 2000–601**

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Foreword

The Research and Development series of reports has been initiated for the following goals:

1. To share studies and research that are developmental in nature. The results of such studies may be revised as the work continues and additional data become available.

2. To share results of studies that are, to some extent, on the cutting edge of methodological developments. Emerging analytical approaches and new computer software development often permit new, and sometimes controversial, analysis to be done. By participating in "frontier research," we hope to contribute to the resolution of issues and improved analysis.

3. To participate in discussions of emerging issues of interest to educational researchers, statisticians, and the federal statistical community in general. Such reports may document workshops and symposiums sponsored by the National Center for Educational Statistics (NCES) that address methodological and analytical issues, or may share and discuss issues regarding NCES practice, procedures, and standards.

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Executive Summary

This study examines the gaps related to gender and race/ethnicity in entrance, persistence, and attainment of postsecondary science and engineering (S&E) education. After reviewing selected prior research and examining potentially relevant variables in two National Center for Education Statistics (NCES) surveys, several variables were selected to create a multivariate model for use in two empirical analyses. The overall goal of the study was to try to determine the relative importance of these variables in sustaining the gender and race/ethnicity gaps in S&E education. The specific goals for the two analyses are described below.

First, this report examines the link between high school experience and entrance into S&E postsecondary programs to explore the extent to which women and underrepresented minorities continue to have lower entry rates into S&E programs at the postsecondary level. This part of the study analyzes data from the National Education Longitudinal Study of 1988 (NELS:88). Now that the 1994 third follow-up survey data are available, researchers can follow a nationally representative population of 1988 eighth-graders through high school and into college or the workforce.

The second analysis addresses issues relating to persistence and degree attainment by underrepresented minorities and women in postsecondary S&E study. It traced a cohort of postsecondary students who began their S&E education in their *first* postsecondary year (i.e., as freshmen) through a 5-year time frame (1989–90 to 1993–94) using data from the Beginning Postsecondary Student Longitudinal Study (BPS).

The two analyses are presented in one report to address an overarching policy concern, namely, gender and racial/ethnic gaps in postsecondary (S&E) entry and persistence. It was thought that presenting both analyses in one report may help readers learn about the policy issues in a more coherent way because entry and persistence are related equity concerns.

The findings from the first analysis support an overall notion that much of the racial/ethnic and gender differences in the entry to S&E programs in postsecondary education can be explained by examining family environment, family support, student behavior, and school factors across race/ethnicity and gender. The reader is cautioned against linking the results of the two analyses because the data sources are independent cohorts.

That is, while the initial findings showed that the racial/ethnic gap only occurred among men and the gender gap mainly happened among Asians and whites, further examination showed that students of whatever race/ethnicity or

gender with the following characteristics had a greater likelihood of majoring in S&E in postsecondary education:

- Students who had taken advanced science courses,
- Students who were self-motivated to study science,
- Students who had parents with relatively higher levels of educational attainment, and
- Students who had parents with high expectations for their children's college education.

Once these key factors were held constant—that is, comparing racial/ethnic and gender groups with similar attributes in these measures—the racial/ethnic and gender differences among S&E majors tend to get smaller.

Additional findings related to S&E entrance include the following:

- A separate analysis of the male students confirmed that the racial/ethnic gap in majoring in S&E among men steadily closes when comparing students who had similar motivation, aspirations, and confidence regarding math and science; earned similar total and advanced credits in the subjects; and whose parents' educational attainment and expectation for their child's education are similar.

- Since the broad gender gap only narrowed to a limited extent after examining family environment and support, student behavior, and school factors, we hypothesized that traditional values that emphasize marriage, family, and children, in contrast to "nontraditional" views that stress individual success and independence, might make a difference in female students' career choice. However, the results did not support this hypothesis.

- A separate analysis of white and Asian students revealed no different pattern of gender gap from that found in the overall analysis.

The second analysis yields important findings regarding underrepresented minority and female students' status in and out of the S&E pipeline.

- While the racial/ethnic gap is not as obvious as the gender gap in enrolling as S&E majors, underrepresented minority students face greater difficulties *in* S&E programs.

  Among the students enrolled in S&E programs in the first year of postsecondary education, underrepresented minority students seemed to have difficulty attaining a degree in S&E fields within a 5-year college calendar. Some of them had to switch to other fields. However, data did not show racial/ethnic differences in college dropout among these S&E students.

- The racial gap remained wide even after the multiple regression analysis considered theoretically important predictors of success, a finding that implies that more extensive factors should be examined in order to understand the racial/ethnic difference in S&E attainment and persistence, including a detailed analysis of course-taking patterns.

- Female students in S&E programs did not fall behind in the pipeline; they actually did better than male students in degree completion and program switch. This finding suggests that although women are less likely than men to enter S&E, those women who do enter S&E fields are likely to do well. Further, among students enrolled in 4-year S&E programs in the first year of college, women tend to have strong family support, high expectation, healthy self-confidence, and solid academic preparation.

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Introduction

The gender and race/ethnicity gaps in entrance to and attainment of postsecondary science and engineering (S&E) education have long been a concern to educators and policymakers. This concern is increasing because, in the modern technology-oriented world, full use of human resources in S&E is imperative to keep the nation competitive with other countries.

Over the years, many efforts in education policymaking and practice have been made to increase underrepresented minority[1] and female participation in S&E areas. Title IX of the Education Amendments of 1972, for example, forbids discrimination on the basis of sex in any education program and institution receiving federal funds. Title VI of the Civil Rights Act of 1964 forbids discrimination on the basis of race, color, and national origin. Both of these statutes are enforced by the U.S. Department of Education's Office for Civil Rights.

Federal programs have been developed to help women and minorities attain S&E education at the postsecondary level. The Women's Educational Equity Act of 1974 was the first piece of legislation enacted by Congress that has exclusively as its aim the funding of projects to improve the quality and scope of education of girls and women. One of the goals of the National Science Foundation's (NSF) human resource development programs is to assure equality in S&E education, and NSF has established a number of programs that prioritize education in science, mathematics, engineering, and technology for students including women and minorities (e.g., National Science Foundation 1997, 1996a). Higher education institutions—public and private sectors alike—have been recruiting women and minorities to study in fields traditionally dominated by white men. Such programs often focus on S&E and professional education (Seymour and Hewitt 1997). At the K–12 level, states and local schools have come up with various strategies to improve math and science education for girls and underrepresented minorities, including African-Americans, Hispanics, and Native Americans.

There are programs to lessen the gaps and there are some improvements, but underrepresentation in these S&E fields still poses a severe challenge to educators and policymakers. Some are asking if the concept of "access" needs to be broadened to link enrollment with results-based *outcomes* and to encompass the *process* by which those outcomes are achieved (Ruppert 1998): an "open door" that acts like a "revolving door" will not solve the problems of underrepresentation.

[1] In this report, underrepresented minorities are African-Americans, Hispanics, and Native Americans. Asian-Americans are grouped with white Americans because they are not underrepresented in S&E fields.

To fully understand the gender and racial/ethnic gaps in S&E education and the resulting S&E workforce requires examining schooling from kindergarten through college. This study is designed to address issues relating to enrolling in S&E programs in college and graduating with a bachelor's degree in an S&E field. In particular, to what extent do differences exist among racial/ethnic groups and between men and women in entry into and completion of S&E studies, and what factors relate to the differences?

This report is organized in the following manner. Chapter 1 presents recent national statistics that describe female and minority underrepresentation in postsecondary S&E education. It also describes selected prior research concerning the underrepresentation of women and underrepresented minorities in S&E postsecondary education, concentrating on studies that have examined the kind of measures that can be addressed with data from the national surveys sponsored by the National Center for Education Statistics. Thus, this chapter provides a background for the two analyses on S&E program entrance and completion that are described in chapters 3 and 4. Chapter 2 describes the study approach used in the two analyses. The first analysis, in chapter 3, uses data from the National Education Longitudinal Study of 1988 (NELS:88). A descriptive analysis of theoretically relevant factors from students' 8^{th} through 12^{th} grade years is followed by a logistic regression analysis that tries to identify which of those factors are actually relevant to students choosing to enter S&E programs in postsecondary school. The analysis in chapter 4 uses data from the Beginning Postsecondary Student Longitudinal Study (BPS) to examine persistence in and completion of a bachelor's degree in S&E studies. Although the data sources and sampled populations are distinct—that is, the students surveyed in BPS are not a follow-up of the NELS:88 students—using them both allows us to examine the relationship of postsecondary S&E entry and completion with students' family environment and support, behavior, and school/institution factors. Understanding these relationships could inform policy and program development dealing with the persistent gender and racial/ethnic gaps in S&E education.

Chapter 1
Narrowed but Persistent Gaps: Background for Research

Gender and racial/ethnic gaps in science and engineering (S&E) postsecondary education have been gradually narrowing over the past 3 decades, but are far from completely eliminated. Relative to men and whites, women and minorities (other than Asian American) are still underrepresented in S&E disciplines at higher education institutions. This general pattern is evident in an array of indicators such as S&E major selection, program attrition, undergraduate degree completion, graduate program enrollment, master's and doctor's degree completion, and S&E workforce participation.

Before providing a snapshot of these measures as a background for the analyses in chapters 3 and 4, it must be mentioned that the federal statistics and other sources that document these persistent gaps differ according to agency purpose. One example of this is that researchers and statistical agencies use different definitions of S&E fields. National Science Foundation (NSF) documents usually include social sciences and psychology in S&E, whereas other sources may exclude these areas from the definition and use the term science to refer to *natural sciences*. When the definition of S&E encompasses the social sciences and psychology, the gender and racial/ethnic differences tend to be smaller than when the definition refers only to natural sciences and engineering. However, much of the national analysis to date has relied upon the NSF definition. Thus, the national statistics cited below use the NSF definition of S&E, which includes social sciences and psychology, unless otherwise noted.

Since including social sciences and psychology could confuse the understanding of the racial/ethnic- and gender-related gaps that legislation and policies intend to address, these disciplines are excluded from the data analyses in chapters 3 and 4. (Our definition of S&E otherwise follows NSF's definition of subfields, see appendix I.)

A Snapshot of Female Underrepresentation in 1996

Gender stratification in education and occupation occurs somewhere along the way between early childhood education and entry into the labor market (Hanson 1996). While learning about gender differences in early life requires in-depth research, national statistics are available to document the gender difference in postsecondary S&E education and in the related workforce.

Gender differences in choice of academic major and future career are apparent in the early years of college. For example, a national study of freshmen (Astin, Korn, Sax, and Mahoney 1994) found that women of all racial/ethnic groups were less likely than men to choose to study S&E. Even among those who had chosen to study S&E, fewer women than men were willing to pursue a career as engineers or research scientists (Astin et al. 1994). This can be seen in the rates of degrees awarded in S&E fields in 1996 (see table 1).

Table 1.—Women as a percentage of science and engineering bachelor's, master's, and doctor's recipients and of graduate enrollment, by major field group, 1996

		Science and Engineering fields							
	All fields	***Total***	Engineer -ing	Earth, atmos-phere, & ocean sciences	Mathe-matical/ computer sciences	Physical sciences	Biologi-cal/ agricul-tural sciences	Social sciences	Psychol -ogy
Associate's[1]	60.6	50.9	13.1	30.7	47.6	46.8	51.1	66.0	74.4
Bachelor's[1]	55.2	47.1	17.9	33.3	33.9	37.0	50.2	50.8	73.0
Graduate Enrollment[2]	--	38.9	17.7	36.1	28.5	28.0	47.3	48.4	71.0
Master's[1]	55.9	39.3	17.1	29.3	30.3	33.2	49.0	50.2	71.9
Doctor's[1]	40.0	31.8	12.3	21.7	18.1	21.9	39.9	36.5	66.7

[1] The associate's, bachelor's, and master's degree data are obtained from universe institution surveys of the National Center for Education Statistics (NCES). The data on doctor's degrees are obtained from the Survey of Earned Doctorates, a universe survey of individual doctorate recipients, sponsored by the National Science Foundation (NSF) and four other federal agencies. These data cover earned degrees conferred in the aggregate United States, which comprises the 50 states, the District of Columbia, and the U.S. Territories and Outlying Areas. Degree data are compiled for a 12-month period, July through June of the following year.
[2] The data on graduate enrollment are derived from the National Science Foundation/National Institutes of Health (NSF/NIH) Survey of Graduate Students and Postdoctorates in Science and Engineering (graduate student survey), Fall 1996. These data represent estimates of total enrollment in S&E programs in approximately 11,592 graduate departments at 603 institutions in the United States and outlying areas.
SOURCE: Burrelli (1998), *Graduate Students and Postdoctorates in Science and Engineering: Fall 1996* (NSF 98–307), tables 1 and 3. Hill (1999a), *Science and Engineering Degrees: 1966–96* (NSF 99–330), tables 11, 18, and 25. U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS) 1996 Completions Survey data file.

In 1996, women received 55 percent of all bachelor's degrees (Hill 1999a) and 47 percent of the bachelor's degrees awarded in science and engineering (Hill 1999a). That is, in 1996, 651,815 women and 528,000 men received bachelor's degrees. Of those, 181,333 women and 203,341 men received bachelor's degrees in science and engineering (Hill 1999a). However, their degrees were not evenly distributed among S&E fields. As shown in table 1, women received:

- 18 percent of engineering degrees (11,316 women and 51,798 men);
- 33 percent of earth, atmosphere, and ocean science degrees (1,485 women and 2,972 men);
- 34 percent of mathematical and computer science degrees (12,764 women and 24,857 men);
- 37 percent of physical science degrees (5,702 women and 9,694 men);

- 50 percent of biological and agricultural science degrees (39,369 women and 39,100 men);
- 51 percent of social science degrees (56,834 women and 54,955 men); and
- 73 percent of psychology degrees (53,863 women and 19,965 men).

A review of national surveys of college students (Astin, Astin, Parrott, Korn, and Sax 1996) reported that, while the career interests of men and women have been becoming increasingly similar during the last 3 decades (1966 to 1996), one of the largest remaining gender gaps was still engineering, a field in which few women intend to study and work. The 1996 numbers cited above bear this out: far fewer women than men earned bachelor's degrees in engineering.[2] Women also earned fewer bachelor's degrees in earth, atmosphere, and ocean sciences; mathematical and computer sciences; and physical sciences. Women slightly outnumbered men in number of degrees earned in biology and agriculture and in the social sciences.

Nonetheless, the gender gap in S&E education has shrunk over the years. From 1966 to 1996, the proportion of women among S&E degree earners rose dramatically: for bachelor's degrees, it rose from 25 percent to 47 percent; for master's degrees, from 13 percent to 39 percent; and for doctor's degrees, from 8 percent to 32 percent (Hill 1999a). The changes are shown field by field in table 2.

Table 2.—Women as a percentage of science and engineering bachelor's, master's, and doctor's degree recipients, by major field group, in 1966 and 1996

	Bachelor's degrees		Master's degrees		Doctor's degrees	
	1966	1996	1966	1996	1966	1996
Total	24.8	47.1	13.3	39.3	8.0	31.8
Engineering	0.4	17.9	0.6	17.1	0.3	12.3
Earth, atmosphere, and ocean sciences	9.4	33.3	5.9	29.3	3.0	21.7
Mathematical and computer sciences	33.2	33.9	20.3	30.3	6.1	18.1
Physical sciences	14.0	37.0	11.5	33.2	4.5	21.9
Biology and agriculture	25.0	50.2	20.8	49.0	12.0	39.9
Social sciences	34.3	50.8	20.2	50.2	10.5	36.6
Psychology	40.8	73.0	32.9	71.9	21.5	66.7

SOURCE: Hill (1999a), *Science and Engineering Degrees: 1966–96* (NSF 99–330), tables 11, 18, and 25.

Consistent with the degree award data, enrollment statistics also suggest a narrowing gender gap. The recent NSF Survey of Graduate Students and Postdoctorates in Science and Engineering (Burrelli 1998, tables 1–3) indicates that, while the number of men enrolled in graduate S&E programs

[2] The numbers are similar throughout the 1990s, although the number of women earning engineering degrees has gradually increased (Hill, 1999a, tables 7 and 9). In 1991 women earned 9,665 bachelor's degrees in engineering and men earned 52,522; in 1992, it was 9,636 women and 52,305 men; in 1993, 9,981 women and 52,724 men; in 1994, 10,403 women and 52,609 men; and in 1995, 10,950 women and 52,421 men.

fell 3 percent from 1995 to 1996, the number of women rose 1 percent (these percentages hold even when the students enrolled in social sciences and psychology are not counted).

Education is not the sole factor leading to women's marginal position in science occupations; workplace discrimination is a consistent barrier to women scientists (Hanson 1996), and S&E workforce participation and employment is the ultimate measure of the S&E pipeline outcome. In 1995, women represented 51 percent of the U.S. population and 46 percent of the nation's labor force, but constituted only 22 percent of the S&E workforce. This difference reflects the gender gap in S&E participation at the higher education level. Data from the 1995 Surveys of Science and Engineering College Graduates (National Science Board 1998) shows that among employed scientists and engineers (including postsecondary teachers), women make up 22 percent of the total S&E workforce, but 50 percent of the social scientists and 9 percent of the engineers (see table 3).

Table 3.—Percentage of women employed as scientists and engineers (includes postsecondary teachers), by occupation: 1995

22.4	All S&E occupations
28.9	Computer and math scientists
34.7	Life scientists (agriculture, biology, and environmental life)
21.5	Physical scientists (chemists except for biochemists, earth scientists, physicists and astronomers, and other physical scientists)
49.9	Social scientists (economists, political scientists, psychologists, sociologists and anthropologists, S&T historians, and other social scientists)
8.6	Engineers (aerospace, chemical, civil and architectural, electrical and related, industrial, mechanical, and other engineers)

SOURCE: National Science Board (1998), *Science and Engineering Indicators—1998* (NSB–98–1), appendix table 3–10.

Women's representation in the S&E workforce has improved in the last two decades. For example, the National Science Board overview of women and minority progress in the S&E workforce (National Science Board 1996, 1998) shows the overall academic employment of women with a Ph.D. in S&E more than doubled from 1979 to 1995, rising from 19,200 to 52,400. The number of women active in research and development work tripled from 1979 to 1993, increasing from 10,200 to 30,500. Due to this high growth rate, women made up 20 percent of all scientists and engineers in academia in S&E in 1993, compared with 11 percent in 1979. In 1995, 28 percent of the scientists and engineers employed in 4-year colleges and universities and 39 percent of the S&E workers in other educational institutions were women. However, many of these were employed in the life and social sciences and psychology fields.

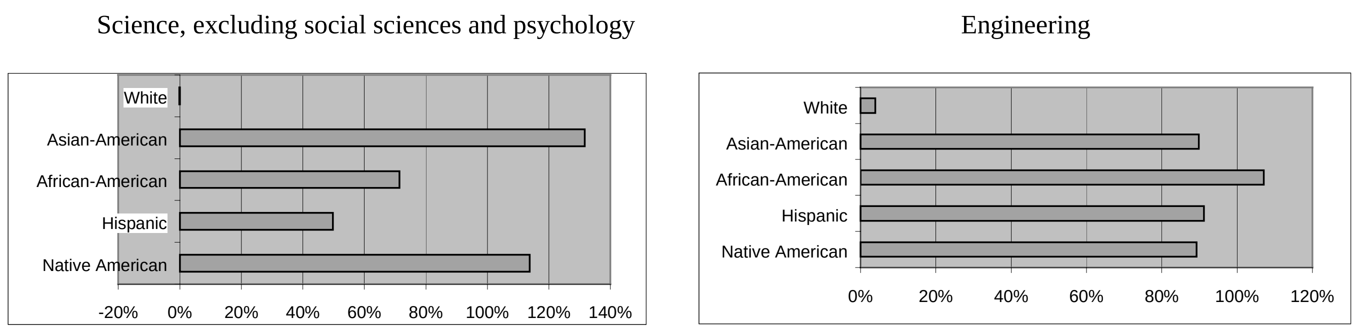
A Snapshot of Racial/Ethnic Underrepresentation in 1996

The underrepresented racial and ethnic minorities, with the exception of African-Americans, have obtained a fairly equal footing at the S&E associate's and bachelor's degree level, but the racial/ethnic gap is still visible at the higher levels of S&E education and in S&E occupations (see table 4). (These results also show the increasingly higher proportion of Asians who receive higher degrees. This is an interesting issue, but not a subject for this report.)

Minority underrepresentation in the S&E educational pipeline leads to the low participation rates of minorities in S&E occupations. For example, look at African-American participation in S&E education (excluding social sciences and psychology): at the end of the 1995–96 academic year, African-Americans had earned 9 percent of the associate's degrees and 6 percent of the bachelor's degrees, were 4 percent of the graduate enrollees, and had earned 4 percent of the master's degrees and 2 percent of the doctor's degrees. However, African-Americans ages 18 to 29 at the start of that academic year accounted for 14 percent of the U.S. resident population, 12 percent of the U.S. labor force, and 8 percent of the S&E workforce.

Recent decades have witnessed improved minority representation in S&E education and in the S&E workforce. African-Americans, for example, have increased their graduate enrollment 71 percent in science and 107 percent in engineering since 1985 (see figure 1). Nonetheless, the underrepresented minorities' share in S&E graduate school attendance is still, proportionally, less than half of their share in the U.S. population (see tables 4 and 5).

Figure 1.—Percentage change in S&E graduate enrollment, by field and race/ethnicity of U.S. citizens and permanent residents: 1985–1995



SOURCE: National Science Foundation (1999), *Women, Minorities, and Persons with Disabilities in Science and Engineering: 1998* (NSF 99–338), figure 4–7 and appendix tables 4–15 through 4–20.

Table 4.—Percentage of U.S. resident population and percentage of S&E participation, by race/ethnicity, 1995–96

Race and ethnicity, U.S. citizens and permanent residents	U.S. resident pop.[1]		Associate's degrees: S&E, excluding social sciences/psych.[2]	Bachelor's degrees[2]		
	18–29 age group	18–64 age group		Total	S&E, including social sciences/ psychology	S&E, excluding social sciences/ psychology
White	75.4	79.5	74.6	77.4	75.4	74.9
Asian-American	1.4	1.3	4.2	5.5	7.9	10.6
Underrepresented minorities, total	22.9	18.9	17.3	14.7	14.1	12.2
African-American	14.3	12.2	9.1	7.8	7.4	6.2
Hispanic	8.1	6.1	7.2	6.2	6.1	5.5
Native American	0.5	0.5	1.0	0.6	0.6	0.5
Unknown	0.4	0.2	2.0	2.4	2.5	2.3

Race and ethnicity, U.S. citizens and permanent residents	Graduate school enrollment[3]: S&E, excluding soc. sci./psych.	Master's degrees[2]: S&E, excluding soc. sci./ psych.	Doctor's degrees[2]: S&E, excluding soc. sci./ psych.	U.S. labor force[1]		S&E workforce[1,4]	
				18–29 age group	18–64 age group	18–29 age group	18–64 age group
White	72.1	74.1	71.7	78.9	81.6	83.0	87.8
Asian-American	14.2	12.3	21.4	1.5	1.4	4.0	2.3
Underrepresented Minorities, total	7.7	7.7	5.5	19.3	16.8	12.8	9.7
African-American	3.8	3.9	2.2	11.8	10.8	7.7	6.2
Hispanic	3.6	3.5	2.8	7.1	5.5	4.9	3.3
Native American	0.3	0.3	0.4	0.4	0.4	0.2	0.2
Unknown	6.0	5.8	1.4	0.3	0.2	0.2	0.2

NOTE: Columns may not add to 100 percent due to rounding.

[1] October 1995 Current Population Survey, public-use data file.

[2] The associate's, bachelor's, and master's degree data were collected by the National Center for Education Statistics (NCES) from all accredited institutions of higher education. The data on doctor's degrees are from the Survey of Earned Doctorates, a universe survey of individual doctorate recipients, sponsored by the National Science Foundation (NSF) and four other federal agencies. These data cover earned degrees conferred in the aggregate United States, which comprises the 50 states, the District of Columbia, and the U.S. Territories and Outlying Areas. Degree data are compiled for a 12-month period, July through June of the following year.

[3] The data on graduate enrollment are derived from the National Science Foundation/National Institutes of Health (NSF/NIH) Survey of Graduate Students and Postdoctorates in Science and Engineering (graduate student survey), Fall 1996. These data represent estimates of total enrollment in S&E programs in approximately 11,592 graduate departments at 603 institutions in the United States and outlying areas.

[4] The following 1980 Standard Occupational Classifications were used to define an S&E workforce: Engineers: aerospace (1622), metallurgical and materials (1623), mining (1624), petroleum (1625), chemical (1626), nuclear (1627), civil (1628), agricultural (1632), electrical and electronic (1633, 1636), industrial (1634), marine (8244), mechanical (1635), operating (8312), stationary (part 693, 7668), engineers, n.e.c. (1639); computer systems analysts and scientists (171); computer programmers (3971, 3972), computer operators (4612); operations and systems researchers and analysts (172); statisticians (1733); scientists: mathematical, n.e.c. (1739), physicists and astronomers (1842, 1843), chemists, except biochemists (1845), atmospheric and space (1846), geologists and geodesists (1847), physical, n.e.c. (1849), biological and life (1854), forestry and conservation (1852), medical (1855); teachers: earth, environmental, and marine science (2212), biological science (2213), chemistry (2214), physics (2215), natural science, n.e.c. (2216), engineering (2226), math. science (2227), computer science (2228), agriculture and forestry (2234); technicians: electrical and electronic (3711), industrial engineering (3712), mechanical engineering (3713), engineering, n.e.c. (3719), biological (382), chemical (3831), science, n.e.c. (3832,

3833, 384, 389), technicians, n.e.c. (399); farmers, except horticultural (5512–5514), horticultural specialty farmers (5515); inspectors, agricultural products (5627); forestry workers, except logging (572).
SOURCE: Burrelli (1998), *Graduate Students and Postdoctorates in Science and Engineering: Fall 1996* (NSF 98–307), table 12. Hill (1999b), *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1989–96* (NSF 99–332), tables 4, 7, and 10. U.S. Department of Commerce, Bureau of the Census, Current Population Survey, October 1995. U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS) 1996 Completions Survey data file.

Table 5.—Racial/ethnic groups as a percentage of S&E graduate enrollment and master's and doctor's degree recipients, by field, in 1989 and 1996

	Science, excluding social sciences and psychology					
	Graduate enrollment		Master's degree		Doctor's degree	
	1989	1996	1989	1996	1989	1996
White	81.2	86.0	72.6	69.4	68.7	60.5
Asian-American	6.0	5.6	7.3	10.0	5.1	16.0
African-American	2.9	2.5	2.2	3.9	1.2	1.8
Hispanic	2.8	2.0	2.0	2.8	1.8	2.3
Native American	0.2	0.2	0.4	0.3	0.3	0.3
Unknown	5.1	2.8	6.5	5.3	1.8	1.2
	Engineering					
	Graduate enrollment		Master's degree		Doctor's degree	
	1989	1996	1989	1996	1989	1996
White	74.3	69.9	67.6	65.4	40.9	42.0
Asian-American	8.7	12.0	10.5	12.6	8.6	16.6
African-American	2.3	4.1	1.9	3.2	0.8	1.4
Hispanic	2.5	4.2	2.4	3.6	1.1	1.8
Native American	0.2	0.3	0.2	0.3	0.2	0.3
Unknown	9.2	6.5	6.9	5.3	1.3	0.8

SOURCE: Burrelli (1998), *Graduate Students and Postdoctorates in Science and Engineering: Fall 1996* (NSF 98–307), table 12. Hill (1999b), *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1989–96* (NSF 99–332), tables 7, and 10.

The growth of underrepresented minority employment in S&E fields is consistent with the increase of underrepresented minority Ph.D.s since the late 1970s (National Science Board, 1996). Among doctor's degree holders, the relative employment gains and consequent increase of researchers have been greater for underrepresented minorities than for the white and Asian-American majority. Employment of underrepresented minorities doubled from 1979 to 1993, and the number of researchers from underrepresented groups tripled. Gains for specific fields varied, with the physical, environmental, and life sciences close to the average in all S&E fields, and with mathematics, the computer sciences, psychology, and engineering exceeding the average (National Science Board, 1996). However, as shown in table 4, underrepresented minorities are still underrepresented in the S&E workforce.

The gains in underrepresented minority participation in S&E are not of the same magnitude at each level in the education process. As shown above, the more advanced the level of training, the lower the rates of underrepresented minorities in the programs. A question facing researchers then is what contributes to the uneven pipeline leakage across education levels.

In a study of racial representation at S&E entry and exit (Astin et al. 1994), the percentage of African-American and Hispanic freshmen who intended to major in S&E was higher than that of whites. Likewise, the rates of minority freshmen who reported willingness to pursue S&E careers were equal or higher than that of whites. These entry level expectations contrast with S&E degree completion rates, which are consistently lower among the minority groups. The differences in entry and exit imply “pipeline leakage” *differentiated by race*; that is, relative to whites and Asian-Americans, proportionally more underrepresented minority students who initially intend to enter the S&E system wind up not majoring in S&E or leaving the programs without completion. Qualitative research has also revealed that minorities do tend to face more barriers to finishing the programs despite their strong motivation to study S&E (e.g., Seymour and Hewitt 1997; see also descriptions of prior research below).

Prior Research

The persistent underrepresentation of women and underrepresented minorities in S&E education has spurred a number of researchers to scrutinize the gaps occurring at the entry into and completion of S&E postsecondary programs because these two measures are crucial points leading to equity in the labor market. A number of theoretically significant factors have been identified. Those that will be discussed here are related to measures that can be addressed with data from the national surveys sponsored by the National Center for Education Statistics (NCES). These factors can be loosely organized in three categories: family environment and support factors; student behavior factors such as attitudes, aspirations, and academic preparation; and school/institution factors such as precollege curriculum and instruction or postsecondary special programs in recruitment, retention, and financial aid. These three categories of variables will form the multivariate model used to analyze data from two NCES surveys in chapters 3 and 4.

Family Environment and Support

Parental support has been identified as a predictor of the selection of an S&E major in college. Conceptually, parents’ educational attainment and occupation do not directly affect their children’s choice of a college major, but they influence the decisionmaking in indirect ways, including providing better financial support and encouraging career choices. Such parental influence differs across race: for whites, both parents’ influence is substantial, whereas for African-Americans, only the mother’s influence is discernible (Maple and Stage 1991; Gruca, Ethington, and Pascarella 1988).

Compared with white and Asian students, underrepresented minority students may be more likely to exit their S&E programs because of such barriers as financial difficulties and demanding family obligations. Hispanic students in particular tend to work while studying in college not only to financially support themselves but also to assist their families. Because of close family ties, they also are expected to provide services to their families when needed during their college years (Seymour and Hewitt 1997). Combined with the pressure of challenging S&E studies, family obligations and financial conditions may become crucial determinants of S&E program completion.

Student Behavior

The values, beliefs, perceptions, and attitudes the students themselves hold regarding mathematics, science, and engineering subjects and related careers differ across gender and race/ethnicity. Research suggests these psychological and social factors are useful for understanding the gender and racial/ethnic gaps in the S&E pipeline.

Attitudes and Aspirations

Self-confidence has been studied extensively in relation to women's mathematics and science education (e.g., Sax 1994, 1995; Seymour and Hewitt 1997; Hyde, Fennema, Ryan, Frost, and Hopp 1990; Ware and Lee 1988). These studies report that gender differences in S&E major selection and persistence are closely related to women's self-perceived ability to learn math and science. Low self-confidence in math-related subjects strongly predicts a non-S&E major, and declining confidence during the early years of college often leads to a switch from S&E to other fields (Ware and Lee 1988; Seymour and Hewitt 1997; Sax 1995).

Low self-confidence among women may be related to institutional factors such as S&E curriculum and instruction, faculty response to female students' needs, and institutional culture regarding equitable education (Seymour and Hewitt 1997). However, gender differentiated self-confidence in S&E learning varies across race. Research has found African-American women independent and assertive and, in some cases, expressing greater confidence than women in other racial/ethnic groups with regard to S&E education and education in general (e.g., see Hanson 1996). On the other hand, Hispanic women seem to lag behind Hispanic men in measures of both performance and confidence (Ware and Lee 1988; Catsambis 1994).

Attitudes regarding quantitative subjects are related to the gender difference in college major choice. Relative to men, women may be more sensitive to social relationships and value more human aspects of the environment. Also, women tend to dislike the highly abstract nature of S&E knowledge and the strong competitive environment in many S&E departments. Such attitudes seem to become apparent during the middle school years and are held by college women. It has been found that the extent of such gender-differentiated attitudes explain much of women's lower probability of choosing and completing S&E programs (Seymour and Hewitt 1997; Maple and Stage 1991; Ware and Lee 1988; Oakes 1990).

Another attitudinal dimension examined by prior research regarding women in S&E concerns the clash between traditional and changing ***gender roles***. Many women confront the issue of prioritizing career versus marriage/family when choosing an S&E major. Research has not arrived at a consensus on which attitudes contribute to selection and persistence in S&E majors. For instance, Ware and Lee (1988), on the basis of national survey data, report that women who have a strong career commitment are more likely to select science, mathematics, and engineering majors. Other studies (Farmer, Wardrop, Anderson, and Risinger 1995; Maple and Stage 1991) report different evidence: women with strong career commitments are more likely to switch from science, engineering, and technological fields into other areas, whereas men's career aspirations are closely related to persistence in these fields.

Some minorities face a unique psychological difficulty in persisting in S&E programs, namely, a ***conflict between over-confidence and poor preparation*** (Seymour and Hewitt 1997). A substantial number of African-American and Hispanic students who choose majors in S&E are from high schools where they have been seen as academically outstanding *relative* to their severely disadvantaged peers. They have developed strong academic self-confidence but have not taken or been offered the advanced placement (AP) or similar coursework necessary for S&E programs at the college level—especially in highly selective universities (Seymour and Hewitt 1997). Overwhelmed, these minority students are often at high risk of switching from S&E programs or even dropping out of college.

Academic Preparation

Academic preparation has been studied extensively as a strong predictor of success in S&E undergraduate and graduate programs. It is widely accepted that the observable gender differences in learning and performance on quantitative-related subjects emerge in mid-adolescence and continue widening in subsequent schooling (e.g., Stipek and Gralinski 1991; Norman 1988; Kahle and Lakes 1983; Fennema 1980). Data from the National Assessment of Educational Progress (NAEP) have systematically identified racial gaps in math achievement as early as in fourth grade (e.g., Vanneman 1998; Reese, Miller, Mazzeo, and Dossey 1997; Campbell, Reese, O'Sullivan, and Dossey 1996). On the other hand, there is some evidence that the gender gap in secondary school science achievement is not as great as gender differences in science-related attitudes and activities (Hanson 1996). While numerous explanations of the learning gaps are available from the literature, academic preparation is often seen as a possible determinant of the gaps in S&E college major selection associated with race/ethnicity and gender. Even among college students intending to major in S&E, girls and underrepresented minorities tend to have taken fewer advanced courses of mathematics in high school than their male and white peers (e.g., Farmer, Wardrop, Anderson and Risinger 1995; Maple and Stage 1991).

Research seems still not fully certain about the extent to which gender and race/ethnicity gaps in secondary school math and science *achievement* are responsible for women and minorities' low rates of entrance to and completion of S&E postsecondary programs. Some have argued that college entrance tests (e.g., SAT) are probably biased toward underestimating the performance of underrepresented minorities and girls (e.g., Jencks and Phillips 1998; Fish 1994; Wainer and Steinberg 1992; Bridgeman and Wendler 1991; Williams 1989). Other research has shown that SAT scores may actually overpredict academic performance for African-Americans (e.g., Vars and Bowen 1998). Some studies have further suggested that female students in high school and college on average score similarly or even higher than male students (e.g., Catsambis 1994; Linn and Kessel 1995) and that their failure in entering or persisting in S&E programs is largely due to such psychological factors as low self-confidence and the male stereotype of the disciplines (Seymour 1995; Lips 1992; Oakes 1990; Ware and Lee 1988). Other investigations, while stressing gender and race/ethnicity gaps in math and science test scores, conclude that secondary school academic preparation has a *direct* effect on postsecondary S&E persistence and completion (for a review, see Seymour and Hewitt 1997). The challenge to S&E programs is perhaps how to deal with both inadequate academic preparation and psychological vulnerabilities among female and minority students.

School/ Institution Factors

Both secondary and postsecondary education systems set the basic conditions for women and minorities to participate in S&E vocations. While secondary education may be more predictive of the individual's entry into the S&E pipeline, postsecondary institutions impact the entire process, from entry to graduation.

Precollege Education

Elementary and secondary education is a salient factor in understanding the differential participation in postsecondary S&E programs by disadvantaged students. Because high school immediately precedes postsecondary school entrance, its impact on college major selection seems conceptually direct and empirically observable relative to the effects of earlier schooling. High school effects have been handled in prior research in a number of ways, as presented below.

Curriculum and instruction of high school mathematics are crucial conditions leading to majoring in S&E in college. Schools that provide advanced math and science courses offer students opportunities for in-depth learning in these subjects and consequently high performance (Oakes 1990; Peng, Wright, and Hill 1995). Intensive curricula and high expectations compel students of all backgrounds to learn, whereas inferior curricula and poor instruction often disadvantage underrepresented minority students to a greater extent than they do other students, perhaps because underrepresented minorities have less access to out-of-school learning opportunities as compared to white peers (Ware and Lee 1988; Smith and Walker 1988; Catsambis 1994).

Teachers and counselors may influence students' choices among college programs. Women were less likely to major in science if they were attending a 4-year college and were influenced by high school teachers or guidance counselors in making college plans. However, men were more likely to major in science if they were attending a 4-year college and their choice was not related to high school personnel influence (Ware and Lee 1988). The quality of math and science teachers has also been found to be an important predictor of student learning in those subjects and perhaps later college S&E attendance. For instance, teacher interaction with girls may be different from their interaction with boys; it may be characterized by low expectation, passive feedback (Jones and Wheatley 1990), and attributing failure to students' lack of ability (Fennema 1980). The small numbers of women and minorities who are willing to teach S&E at elementary and secondary levels make it difficult for girls and minority students to find role models. Additionally, the fact that math and science courses at the secondary school level are increasingly taught by education majors rather than by math and science majors may have worsened the quality of instruction (see Seymour and Hewitt 1997).

Learning opportunities—as a broad construct—have frequently been used in examining gender and race/ethnicity differences in academic performance, including math and science learning (e.g., Catsambis 1994; Oakes 1990; Norman 1988). In some high schools, these learning opportunities—as indicated by curriculum provision—are organized by ability grouping or tracking. Commonly, students are grouped in three curricular tracks: academic or college preparation, vocational and technology, and general programs (Oakes 1990). Such tracking systems in math and science have been criticized as much to the disadvantage of girls and underrepresented minorities because, more often than not, these groups have a lesser chance to be in academic programs than white boys (Ware and Lee 1988; Oakes 1990). Thus, some researchers say that schools that provide curriculum via ability grouping tend to compromise the equity of student learning, including learning in math and science (e.g., Coleman and Hoffer 1987; Lee and Bryk 1988).

Postsecondary Institutions

Under the general rubric of institutional environment for S&E equity, prior research has specified a number of factors that are theoretically and empirically relevant to explaining gender and race/ethnicity gaps in the S&E pipeline.

Institutional structure and commitment to equitable S&E education are key factors leading to varying S&E pipeline outcomes *vis-à-vis* underrepresented groups. Compared to large universities, small liberal arts colleges, community colleges, and historically black colleges and universities are believed to have contributed strongly to narrowing the gaps related to gender or race/ethnicity in major selection and graduation (e.g., U.S. Congress 1992). In this perspective, small liberal arts colleges, with an apprenticeship model of education facilitating close interaction between faculty and students, are better able to provide *all* students adequate opportunities for math and science careers (U.S. Congress 1992). The nationwide community college system has been functioning well in expanding minorities' postsecondary education opportunities in general, and enrollment in science and technology in particular (Brazziel and Brazziel 1994; U.S. Congress 1992; Quimbita 1991).

Prior research has also examined the student racial composition of postsecondary institutions as a predictor of campus racial relations, which further relates to minority students' condition in college. Some earlier reports revealed that on campuses with highly diverse student bodies (relatively high rates of minority students), racial tension tended to be high (e.g., Evans and Giles 1986; Longshore 1981). Recent studies have provided further insights on the issue. Seymour and Hewitt (1997) use ethnographic data to suggest that in S&E institutions with relatively high proportions of minorities, resentment and hostility among white students are more obvious regarding minority admission, performance, graduation, and other related issues. Interestingly, minorities on these campuses seem to respond to such conditions with fairly positive perceptions. Hurtado and colleagues synthesized research on campus racial climate in a recent report (Hurtado, Milem, Clayton-Pedersen, and Allen 1998) to provide a conceptual model for examining the institutional history of racial inclusion, current diversity of race/ethnicity, campus psychological climate (attitudes, perceptions held by different groups), and intergroup relationships.

Academic and social climates of the institution are difficult to measure but may have a substantial influence on underrepresented students' persistence and success in S&E studies, as the researchers mentioned below demonstrate. Some observers contend that the contents and the approach of S&E education are inherently disadvantageous to women and underrepresented minorities (Seymour and Hewitt 1997; Tate 1995; Hurtado and Carter 1997). Some argue that the S&E establishment is rooted in a culture in conflict with the intellectual and cultural orientation of underrepresented groups (Tate 1995; Anderson 1990; Seymour and Hewitt 1997). For example, in S&E institutions, personal success is highly regarded; however, women and underrepresented minorities commonly place primary value on people and groups. Grades as a main source for measuring a person's value and social status force many women and minority students to leave the fields (Seymour and Hewitt 1997).

Conceptual difficulties, faculty nonresponsiveness, the poor teaching quality associated with extensive use of teaching assistants, and lack of collaboration have been cited as major problems facing women and underrepresented minorities who participated in S&E programs (Seymour and Hewitt 1997).

Special programs in recruitment, retention, and financial aid are available in many universities to support S&E participation by women and minorities. The *availability* of such programs, however, can be an overly simplistic predictor of the pipeline outcome. Instead, *program organization* and operation are important in determining the outcomes. For example, S&E enrollment of women and minorities may increase as a result of strong recruitment programs, but their persistence in and completion of these programs also often require assistance (Friedman and Kay 1990). Unless S&E institutions make equally effective assistance efforts, their strong recruitment programs can be counterproductive if disadvantaged students are overwhelmed by difficulties in S&E programs (Seymour and Hewitt 1977).

Research also suggests that S&E specific assistance programs available to students of all backgrounds are particularly useful to women and underrepresented minority students (Seymour and Hewitt 1997). Contrary to *remedial* programs provided only to specific groups, *enrichment* programs offered to *all* students work better for underrepresented minorities and women because such programs are not subject to stigmatization. Such programs run by S&E departments (as opposed to by the university) with S&E field related material (as opposed to general calculus, for example) are effective (Seymour and Hewitt 1997; Bonsangue and Drew 1995). Some universities have collaborated with high schools to support underrepresented students' learning of S&E subjects by offering learning and research opportunities to these students. Some of these programs are reported to have been quite successful in raising the rates of girls and underrepresented minorities who intended to study in S&E fields at college (Anderson 1992; New Mexico Commission on Higher Education 1987; Hamburg 1984; Thomson 1984; U.S. Congress 1992).

Lack of financial support has been repeatedly cited as a main reason for underrepresented minority students' low enrollment in and dropout from S&E programs (e.g., Porter 1990; Rotberg 1990; Seymour and Hewitt 1997). Institutions that provide strong financial aid to promising underrepresented minority students who need support are said to be better able to recruit and retain these students in the programs (Swail 1995; National Action Council for Minorities in Engineering 1994).

Chapter 2
Study Approach

As seen in the preceding chapter, the gender and race/ethnicity gaps in entry and completion of postsecondary science and engineering (S&E) education still exist, although they are narrowing. The prior research discussed in chapter 1 has generally established that women and underrepresented minorities differ in their experiences of the S&E system. To summarize, it appears that women are disadvantaged by socially learned low self-confidence and a disinterest in S&E to a greater extent than underrepresented minorities, whereas underrepresented minorities are often blocked by an absence of learning opportunities and inferior academic preparation in secondary school. At the postsecondary level, women tend to suffer from the male-dominated *social environment* in S&E institutions. Underrepresented minorities, on the other hand, are hindered to a greater extent by *practical difficulties* in S&E education, including financial support and lack of S&E discipline-specific assistance. These differences have been identified by researchers examining three basic categories of variables: family environment and support, student behavior, and school/institution factors. We will use these categories to create a multivariate model that we will test in two empirical analyses with the overall goal of trying to determine the relative importance of these categories in sustaining the gender and race/ethnicity gaps in S&E education.

Each analysis will have a specific goal, as well. The specific goal of the first analysis is to examine the patterns of entry into S&E programs in postsecondary institutions and factors relating to these patterns. This portion of the study analyzes data from the National Education Longitudinal Study of 1988 (NELS:88). The second analysis examines women's and underrepresented minorities' *persistence in* and *attainment of* postsecondary S&E education by tracing a cohort of postsecondary students who began their S&E education in their first postsecondary year through a 5-year time frame, using data from the Beginning Postsecondary Student Longitudinal Study (BPS). Details about these data sources are given in their respective sections of the report. NELS:88 has been widely used in research of high school through postsecondary education, including S&E education. BPS has not been used in previous S&E education research, but with its national sample and longitudinal information about how respondents travel through the S&E pipeline, BPS is a useful source to researchers interested in this subject.

The two analyses are presented in one report to address the overarching policy concern—gender and racial/ethnic gaps in postsecondary S&E entry and persistence—not to portray a follow-up of a population of high school graduates or to describe patterns in a continued time frame. Note that the NELS:88 cohort student did not graduate from high school until 1992 while the BPS cohort student enrolled in postsecondary education in the 1989–90 school year (i.e., when the NELS:88 cohort student was in the ninth grade). The study populations are described in more detail below.

Study Populations

- In the NELS:88 analysis, the population is the 1988 cohort of eighth-graders who were followed through high school.

- In the BPS analysis, three reference populations were defined for three different purposes:

  (1) **to examine S&E enrollment across 5 years**, we used the beginning postsecondary student population (excluding those age 30 or older) in school year 1989–90—call it the "full BPS sample" or population 1;

  (2) **to examine the postsecondary S&E education outcome by the end of the fifth year of school**, we used the subgroup of population 1 that enrolled in S&E programs in the first year of postsecondary education—call it the "first-year S&E subsample" or population 2; and

  (3) **to examine multiple predictors in relation to S&E completion by the end of 5 years**, we used the subgroup of population 2 that enrolled in 4-year S&E programs in the first year of postsecondary education—call it the "first-year BA subsample" or population 3.

Other "logical" reference populations were not examined because of data-related limitations. Because BPS has a 5-year time span, the S&E education outcomes (completion, program switch, college dropout, and persistence) can only be defined tentatively *by the end of the 1993–94 school year* (i.e., some switchers may switch back, and some dropouts may drop back in and—given a longer time span—turn into completers). The limited time span handicaps the examination of more complicated paths taken by students other than the first-year S&E group and the first-year bachelor's group. More specific discussions on methodological and analytical issues are provided in chapters 3 and 4.

Minority subgroups may have distinct problems in accessing S&E education, perhaps relating to their cultural, linguistic, and historical differences. However, they also share many difficulties in participating and succeeding in S&E education, including limited family and school resources and disadvantaged learning opportunities. Relative to unique—and often unalterable—historical and cultural differences, such common problems are probably more relevant to policymaking considerations and program development. Thus, many analyses in this study categorized underrepresented minorities into one group and did not look at subgroup differences. However, when data were available from released NCES publications, subgroup statistics are presented in the reprinted tables.

Another possible concern is these analyses having used ***self-reported information vis-à-vis transcript records***. Self-reports of program enrollment are possibly inaccurate compared with administrative records. It may be especially so with BPS data for the years when data were collected in a retrospective manner (data for academic year 1990–91 were collected in AY 1991–92 and data for AY 1992–93 in AY 1993–94). On the other hand, if what interests us is how students made their own decisions in pursuing various paths through postsecondary education, self claims of academic major may better reflect students' "academic identity" than administrative records. Moreover, transcripts records do not directly indicate program enrollment. Defining students' academic path or curricular "threshold" entails induction by researchers (Adelman 1998, 14), which may introduce some bias given diverse institutional conditions. Thus, using student-reported academic majors has merits as well as shortcomings.

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Chapter 3
Entering the S&E Pipeline: Analyses of NELS:88 Data

To understand racial/ethnic and gender gaps in postsecondary Science and Engineering (S&E) education entry, the array of variables included in this study are examined individually and then jointly. The first type of analysis employs descriptive techniques to show the differences among genders and racial/ethnic groups in family environment and support, student behavior, and school factors, including school programs and teachers. The second type of analysis uses statistical modeling techniques to focus on S&E enrollment in relation to these same three sets of variables. The overall goal of the logistic regression analysis is to describe the entry rates of women and underrepresented minorities into S&E programs at the postsecondary level and to assess the role of these three sets of variables in relation to female and minority underrepresentation in S&E entrance. This sets the stage for the analysis in chapter 4 regarding postsecondary S&E program persistence and completion.

NELS:88 Data

The National Education Longitudinal Study of 1988 (NELS:88) offers national survey data for studying postsecondary education—S&E program entrance included—relating to high school student background and high school experience (Berkner, Chavez, and Carroll 1997). NELS:88 began its base year data collection in 1988 when the sampled cohort was in eighth grade. Follow-up surveys were conducted in 1990, 1992, and 1994.

Survey Components

The base year survey included a student questionnaire and cognitive tests, and parent, teacher, and school administrator questionnaires. The first follow-up survey collected information from students, teachers, and school administrators, but it did not survey parents. The first follow-up also included a dropout questionnaire, the Base Year Ineligible Study, and the High School Effectiveness Study (research on school effects). The second follow-up repeated all components of the first follow-up study and reinstated the parent questionnaire. A new Transcript Study provided archival data on the academic experience of high school students, while a new Course Offerings Component gathered information on the curricula offered by the schools. The third follow-up study contained only the student questionnaire.

Sample Design

The NELS:88 base year survey included a national probability sample of 1,052 public and private eighth-grade schools in the 50 states and the District of Columbia. Student sampling produced a random selection of 26,435 eighth-graders in 1988; 24,599 participated. Hispanic and Asian/Pacific Islander students were oversampled. Within each school, approximately 26 students were randomly selected (typically, 24 regularly sampled students and 2 oversampled students). In schools with fewer than 24 eighth-graders, all eligible students were selected. Potential sample members were considered ineligible and excluded from the survey if disabilities or language barriers were seen as obstacles to successful completion of the survey. The eligibility status of excluded members was reassessed in the first follow-up. The sample was freshened in both the first and second follow-ups to provide valid probability samples that would be nationally representative of 10^{th}-graders in spring 1990 and 12^{th}-graders in spring 1992. *The sample used in the analysis reported here represents the national population of eighth-graders in 1988 who went through high school and went to college or elsewhere by 1994.*

Our sample includes the respondents who did not go on to college after high school[3] for the following reasons. First, an important goal of this study is to examine the racial/ethnic and gender gaps that exist in the U.S. population: excluding respondents who did not go to college would lead to underestimated gaps. Second, lower college attendance of minorities should be seen as a component of the gaps in S&E education. From a policy research viewpoint, information that sheds light on means of reducing the gaps that are defined among the nation's population should be more valuable than information that deals with the gaps measured only among college students. Finally, the subgroup of college goers in NELS:88 was not a representative sample by design: modeling the national patterns in such a subgroup may generate misleading statistical results. Because of these concerns, it was decided to analyze the whole panel data, rather than the data for the subgroup of college students in the panel. (This marks another difference between the NELS and BPS analyses: BPS is designed to survey only beginning postsecondary students.)

Table 6 presents a detailed breakdown of the unweighted NELS:88 sample sizes by gender and race/ethnicity for the descriptive and regression analyses. The descriptive analysis provides a picture of students from 8^{th} grade through 12^{th} grade and thus uses data for students who could be followed from the base year through the second follow-up. The logistic regression analysis, which focuses on S&E major choice, looks at those students who could be followed from eighth grade into a postsecondary institution or the workforce; it uses base year through third follow-up data.

[3] The dependent variable in the analysis was coded 1 for those who majored in S&E and 0 for those who either majored in other fields or did not enter postsecondary institutions.

Table 6.—Unweighted NELS:88 sample sizes used in the descriptive analysis and the logistic regression analysis, by gender and race/ethnicity

	Descriptive analysis[1] BY–F2 panel sample	Regression analysis[2] BY–F3 panel sample
Total	16,489	13,120
Female	8,349	6,759
Male	8,140	6,361
White, not Hispanic	11,659	8,922
Asian	985	914
African-American, not Hispanic	1,628	1,380
Hispanic	2,016	1,740
Native American	164	163

[1] The descriptive analysis uses data for students represented in the base year through second follow-up surveys.
[2] The regression analysis uses data for students represented in the base year through third follow-up surveys.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988, “Base Year” through “Third Follow-Up,” 1988–94.

Weighting and Treatment of Missing Data

The complex sample design in NELS:88 requires weighting to compensate estimate bias caused by differential sampling probabilities and response rates. In the descriptive analysis, the base year through second followup (BY–F2) panel weight (F2PNLWT) was used to generate estimates; in the logistic regression analysis, the base year through third followup (BY–F3) panel weight (F3PNLWT) was used.

The descriptive analysis focuses on respondents’ math- and science-relevant experiences during middle school and high school years. It is designed to demonstrate racial/ethnic and gender differences in family background, psycho-behavioral attributes, and educational processes, through largely bivariate analysis. This part of the analysis did not link the racial/ethnic and gender differences to the outcome of postsecondary majoring in S&E, which was collected in the third followup. The multiple regression analysis, however, involves predicting the postsecondary outcome with the secondary school variables, and therefore requires using the base year through third followup panel data.

Because of the stratified, clustered sample design, within-school data are correlated to some extent and the conventional assumptions of simple random sample are not warranted. Such potential bias, associated with *design effects*, needs to be taken into account when estimating statistics. The regression analysis used the software package SUDAAN (Shah, Barnwell, and Bieler 1995), which, with a Taylor series approach, was specifically designed for analyzing data from complex surveys such as NELS:88.

Missing cases on continuous variables were deleted from both the descriptive analysis and the logistic regression analysis. Missing values on categorical variables were treated differently in the descriptive analysis and logistic regression analysis. In the descriptive analysis, different nonresponses (e.g., don't know, multiple response, refusal, or simply missing) to each categorical variable—with the exception of race/ethnicity—were combined into a single missing category that was not counted in the crosstabulation. In the logistic regression analysis, however, cases with such nonresponses to categorical variables were treated differently, depending on the number of missing cases and the meanings of the response categories (for details, see the section on missing cases under "Predictor Variables" in the logistic regression analysis portion of chapter 3).

Descriptive Analysis

As discussed in the section on prior research, family environment and support factors, student behavior factors, and school factors are among the *theoretically* significant factors explaining female and minority underrepresentation related to S&E entry. The first step in the analysis is an examination of NELS:88 base year through second follow-up data, covering the period when students were in 8^{th} through 12^{th} grades, to identify—through descriptive statistics—which potential family, behavior, and school variables might be associated with entrance into S&E studies. NELS:88 data allow us to look at a student behavior factor such as career aspiration, for example, through students' answers to questions on whether they thought (as 8^{th}-, 10^{th}-, and 12^{th}-graders) they would go to college and graduate school. Other variables examined include parents' aspirations for their children, parental support, students' program participation and coursework, attitudes and learning strategies, math and science performance, school programs, and teachers.

Family Environment and Support

Parents' aspirations for their children's education are presented in table 7. When their children were in the eighth grade, more underrepresented minority parents than other parents expected the children to earn a master's degree or other advanced degree. This difference could be attributed to the high expectations of underrepresented minority *girls*' parents, 25.5 percent of whom expected their daughters to earn a master's degree or other advanced degree, a rate higher than Asian and white girls' parents. On the other hand, fewer underrepresented minority parents than Asian and white parents expected their children to earn either a 2- or 4- to 5-year degree. Parents' educational aspirations for their children did not seem to differ across gender.

When their children were in the 12^{th} grade, the racial/ethnic difference in the parents' aspirations was largely similar to that when their children were in the 8^{th} grade. Again, more underrepresented minority parents than Asian and white parents wanted their children to earn a master's degree or other advanced degree, and underrepresented minority girls' parents had a higher

(47.2 percent) level of aspiration for their daughters to earn a master's degree or other advanced degree than did parents of Asian and white girls. The difference here is that underrepresented minority boys' parents also were more likely than Asian and white boys' parents to want their children to earn a master's degree or other advanced degree, though at a smaller margin relative to underrepresented minority girls' parents.

Table 7.—Parents' educational aspirations for their children: Percentage of 8th-graders (1988 cohort in 1988) whose parents answered how far in school they expected their children to go and percentage of 12th-graders (1988 cohort in 1992) whose parents answered how far in school they wanted their children to go,[1] by race/ethnicity and gender

	To complete high school %	To attend vocational, trade, or business school %	To attend a 2- or 4-year college %	To finish a 2- or 4- to 5-year college program %	To earn a master's degree or other advanced degree %
			8th-graders (1988 cohort in 1988)		
Underrepresented minority	14.36	7.77	16.63	*37.20	*23.39
Asian and white	12.26	7.78	15.32	*44.82	*19.27
Female	12.18	7.36	16.47	42.93	20.66
Male	13.33	8.20	14.79	43.12	19.83
Female					
Underrepresented minority	14.04	7.27	16.87	*35.95	*25.52
Asian and white	11.59	7.39	16.34	*45.15	*19.11
Male					
Underrepresented minority	14.70	8.29	16.39	*38.53	21.14
Asian and white	12.92	8.18	14.31	*44.49	19.43
			12th-graders (1988 cohort in 1992)		
Underrepresented minority	*4.27	11.26	7.37	*32.63	*44.13
Asian and white	*5.42	13.12	7.99	*38.85	*34.33
Female	*4.52	*10.52	*8.57	37.25	*38.90
Male	*5.69	*14.68	*7.10	37.15	*35.00
Female					
Underrepresented minority	*3.34	10.24	7.68	*31.31	*47.15
Asian and white	*4.96	10.62	8.90	*39.44	*35.86
Male					
Underrepresented minority	5.20	12.30	7.05	*33.96	*41.09
Asian and white	5.86	15.52	7.11	*38.28	*32.85

* p<0.05

[1] The second followup parent questionnaire item contained the additional instruction "Please circle the highest level that applies."

NOTE: Rows do not add to 100 percent because the category "less than high school" is not included.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "Base Year" and "Second Follow-Up" parent survey combined with student data, weighted by the panel weight F2PNLWT. Unweighted sample size for the base year variable was 14,002 (with 15 percent missing cases in the panel sample); for the second follow-up it was 16,389.

Across gender, girls' parents were somewhat more likely than boys' parents to want their child to earn a master's degree or other advanced degree (38.9

percent and 35.0 percent, respectively). And fewer girls' parents than boys' expected their child to go to vocational schools (10.5 percent and 14.7 percent, respectively).

It is also interesting to note some basic shifts between the answers given by 8th-graders' parents and 12th-graders' parents. Where about 12 to 15 percent of the 8th-graders' parents expected their children simply to complete high school, only 3 to 6 percent of the 12th-graders' parents wanted high school to be the end of their children's education. Similarly, where 14 to 17 percent of 8th-graders' parents expected their children simply to attend college, only 7 to 9 percent of 12th-graders' parents wanted that. More 12th-graders' parents wanted their children to attend vocational, trade, or business school (10 to 16 percent versus 7 to 8 percent) and far more wanted their children to earn a master's degree or other advanced degree (33 to 47 percent versus 19 to 26 percent).

Parents' support relevant to postsecondary math and science education includes taking their 8th-grade children to science museums and saving money for their education after high school, and talking to their 12th-grade children about applying for college and discussing issues about study (see table 8).

When the children were in the eighth grade, fewer underrepresented minority parents than white and Asian parents reported that they or their eighth-grade children went to science museums or saved money for education after high school. Eighth-grade girls' parents were also less likely than boys' parents to do either.

In the 12th grade, the situation changed. There were few statistically significant differences in the two measures of parental support: the gender difference in parental support resembled the racial/ethnic difference. But on one of the two measures of parental support—being more likely to often discuss issues about study with their children—girls' parents surpassed boys' parents. The three-way crosstabulation essentially generated consistent results.

Table 8.—Parents' support for math and science education: Percentage of 8th- and 12th-graders (1988 cohort in 1988 and 1992) whose parents provided support relevant to postsecondary math and science, by race/ethnicity and gender

	8th-graders (1988)		12th-graders (1992)	
	Go to science museums %	Any money saved for education after high school %	Often talked about applying for college %	Often discussed issues about study[1] %
Underrepresented minority	*44.90	*39.05	72.24	25.06
Asian and white	*57.10	*50.91	75.71	22.51
Female	*52.04	*46.18	75.73	*24.75
Male	*56.60	*50.04	74.09	*21.51
Male				
Underrepresented minority	*44.68	*40.89	*71.64	21.59
Asian and white	*59.96	*52.78	*74.83	21.49
Female				
Underrepresented minority	*45.12	*37.29	72.86	*28.57
Asian and white	*54.14	*49.01	76.62	*23.57

* $p<0.05$

[1] A set of six items (F2P49A, F2P49B, F2P49C, F2P49D, F2P49E, and F2P49F) was used to create this composite variable. The items asked about the frequency with which the parent(s) discuss specific issues related to academic study (e.g., selecting courses, school activities, things the child was studying, and child's grades). The composite variable was dichotomized to distinguish parents who often discussed one or more of these issues from those who never did so.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "Base Year" and "Second Follow-Up" parent survey combined with student data, weighted by F2PNLWT. Unweighted sample size varies across runs of crosstabulations due to different numbers of missing cases on the parent data items and student race.

Student Behavior

This category of variables includes student aspirations, program participation and coursework, attitudes and learning strategies, and math and science performance.

Aspirations

Aspirations are indicated by the students' reports on how far they expected to get in school and how many expected to be in scientific, engineering, or technical fields when they were 30 years old.

Students were asked in the 8th, 10th, and 12th grades how far they expected to get in school (see table 9). Proportionally, more underrepresented minority students than Asian and white students expected only to complete high school or only attend college, and fewer underrepresented minorities than Asian and white students expected to *graduate* from college. These differences occurred when students were in the 8th and 10th grades but not in their senior year. No racial difference was found in expectation for further education after college graduation in any of the three grades.

In contrast, more girls than boys expected to continue their education after graduating from college, but girls did not seem to differ from boys in aspiring to college attendance and completion. These patterns were evident across the three grade levels. Further analysis of the three-way crosstabulation confirmed the above findings and revealed no interaction effect between gender and race/ethnicity.

There is a drop in the percentages of all categories of students expecting to complete college between 8th and 10th grade. The percentages increased in 12th grade, although they did not regain the 8th-grade heights. Notice that the category wording changed between these years. In the 8th grade, the category was "will graduate from college"; in 10th and 12th grade the category stated "will finish college (4- or 5-year degree)."

Table 9.—Aspirations for postsecondary education: Percentage of 8th-, 10th-, and 12th-graders (1988 cohort in 1988, 1990, and 1992) who thought they would attain college and graduate education, by race/ethnicity and gender

	Will graduate from high school, but won't go any further[1] %	Will attend college[1] %	Will graduate from college[1] %	Will attend a higher level of school after graduating from college[1] %
		8th-graders (1988)		
Underrepresented minority	10.91	*17.06	*37.30	22.32
Asian and white	9.81	*11.98	*45.28	22.43
Female	*8.96	13.28	42.84	*24.69
Male	*11.19	13.18	43.80	*20.13
Female				
Underrepresented minority	9.62	*17.53	*34.68	25.95
Asian and white	8.73	*11.83	*45.62	24.27
Male				
Underrepresented minority	12.29	*16.55	*40.09	18.44
Asian and white	10.85	*12.13	*44.95	20.65

Table 9.—Aspirations for postsecondary education: Percentage of 8th-, 10th-, and 12th-graders (1988 cohort in 1988, 1990, and 1992) who thought they would attain college and graduate education, by race/ethnicity and gender—Continued

	Will graduate from high school, but won't go any further[1] %	Will attend college[1] %	Will graduate from college[1] %	Will attend a higher level of school after graduating from college[1] %
	10th-graders (1990)			
Underrepresented minority	*14.60	*19.26	*25.02	24.16
Asian and white	*10.07	*16.09	*32.02	26.99
Female	*10.18	17.09	29.79	*29.74
Male	*12.19	16.67	30.78	*22.87
Female				
Underrepresented minority	*13.83	18.49	*24.91	*26.73
Asian and white	*8.93	16.61	*31.46	*30.77
Male				
Underrepresented minority	*15.41	*20.08	*25.14	21.45
Asian and white	*11.18	*15.59	*32.56	23.32
	12th-graders (1992)			
Underrepresented minority	6.58	15.33	33.87	32.59
Asian and white	5.33	13.90	36.27	32.58
Female	*4.25	14.54	35.25	*35.46
Male	*6.99	13.90	36.24	*29.67
Female				
Underrepresented minority	4.76	15.30	*31.85	36.74
Asian and white	4.09	14.31	*36.28	35.07
Male				
Underrepresented minority	8.59	15.37	36.11	28.00
Asian and white	6.55	13.50	36.27	30.12

* $p<0.05$

[1] The categories were slightly different in the first and second follow-up questionnaires. "Will graduate from high school, but won't go any further" became "high school graduation only" on the first and second follow-up questionnaires. "Will attend college" became "Less than 2 years of college" and "Two or more years of college (including 2-year degree)" on subsequent questionnaires. "Will graduate from college" became "Will finish college (4- or 5-year degree)." Finally, "Will attend a higher level of school after graduating from college" also divided into two categories: "Master's degree or equivalent" and "Ph.D., M.D., or other professional degree."

NOTE: Rows do not add to 100 percent because the categories "less than high school" and "will go to vocational, trade or business school after high school" are not included.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 "Base Year" through "Second Follow-Up" data, weighted by the panel weight F2PNLWT. Unweighted sample size for the base year variable was 16,359, for the first follow-up variable 16,299, and for the second follow-up variable 13,698 (with 17 percent missing cases in the panel sample for the second follow-up). Additionally, there are nine missing cases on the variable of race (F2RACE1) from base year through the second follow-up.

Eighth-grade ***students' aspirations for technical and science or engineering occupations*** are shown in table 10, a reprint from a released NCES report. The racial/ethnic difference among students aspiring to a technical profession such as draftsman, medical or dental technician, or computer programmer, or to be a scientist or engineer, existed but was not very strong. However, the gender difference was obvious: boys had double the percentage of girls aspiring for careers in technical, scientific, and engineering occupations.

Table 10.—Career aspirations: Percentage of eighth-graders (1988 cohort in 1988) aspiring to technical and science or engineering occupations, by race/ethnicity and gender (standard errors in parentheses)

	Technical %	Science or Engineering %
White	5.7 (0.205)	6.1 (0.219)
Asian and Pacific Islander	7.6 (0.797)	9.7 (1.004)
African-American	8.0 (0.549)	4.2 (0.427)
Hispanic	7.3 (0.468)	4.8 (0.521)
American Indian/Native Alaskan	6.5 (1.782)	6.4 (1.796)
Female	4.2 (0.201)	3.3 (0.181)
Male	8.3 (0.286)	8.5 (0.308)

SOURCE: Reprint from the Hafner, Ingels, Schneider, Stevenson, and Owings (1990), *National Education Longitudinal Study of 1988 (NELS:88) A Profile of the American Eighth-Grader* (NCES 90–458), pp. 70, E–31.

Program Participation and Coursework

This section describes the types of programs students were in, the nature of the math and science courses they took, and their participation in math and science enrichment activities.

Students were asked to report on their ***academic program placement*** in the 8th, 10th, and 12th grades (see table 11). Consistently, fewer underrepresented minority students than other students reported being placed in such favorable programs as high ability programs, college preparation programs, and advanced placement programs. The exception to this was with the gifted and talented program, where no statistically significant difference was observed. The gender gap existed at the 8th-grade level, when girls were less likely to be in high ability math or science programs, but did not exist in 10th or 12th grade, when girls were more likely to be in college preparation programs. The results in the three-way crosstabulation reinforced these findings. Note that the data presented here are from students' self-reports, which may differ to some extent from their actual program participation (see table 12).

Table 11.—Program placement (student self-report): Percentage of 8th-, 10th-, and 12th-graders (1988 cohort in 1988, 1990, and 1992) who reported being in high ability groups, college preparatory programs, advanced placement courses, and gifted/talented programs, by race/ethnicity and gender

	8th-graders (1988)		10th-graders (1990)		12th-graders (1992)		
	High ability group for math %	High ability group for science %	In college prep. program[1] %	Ever been in advanced placement %	In college prep. program[1] %	Ever been in advanced placement %	Ever been in gifted/ talented program %
Underrepresented minority	*25.32	*19.99	*24.80	26.97	*32.47	34.81	19.57
Asian and white	*32.37	*23.83	*35.21	27.80	*45.89	37.25	18.92
Female	*29.40	*20.87	*33.85	28.03	*44.42	37.50	18.27
Male	*31.93	*24.94	*31.48	27.18	*41.22	35.90	19.86
Female							
Underrepresented minority	*23.26	*19.23	*26.55	27.83	*33.78	35.81	18.47
Asian and white	*31.47	*21.42	*36.29	28.09	*47.72	38.01	18.21
Male							
Underrepresented minority	*27.56	*20.82	*22.98	26.06	*31.11	33.74	20.75
Asian and white	*33.25	*26.18	*34.15	27.51	*44.14	36.50	19.61

* $p<0.05$

[1] The exact wording on the questionnaires is "college prep, academic, or specialized academic (such as Science or Math)."

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "Base Year" through "Second Follow-Up" panel data, weighted by F2PNLWT. Unweighted sample sizes for base year variables are 16,052 and 15,935, for first follow-up data 16,142 and 15,390, and for second follow-up data 14,854, 14,456, and 14,410.

Transcript data provides another look at ***program placement*** differences by race/ethnicity and gender (see table 12). Students were designated as following a rigorous academic track if they had four credits in English, three credits in social studies, three credits in science, three credits in mathematics, a half credit in computer science programming/data programming, and two credits in a foreign language. (One credit is equivalent to completion of a 1-year academic course taken one period a day, 5 days a week; see Ingels, Dowd, Taylor, Bartot, Frankel, Pulliam, and Quinn 1995, 44.)

According to student transcripts, lower rates of underrepresented minority students were placed in gifted/talented programs and followed a rigorous academic track compared with other students. However, girls were more likely to have been enrolled in gifted/talented programs and followed a rigorous academic track than were boys. This is slightly different than the picture provided in table 11 when no statistically significant differences were found between the percentages of girls reporting to have been in advanced placement classes or in a gifted/talented program. The three-way crosstabulation again supported the basic patterns described here.

Table 12.—Program placement (transcript data): Percentage of 12th-graders (1988 cohort in 1992) who participated in a gifted/talented program or in an academic program, according to their transcript data, by race/ethnicity and gender

	Gifted/talented program[1]	Rigorous academic track[2]
	%	%
Underrepresented minority	*6.00	*13.38
Asian and white	*8.98	*18.91
Female	*9.10	*19.12
Male	*7.57	*16.27
Female		
Underrepresented minority	*6.49	*15.62
Asian and white	*9.87	*20.18
Male		
Underrepresented minority	5.52	*11.12
Asian and white	8.14	*17.71

* p<0.05

[1] The original data item (F2RSPFLG) was recoded to combine participation in "gifted education" and "bilingual education and gifted education" programs into a category in contrast to other programs.

[2] The original data item (F2RTRPRG) was recoded to combine students in "rigorous academic track" and "vocational and rigorous academic track" into a category in contrast to students in other programs.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "Second Follow-Up" transcript data, weighted by F2PNLWT. Unweighted sample size was 14,050, with 2,430 missing cases, on the variable of gifted programs (F2RSPFLG). Unweighted sample size was 14,276, with 2,204 missing cases, on the variable of academic programs (F2RTRPRG).

When the responses of eighth-graders asked about the ***math and science courses*** in which they were enrolled are examined, they suggest the disadvantages facing underrepresented minorities (see tables 13 and 14). In comparing African-American, Hispanic, and American Indian/Native Alaskan with Asian and white students, the former groups were less likely to be enrolled in advanced math and algebra but more likely to take remedial math (see table 13). Further, relative to Asians, underrepresented minorities seemed less likely to take science classes with laboratory work, an important feature enhancing learning and interest in science (see table 14). No substantial gender gap was found in these measures.

Table 13.—Math coursework: Percentage of eighth-graders (1988 cohort in 1988) who reported being enrolled in various math courses or combinations of math courses, by race/ethnicity and gender (standard errors in parentheses)

	Advanced math/Algebra[1] %	Regular math %	Remedial math[2] %	No math %
White	33.9 (0.786)	58.5 (0.744)	4.4 (0.207)	2.0 (0.130)
Asian and Pacific Islander	46.1 (1.957)	41.7 (1.800)	5.5 (0.804)	4.4 (0.676)
African-American	26.3 (1.208)	60.5 (1.316)	7.3 (0.568)	3.2 (0.398)
Hispanic	24.4 (1.255)	61.6 (1.224)	7.8 (0.722)	3.8 (0.429)
American Indian and Native Alaskan	26.3 (2.348)	57.2 (2.820)	8.4 (2.096)	4.4 (1.118)
Female	32.7 (0.740)	59.5 (0.732)	4.3 (0.229)	2.3 (0.156)
Male	31.8 (0.719)	57.3 (0.687)	6.2 (0.268)	2.7 (0.176)

NOTE: Percents do not add to 100 percent because 2 percent of students gave questionable responses and were excluded from the table (e.g., reported taking both algebra and remedial math). There were differential response rates across categories, especially for racial/ethnic groups.

[1] Includes prealgebra, advanced or honors classes, algebra, and those reporting algebra and a regular math course.

[2] Includes students who reported being in "remedial math" and in both "remedial math" and "regular math" courses.

SOURCE: Reprint from the Hafner, Ingels, Schneider, Stevenson, and Owings (1990), *National Education Longitudinal Study of 1988 (NELS:88) A Profile of the American Eighth-Grader* (NCES 90–458), pp. 36, E–14.

Table 14.—Science coursework: Percentage of eighth-graders (1988 cohort in 1988) who reported being enrolled in science courses with laboratory, science courses without laboratory, or no science courses, by race/ethnicity and gender (standard errors in parentheses)

	Science course with laboratory %	Science course without laboratory %	No science %
White	21.9 (0.782)	74.8 (0.789)	3.2 (0.251)
Asian and Pacific Islander	25.1 (1.698)	65.7 (2.262)	9.3 (2.391)
African-American	19.5 (1.230)	74.4 (1.556)	6.0 (1.209)
Hispanic	19.2 (1.254)	72.5 (1.590)	8.3 (1.033)
American Indian and Native Alaskan	21.2 (2.863)	73.4 (2.262)	5.3 (1.294)
Female	20.9 (0.743)	74.9 (0.784)	4.3 (0.376)
Male	22.1 (0.735)	73.4 (0.777)	4.5 (0.342)

NOTE: Owing to rounding, rows may not sum to 100 percent.
SOURCE: Reprint from the Hafner, Ingels, Schneider, Stevenson, and Owings (1990), *National Education Longitudinal Study of 1988 (NELS:88) A Profile of the American Eighth-Grader* (NCES 90–458), pp. 38, E–15.

Transcript data demonstrates that race/ethnicity marked a salient difference in the ***nature of students' math and science coursework*** (see table 15). Consistently across all course categories in math and science—except algebra I and computer science, where no significant differences were found—underrepresented minorities on average took fewer courses. The gender gap in coursework, however, somewhat favored girls. In algebra II, geometry, biology, chemistry, and computer science, girls on average completed more units than boys. Boys completed only more physics classes than girls. On many categories, there was no gender difference. The comparison of means by gender and race/ethnicity supported these identified patterns.

Table 15.—Math and science coursework: Mean of course units[1] taken by students by race/ethnicity and gender; student transcript data

	Underrepresented minority (mean)	Asian/ White (mean)	Female (mean)	Male (mean)
Total units in mathematics	*2.63	*3.30	2.91	2.88
Units in algebra I	0.99	0.91	0.93	0.91
Units in algebra II	*0.35	*0.59	*0.50	*0.46
Units in geometry	*0.55	*0.75	*0.65	*0.62
Units in trigonometry	*0.08	*0.22	0.14	0.14
Units in precalculus	*0.08	*0.25	0.12	0.13
Units in calculus	*0.04	*0.22	0.09	0.09
Total units in science	*2.22	*3.07	2.68	2.64
Units in earth science	*0.12	*0.19	0.20	0.19
Units in biology	*0.98	*1.17	*1.13	*1.03
Units in chemistry	*0.35	*0.74	*0.54	*0.50
Units in physics	*0.13	*0.42	*0.20	*0.26
Units in computer science	0.56	0.57	*0.52	*0.47

	Male		Female	
	Underrepresented minority (mean)	Asian/ White (mean)	Underrepresented minority (mean)	Asian/ White (mean)
Total units in mathematics	*2.65	*3.27	*2.62	*3.33
Units in algebra I	0.95	0.86	1.04	0.98
Units in algebra II	*0.36	*0.60	*0.35	*0.59
Units in geometry	*0.56	*0.71	*0.53	*0.80
Units in trigonometry	*0.08	*0.23	*0.09	*0.21
Units in precalculus	*0.09	*0.24	*0.07	*0.26
Units in calculus	*0.05	*0.23	*0.03	*0.21
Total units in science	*2.22	*3.05	*2.21	*3.09
Units in earth science	0.13	0.19	0.12	0.19
Units in biology	*0.96	*1.14	*1.01	*1.20
Units in chemistry	*0.35	*0.71	*0.35	*0.78
Units in physics	*0.16	*0.47	*0.10	*0.37
Units in computer science	0.50	0.62	0.61	0.51

*p<0.05

[1]Course units are presented in NAEP equivalent units, compatible with data collected in the National Assessment of Education Program (NAEP). That is to say, one unit is equivalent to completion of a 1-year academic course taken one period a day, 5 days a week.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) transcripts study data, unweighted estimates. Unweighted sample size was 14,276.

The final issue to be examined under program participation and coursework is ***participation in math and science enrichment activities*** (see table 16). In the eighth grade, more underrepresented minority students than Asian and white students reported participating in one or more math and science related activities (37.59 percent and 33.16 percent, respectively). The difference was not statistically significant, however, in the 10^{th} grade. Girls were less likely than boys to participate in such activities in both the 8^{th} and 10^{th} grades. The three-way crosstabulation did not identify any significant estimates.

Table 16.—Math and science enrichment activities: Percentage of 8^{th}-and 10^{th}-graders (1988 cohort in 1988 and 1990) who participated, by race/ethnicity and gender

	Participated in one or more math- and science-related activities	
	8^{th}-graders (1988)[1] %	10^{th}-graders (1990)[2] %
Underrepresented minority	*37.59	12.37
Asian and white	*33.16	10.09
Female	*33.03	*9.26
Male	*35.40	*12.03
Female		
Underrepresented minority	36.49	10.52
Asian and white	31.89	8.86
Male		
Underrepresented minority	38.88	14.34
Asian and white	34.43	11.34

* $p<0.05$

[1] This indicator was derived by combining four base year items (BYS82A, BYS82I, BYS82J, and BYS82S) to cover participation in one or more activities including science fairs, science clubs, math clubs, and computer clubs.

[2] This indicator was a first follow-up item (F1S8D) that asked about participation in a science or math fair.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) “Base Year” through “First Follow-Up” panel data, weighted by F2PNLWT. Unweighted sample sizes were 15,311 for the base year data and 14,390 for the first follow-up data.

Attitudes and Learning Strategies

In attempting to describe students' attitudes and learning strategies vis-à-vis math and science, we examined questionnaire items that asked why students were taking math and science courses, whether they did their math and science homework, how many engaged in certain learning strategies, and how self-confident they were in their level of math and science learning.

The three indicators chosen to describe ***personal interest in math and science learning*** across grade levels are **not** directly comparable because they are based on questionnaire items that were worded differently and represented different, albeit related, concepts (see table 17). However, the results are still indicative. Underrepresented minority students seemed to be more likely to express a desire to learn math and science at an earlier grade level. At eighth grade, they had high rates saying that they looked forward to math and science classes, relative to Asian and white students. But among 10^{th}-graders who were actually taking math and science courses, relatively low rates of underrepresented minority students compared with other students said they did so because they themselves wanted to, rather than being required or advised to do so by the school or significant others. The pattern in 12^{th} grade was similar to that in 10^{th} grade. This difference seems related to the crucial difference in so-called "internal motivation" across racial/ethnic groups. When asked in generic terms about interest in the subjects, underrepresented minority students expressed equal or higher interest relative to other students, but when explaining the decisionmaking for studying the subjects, minority students were less likely than other students to assert personal interest in the subjects.

The gender difference in their interest measures is obvious. Fewer girls than boys, consistently across the indicators and grade levels, expressed personal interest in math and science learning. A three-way comparison generated estimates compatible with the above findings.

Table 17.—Interest in math and science learning: Percentage of 8th-, 10th-, and 12th-graders (1988 cohort in 1988, 1990, and 1992) who expressed positive attitudes relating to math and science, by race/ethnicity and gender

	Look forward to…class 8th-graders (1988) %	Took…because wanted to 10th-graders (1990) %	Took…because of interest 12th-graders (1992) %
		Interest in math[1]	
Underrepresented minority	*67.71	*23.18	50.22
Asian and white	*52.96	*31.02	46.75
Female	*54.76	*27.06	*44.16
Male	*58.25	*31.26	*50.57
Female			
Underrepresented minority	*65.63	*20.94	45.57
Asian and white	*51.12	*29.02	43.70
Male			
Underrepresented minority	*70.05	*25.52	54.95
Asian and white	*54.77	*32.98	49.36
		Interest in science[2]	
Underrepresented minority	*66.50	*21.62	*42.26
Asian and white	*60.13	*29.37	*51.94
Female	*58.22	*24.15	*47.65
Male	*65.14	*30.89	*52.06
Female			
Underrepresented minority	*65.27	*17.84	*42.22
Asian and white	*55.85	*26.17	*49.11
Male			
Underrepresented minority	67.87	*25.56	*42.30
Asian and white	64.33	*32.49	*54.37

* p<0.05

[1] These variables were derived from three items in the base year through second follow-up data (BYS69A, F1S21A, and F2S22CA). For BYS69A, students who responded with “strongly agree” or “agree” to the statement “usually look forward to math class” were separated from students who responded otherwise. For F1S21A, students who responded “I wanted to take math” to the question “main reason you take math” were separated from others who responded with such reasons as “it was required,” “parents requested,” “teacher recommended,” and “school assigned.” For F2S22CA, students who indicated interest as the important or very important reason to take math (by marking 3 or 4 from a scale ranging from 0 to 4) were separated from students who indicated otherwise. Due to different questionnaire items used, the estimates may not be comparable across grade levels.

[2] Variables were derived from three items from the base year through second follow-up data (BYS72A, F1S21B, and F2S18CA), using the approach described above.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) “Base Year” through “Second Follow-Up” panel data, weighted by F2PNLWT. Unweighted sample size varies across runs of crosstabulations due to missing cases on race and motivation items. Additionally, 7,718 and 6,064 cases were legitimate skips related to science and math, respectively, in the second follow-up because these questions were asked only of respondents who were taking math or science at the time of survey. The sample size of the science variable is 6,504 with 23 percent missing cases (not involving the legitimate skips) and the sample size of the math variable is 7,974 with 24 percent missing cases (not involving the legitimate skips).

Student efforts in learning math and science are indicated by whether they did their math and science homework (see table 18). The racial/ethnic difference was not observed regarding doing math homework. In science, the difference was only observed in the 10th grade; fewer underrepresented minority students than other students had done homework.

The gender difference in homework efforts favored girls. In both math and science, proportionately more girls than boys reported doing homework in the 8th, 10th, and 12th grades. The three-way crosstabulation revealed a racial difference among girls, where consistently lower rates of underrepresented minority students did math homework across grades, but not among boys.

Table 18.—Math and science learning efforts: Percentage of 8th-, 10th-, and 12th-graders (1988 cohort in 1988, 1990, and 1992) who do their math and science homework, by race/ethnicity and gender

	Do math homework[1]		
	8th-graders (1988) %	10th-graders (1990) %	12th-graders (1992) %
Underrepresented minority	89.51	71.06	79.21
Asian and white	91.56	73.21	81.01
Female	*92.99	*77.13	*83.96
Male	*89.14	*68.33	*77.59
Female			
Underrepresented minority	*90.43	*73.22	*79.87
Asian and white	*93.83	*78.27	*85.27
Male			
Underrepresented minority	88.49	68.82	78.55
Asian and white	89.34	68.19	77.32
	Do science homework[1]		
	8th-graders (1988) %	10th-graders (1990) %	12th-graders (1992) %
Underrepresented minority	82.25	*64.12	84.78
Asian and white	82.37	*68.80	83.29
Female	*84.24	*71.54	*86.42
Male	*80.42	*64.09	*81.10
Female			
Underrepresented minority	83.02	*68.12	86.30
Asian and white	84.65	*72.48	86.47
Male			
Underrepresented minority	81.40	*59.99	83.25
Asian and white	80.14	*65.17	80.43

*p<0.05

[1] The base year items (BYS79A and BYS79B) were dichotomized to indicate students who never do math and science homework versus students who do their math and science homework for periods ranging from less than 1 hour up to 10 hours a week. The first follow-up items (F1S36B1, F1S36B2, F1S36C1, and F1S36C2) were combined into two dichotomized variables distinguishing students who never do either math or science homework *in or out of* school from students who do math or science homework *either in or out of school* for periods ranging from less than 1 hour up to 10 hours a week. This same approach was taken with four items from the second follow-up (F2S25A1, F2S25A2, F2S25B1, and F2S25B2).

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) “Base Year” through “Second Follow-Up” panel data, weighted by F2PNLWT. Unweighted panel sample size varies across the runs of crosstabulations due to missing cases on race and ethnicity for each variable. Additionally, 1,799 and 1,282 legitimate skips occurred on the items relating to science and math, respectively, in the second follow-up because those questions were asked only of respondents who were taking math or science courses at the time of the survey or who had taken them in the recent term.

To describe 10th- and 12th-graders' ***math and science learning strategies*** we constructed measures from multiple data items to indicate the intensity with which students engaged in certain learning strategies (e.g., reviewing the previous day's work, choosing study topics, making notes of teachers' lectures). In the 10th grade, underrepresented minority students on average engaged in strategies for learning science more intensively than did Asian and white students (with mean scores of 2.41 and 2.36, respectively; the range is 0 to 4.9, with 0 meaning students did not engage in any of these learning strategies). Also in the 10th grade, girls on average engaged more intensively in learning math than boys. By the 12th grade, these differences were not found. A three-way comparison seems to imply that the racial difference found in 10th grade science learning was only evident among girls, as the difference between underrepresented minority girls and Asian and white girls was the only estimate which proved to be statistically significant.

Table 19.—Math and science learning strategies: Mean scores of 10th- and 12th-graders (1988 cohort in 1990 and 1992) who engaged in strategies in math and science learning[1], by race/ethnicity and gender

	10th-graders (1990)	
	Engagement in strategies for math learning	Engagement in strategies for science learning
Underrepresented minority	1.65	*2.41
Asian and white	1.63	*2.36
Female	*1.66	2.37
Male	*1.61	2.37
Female		
Underrepresented minority	1.68	*2.43
Asian and white	1.66	*2.35
Male		
Underrepresented minority	1.62	2.39
Asian and white	1.61	2.37
	12th-graders (1992)	
	Engagement in strategies for math learning	Engagement in strategies for science learning
Underrepresented minority	3.34	2.99
Asian and white	3.09	2.87
Female	3.07	2.93
Male	3.23	2.87
Female		
Underrepresented minority	3.31	3.12
Asian and white	2.99	2.87
Male		
Underrepresented minority	3.37	2.85
Asian and white	3.19	2.87

* $p<0.05$

[1] A set of raw data items was used to construct each of the four composite measures of engagement. These items are ordinal measures of the intensity with which students engage in certain learning strategies (e.g., review work on the subject from the previous day, make choice of topics to study, make notes of teacher's instruction, etc.). The coding is consistent across subjects and grade levels, reflecting the degree in which each strategy was used, ranging from rarely, once a month, or once a week, to everyday. For science learning in 10th grade, the non-missing values of F1S29A through F1S29N were summed up and then divided by the total non-missing counts on these items (missing cases, including multiple response, refusal, and nonresponse, were coded zero). In the same way, F1S32A through F1S32N were used to construct the measure for 10th-grade math learning; F2S15BA through F2S15BL for 12th-grade science learning; and F2S19BA through F2S19BL for 12th-grade math learning. The range is 0 to 4.9, with 0 indicating students did not engage in any of these learning strategies.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "First Follow-up" through "Second Follow-Up" panel data, unweighted estimates. Unweighted sample sizes were 15,185, 15,620, 13,178, and 13,692, respectively, for estimates of the engagement in science and math learning at the 10th and 12th grades.

Self-confidence in math and science learning was measured by looking at who reported getting mostly A's in math and science in 8th grade and who claimed to "always do well in math" in 10th grade (see table 20). Underrepresented minorities were less likely than other students to claim high performance in the two subjects in the 8th grade, but the difference was not statistically significant as measured by self-claiming "always do well in math" in the 10th grade. The gender difference was the opposite: in the 8th grade, girls were more likely to report having mostly A's in math, but fewer reported "always do well in math" in 10th grade. The three-way comparison generated consistent results with no evidence of interaction effect between gender and race/ethnicity.

Table 20.—Self-confidence in math and science learning: Percentage of 8th- and 10th-graders (1988 cohort in 1988 and 1990) who self-reported having mostly A's and always doing well in the subjects, by race/ethnicity and gender

	8th-graders (1988)		10th-graders (1990)
	Mostly A's in math %	Mostly A's in science %	Always do well in math[1] %
Underrepresented minority	*28.22	*22.52	44.33
Asian and white	*35.33	*32.34	45.48
Female	*35.72	30.67	*41.48
Male	*31.47	29.25	*48.96
Female			
Underrepresented minority	*29.79	*22.99	41.03
Asian and white	*37.73	*33.26	41.62
Male			
Underrepresented minority	*26.54	*22.02	47.84
Asian and white	*32.99	*31.44	49.28

*p<0.05

[1] This variable has six categories labeled "false," "mostly false," "more false than true," "more true than false," "mostly true," and "true." It was recoded to combine students who responded with "mostly true" and "true" to calculate the percentage as presented.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "Base Year" and "Second Follow-Up" student data, weighted by the panel weight (F2PNLWT). Unweighted sample sizes for the base year variables were 16,084 and 16,076 and for the first follow-up variable 14,931.

Math and Science Performance

NELS:88 students took math and science tests in grades 8, 10, and 12. The group rates of students who achieved different proficiency levels[4] in math and science are presented in tables 21 through 26 while table 27 presents data on science learning growth between 8th and 12th grades. The tables show substantial math and science achievement gaps relating to race/ethnicity and gender. Relative to Asian and white students, there were higher rates of underrepresented minority students among the students at low proficiency levels and lower rates of underrepresented minority students among those at the high proficiency levels in both math and science. This pattern is evident with the panel data across the three grades. At eighth grade, 28 percent of underrepresented minority students were below level 1—the lowest level—in math proficiency, in contrast to 15 percent of Asian and white students being at this level (see table 21). Moreover, only 7 percent of minority students reached the highest level (level 3), about one quarter of the rate of Asian and white students (23.41 percent). A similar difference was observed in eighth-grade science (see table 22). The rate of underrepresented minority students below level 1 almost doubled the rate of Asian and white students (45.69 percent and 23.78 percent, respectively); whereas at the higher level of proficiency (level 2), the rate of underrepresented minority students was less than a half of that of Asian and white students (12.31 percent and 29.07 percent, respectively).

Gender gaps in math and science performance appear as well in tables 21 and 22, with girls achieving at lower rates than boys in the two subjects. In eighth-grade math (table 21), girls were slightly less likely than boys to reach high proficiency (18.05 percent and 20.64 percent at level 3, respectively); on the other hand, a smaller portion of girls than boys fell below level 1 (16.08

[4] NELS:88 students were asked to take a series of exams to test their achievement in math and science. The skill levels reported for grades 8, 10, and 12 are shown below (Green, Dugoni, Ingels, Camburn, and Quinn 1995, 51 and 53; Ingels, Schneider, Scott, Plank, and Wu 1995, 26).

8th	10th	12th	
			Math skill levels
✔	✔	✔	Level 1: Simple arithmetical operations on whole numbers
✔	✔	✔	Level 2: Simple operations with decimals, fractions, and roots
✔	✔	✔	Level 3: Simple problemsolving requiring conceptual understanding or the development of a solution strategy
	✔	✔	Level 4: Conceptual understanding and complex problemsolving
		✔	Level 5: Proficiency in solving complex multistep word problems and/or the ability to demonstrate knowledge of mathematics material found in advanced mathematics courses
			Science skill levels
✔	✔	✔	Level 1: Understanding of everyday science concepts; “common knowledge” that can be acquired in everyday life
✔	✔	✔	Level 2: Understanding of fundamental science concepts upon which more complex science knowledge can be built
	✔	✔	Level 3: Understanding of relatively complex scientific concepts; typically requiring an additional problemsolving step

percent and 20.12 percent, respectively). This comparison implies that girls seemed to concentrate in the middle levels of math performance; a pattern distinctive from the racial/ethnic gap that was characterized by minorities' low rates of high achievers and high rates of low achievers. In eighth-grade science (see table 22), however, the gender gap resembled the racial/ethnic gap: proportionally, more girls than boys falling below level 1 (32.02 percent and 25.92 percent, respectively); whereas fewer girls than boys were studying at level 2 (22.07 percent and 27.45 percent, respectively). Three-way crosstabulation with both gender and race/ethnicity generated results consistent with the above interpretation.

The racial/ethnic gap in math and science performance remained striking—if not increasing—across grades 10 and 12 (see tables 23–26). Consistently, in comparison with Asian and white students, underrepresented minority students had high rates in the low proficiency levels and low rates in the high proficiency levels in the two subjects at the two grades. Three-way crosstabulation with both gender and race/ethnicity generated consistent results, with no interaction effect.

Tables 23 through 26 also showed that girls continued to perform poorly relative to boys in high school math and science. At 10th grade (see tables 23 and 24), proportionally fewer girls than boys achieved highest proficiency in math (at level 4, 19.22 percent and 23.74 percent, respectively) and science (at level 3, 11.10 percent and 16.63 percent, respectively). At 12th grade (see tables 25 and 26), a similar pattern was clear: in both subjects, girls had lower rates in the highest performance levels than did boys. There was, however, a notable difference by subjects. In math, girls were not more likely than boys to be in the *lowest* proficiency level, a pattern consistently found at the three grades. As noted earlier, this finding suggests that girls' lower achievement in math was more attributable to their concentration in middle performance levels than to their falling below the lowest level. In science, however, the gender gap was similar to the race/ethnicity gap in that both girls and minorities not only were less likely to achieve the highest level, but also were more likely to fall in the lowest level. Again, three-way crosstabulation found supportive patterns of the racial/ethnic and gender differences. No interaction effect was revealed.

Data on science learning growth between 8th and 12th grade are presented in table 27. They suggest wide gaps between underrepresented minorities and white and Asian students in the rates of science proficiency increase. Fifty-six percent of white and 62 percent of Asian students had increased their proficiency level; whereas among African-Americans, Hispanics, and American Indian/Native Alaskan students, the rates were below 50 percent, ranging from 39 to 49 percent. The data also indicate a gender gap in learning progress. Girls were less likely than boys to increase their science proficiency (51 percent and 56 percent, respectively).

Table 21.—Math performance: Percentage of eighth-graders (1988 cohort in 1988) at different levels of proficiency, by race/ethnicity and gender

	Below Level 1 %	Level 1 %	Level 2 %	Level 3 %
Underrepresented minority	*27.51	*48.67	*17.31	*6.51
Asian and white	*15.06	*37.28	*24.23	*23.43
Female	*16.06	*43.34	22.55	*18.05
Male	*20.12	*36.69	22.56	*20.64
Female				
Underrepresented minority	*25.40	*50.80	*17.96	*5.84
Asian and white	*12.86	*40.78	*24.13	*22.24
Male				
Underrepresented minority	*29.91	*46.26	*16.57	*7.27
Asian and white	*17.21	*33.85	*24.33	*24.60

* $p<0.05$
NOTE: Owing to rounding, rows may not sum to 100 percent.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), "Base Year" through "Second Follow-Up" panel data. The total sample size used in the analysis is 16,489. The unweighted sample contains 1,730 missing cases on the proficiency score (approximately 10.5 percent of the sample).

Table 22.—Science performance: Percentage of eighth-graders (1988 cohort in 1988) at different levels of proficiency, by race/ethnicity and gender

	Below Level 1 %	Level 1 %	Level 2 %
Underrepresented minority	*45.69	*42.00	*12.31
Asian and white	*23.78	*47.15	*29.07
Female	*32.02	45.23	*22.74
Male	*25.92	46.63	*27.45
Female			
Underrepresented minority	*49.48	*38.60	*11.91
Asian and white	*26.21	*47.44	*26.35
Male			
Underrepresented minority	*41.50	45.76	*12.74
Asian and white	*21.47	46.88	*31.65

* $p<0.05$
NOTE: Owing to rounding, rows may not sum to 100 percent.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), "Base Year" through "Second Follow-Up" panel data. The total sample size in the analysis is 16,489. The unweighted sample contains 1,756 missing cases on the proficiency score (approximately 10.7 percent of the sample).

Table 23.—Math performance: Percentage of 10th-graders (1988 cohort in 1990) at different levels of proficiency, by race/ethnicity and gender

	Below Level 1 %	Level 1 %	Level 2 %	Level 3 %	Level 4 %
Underrepresented minority	*18.82	*43.06	15.96	*14.80	*7.36
Asian and white	*9.75	*23.17	13.97	*27.15	*25.96
Female	11.29	*29.62	14.51	*25.36	*19.22
Male	12.53	*26.30	14.39	*23.04	*23.74
Female					
Underrepresented minority	*18.62	*45.00	14.91	*15.11	*6.35
Asian and white	*8.89	*24.95	14.38	*28.72	*23.43
Male					
Underrepresented minority	*19.02	*41.06	*17.04	*14.47	*8.42
Asian and white	*10.56	*21.81	*13.58	*25.65	*28.40

* $p<0.05$
NOTE: Owing to rounding, rows may not sum to 100 percent.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), “Base Year” through “Second Follow-Up” panel data. The total sample size in the analysis is 16,489. The unweighted sample contains 2,909 missing cases on the proficiency score (approximately 17.7 percent of the sample).

Table 24.—Science performance: Percentage of 10th-graders (1988 cohort in 1990) at different levels of proficiency, by race/ethnicity and gender

	Below Level 1 %	Level 1 %	Level 2 %	Level 3 %
Underrepresented minority	*37.07	*40.63	*17.71	*4.59
Asian and white	*16.60	*33.09	*33.60	*16.72
Female	*23.24	35.68	29.98	*11.10
Male	*19.49	34.01	29.87	*16.63
Female				
Underrepresented minority	*40.66	*39.03	*15.62	*4.69
Asian and white	*17.79	*34.63	*34.47	*13.11
Male				
Underrepresented minority	*33.37	*42.27	*19.87	*4.49
Asian and white	*15.48	*31.61	*32.76	*20.15

* $p<0.05$
NOTE: Owing to rounding, rows may not sum to 100 percent.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), “Base Year” through “Second Follow-Up” panel data. The total sample size in the analysis is 16,489. The unweighted sample contains 2,805 missing cases on the proficiency score (approximately 17 percent of the sample).

Table 25.—Math proficiency results: Percentage of 12th-graders (1988 cohort in 1992) at different levels of proficiency, by race/ethnicity and gender

	Below Level 1 %	Level 1 %	Level 2 %	Level 3 %	Level 4 or 5 %
Underrepresented minority	*10.88	*37.52	*19.46	*18.23	*13.92
Asian and white	*6.35	*18.74	*13.46	*24.71	*36.74
Female	7.11	*25.18	14.03	24.35	*29.33
Male	7.62	*20.89	15.56	22.20	*33.74
Female					
Underrepresented minority	*11.42	*40.51	*17.62	*17.94	*12.51
Asian and white	*5.79	*20.48	*12.94	*26.31	*34.49
Male					
Underrepresented minority	*10.32	*34.42	*21.36	*18.53	*15.37
Asian and white	*6.87	*17.12	*13.94	*23.22	*38.85

* $p<0.05$

NOTE: Owing to rounding, rows may not sum to 100 percent.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), “Base Year” through “Second Follow-Up” panel data. The total sample size in the analysis is 16,489. The unweighted sample contains 5,094 missing cases on the proficiency score (approximately 30.9 percent of the sample).

Table 26.—Science performance: Percentage of 12th-graders (1988 cohort in 1992) at different levels of proficiency, by race/ethnicity and gender

	Below Level 1 %	Level 1 %	Level 2 %	Level 3 %
Underrepresented minority	*31.82	*37.07	*23.39	*7.73
Asian and white	*13.49	*29.45	*32.34	*24.72
Female	*19.83	31.38	*31.97	*16.81
Male	*15.63	31.01	*28.71	*24.66
Female				
Underrepresented minority	*35.58	*36.57	*21.92	*5.93
Asian and white	*14.99	*29.79	*35.06	*20.16
Male				
Underrepresented minority	*28.04	*37.56	24.86	*9.54
Asian and white	*12.09	*29.14	29.81	*28.97

* $p<0.05$

NOTE: Owing to rounding, rows may not sum to 100 percent.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), “Base Year” through “Second Follow-Up” panel data. The total sample size in the analysis is 16,489. The unweighted sample contains 5,009 missing cases on the proficiency score (approximately 30.4 percent of the sample).

Table 27.—Science performance: Percentage of 1988 eighth-graders whose science proficiency level decreased, remained the same, or increased between 1988 and 1992, by race/ethnicity and gender (standard errors in parentheses)

	Decrease %	Same %	Increase %
White	10 (0.5)	34 (0.9)	56 (1.0)
Asian and Pacific Islander	8 (1.8)	30 (2.7)	62 (2.9)
African-American	18 (3.6)	42 (2.8)	39 (2.7)
Hispanic	11 (1.4)	41 (2.6)	49 (2.4)
American Indian/Native Alaskan	15 (6.3)	45 (6.7)	40 (6.2)
Female	11 (0.6)	38 (1.0)	51 (1.3)
Male	11 (0.9)	33 (1.2)	56 (1.3)

NOTE: Owing to rounding, rows may not sum to 100 percent. The racial/ethnic and gender differences in the rates of increased proficiency level are statistically significant at $p<0.05$ level.
SOURCE: Reprint from the Madigan (1997), *National Education Longitudinal Study of 1988 (NELS:88) Science Proficiency and Course Taking in High School* (NCES 97–838), pp. 4, 16.

School Programs

It is also important to look at the environment in which students are learning—their high schools. Do students have access to computer labs? Do the schools offer advanced placement or college-level math and science courses? What are the schools' math and science graduation requirements?

Underrepresented minority students attended schools with less ***access to computer labs*** than did other students (see table 28). Only 30 percent of underrepresented minority students attended schools that provided access to computer labs in contrast to 36 percent of Asian and white students. No gender difference emerged in this measure. The three-way crosstabulation found no interaction effects between race/ethnicity and gender.

Table 28.—School access to computer labs: Percentage of 10th-graders (1988 cohort in 1990) whose schools reported high rates (greater than 50 percent) of accessing computer labs, by race/ethnicity and gender

	10th-graders (1990) %
Underrepresented minority	*30.45
Asian and white	*35.83
Female	34.70
Male	34.71
Female	
Underrepresented minority	*31.44
Asian and white	*35.59
Male	
Underrepresented minority	29.40
Asian and white	36.07

* $p<0.05$

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "First Follow-Up" school survey data combined with panel data, weighted by F2PNLWT. Unweighted sample size was 13,091 with 21 percent missing cases in the panel sample.

School offerings of advanced placement (AP) or college-level math and science courses are shown below (see table 29). A significantly lower percentage of underrepresented minority students attended schools that offered AP or college-level 2nd year chemistry and 2nd year physics courses. Gender gaps were identified in one of the AP or college-level math courses examined, calculus, and in AP or college-level computer programming: the percentage of girls whose schools offered either of these courses was lower than that for boys. The three-way tabulation revealed significant estimates only for the two science courses. A lower percentage of underrepresented minority students, both boys and girls, attended schools which offered AP or college-level 2nd year chemistry or physics; however, the estimate was significant only among the boys for physics.

Table 29.—School offerings of advanced courses: Percentage of 10th-graders (1988 cohort in 1990) whose schools offered advanced placement or college-level math and science courses, by race/ethnicity and gender

	AP/College-level courses offered in…						
	Biology 2nd year %	Chemistry 2nd year %	Physics 2nd year %	Algebra 2nd year %	Trigonom-etry %	Calculus %	Computer programming %
Underrepresented minority	27.04	*21.77	*12.44	9.84	10.00	37.42	14.77
Asian and white	29.10	*27.59	*16.35	8.28	8.90	36.14	16.82
Female	28.26	25.95	15.35	8.17	8.85	*35.17	*15.40
Male	28.91	26.32	15.40	9.15	9.49	*37.64	*17.41
Male							
Underrepresented minority	26.67	*21.68	*12.39	9.28	9.91	38.96	15.54
Asian and white	29.62	*27.80	*16.36	9.12	9.36	37.31	17.88
Female							
Underrepresented minority	27.40	*21.85	12.48	10.38	10.08	35.99	14.05
Asian and white	28.56	*27.37	16.34	7.41	8.43	34.95	15.77

* $p<0.05$

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) “First Follow-Up” school survey data combined with BY–F2 student panel data, weighted by F2PNLWT. Unweighted sample sizes of the course offering variables were, respectively, 11,837 (28 percent missing cases), 12,243 (26 percent missing cases), 12,762 (23 percent missing cases), 11,368 (31 percent missing cases), 12,644 (23 percent missing cases), 12,551 (24 percent missing cases), and 13,017 (21 percent missing cases).

The final high school factor considered was ***schools’ graduation requirements for math and science credits***: 2 years or less versus 3 years or more (see table 30). There was no statistically significant difference in math requirements, but significant differences did emerge in graduation requirements for science. The schools attended by underrepresented minorities were less likely than the Asian and white students’ schools to require 3 or more years of science coursework.

Table 30.—School math and science graduation requirements: Percentage of 10th-graders (1988 cohort in 1990) who attended schools requiring "2 years or less" or "3 years or more" of math and science courses to graduate, by race/ethnicity and gender

	Graduation requirement for math		**Graduation requirement for science**	
	2 years or less (%)	3 years or more (%)	2 years or less (%)	3 years or more (%)
Underrepresented minority	59.91	40.09	*83.25	*16.75
Asian and white	62.07	37.93	*77.92	*22.08
Female	61.70	38.30	78.96	21.04
Male	61.44	38.56	79.36	20.64
Female				
Underrepresented minority	61.03	38.97	*84.80	*15.20
Asian and white	61.91	38.09	*77.12	*22.88
Male				
Underrepresented minority	58.72	41.28	81.60	18.40
Asian and white	62.23	37.77	78.71	21.29

* p<0.05

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "First Follow-Up" school survey data combined with BY–F2 student panel data, weighted by F2PNLWT. Unweighted sample sizes were 14,309 and 14,336.

Teachers

Table 31, reprinted from an NCES report, presents data on ***math and science teachers' specialized credentials*** at the eighth-grade level. Underrepresented minority students' eighth-grade teachers were less likely to have majored in math or math education than were teachers of eighth-grade Asian and white students.

Table 31.—Teachers' credentials: Percentage of public school eighth-graders (1988 cohort in 1988) whose math and science teachers majored or minored in math and science, by race/ethnicity (standard errors in parentheses)

	Major in Mathematics/ math education	Minor in mathematics/ math education	Major in science/ science education	Minor in science/ science education
White	45.7 (n.a.)	27.2 (1.981)	48.6 (2.594)	24.2 (2.094)
Asian and Pacific Islander	44.1 (3.742)	23.5 (3.029)	53.3 (3.477)	22.6 (n.a.)
African-American	40.0 (3.342)	26.6 (3.136)	48.9 (3.627)	19.6 (2.755)
Hispanic	33.3 (3.875)	28.5 (3.909)	46.6 (6.345)	20.5 (3.605)
American Indian/Native Alaskan	30.5 (6.075)	23.5 (5.613)	39.9 (9.805)	47.7 (12.015)

n.a. The statistic is not available from the original source.

SOURCE: Reprint from the Horn, Hafner, and Owings (1992), *National Education Longitudinal Study of 1988 (NELS:88) A Profile of American Eighth-Grade Mathematics and Science Instruction* (NCES 92–486), pp. 26–27, 87–88.

Findings

This descriptive analysis has demonstrated racial/ethnic and gender differences among the 1988 eighth-grader cohorts for understanding uneven postsecondary S&E enrollment across groups. The examination of school variables has identified different learning opportunities available to the groups and the examination of student behavior variables has identified distinct psychological attributes. The data suggest two types of inequality: underrepresented minority students were disadvantaged by *both* inferior learning opportunities and eroded psychological attributes; whereas girls suffered essentially from a psychological disadvantage.

Racial/ethnic differences were observed in a number of factors relevant to preparation for postsecondary S&E education. Relative to white and Asian students, underrepresented minorities were less likely to expect to *complete* college (i.e., earn a college degree), though they were no less likely to want to *attend* college. Fewer underrepresented minority students than other students expressed strong personal interest and self-confidence in studying math and science. Moreover, underrepresented minority students on average had a smaller chance of participating in favorable academic programs, such as high ability programs, college preparation programs, and advanced curricula in math and science. Further, underrepresented minority students' schools also seem more restrained than other schools in providing curricular and extracurricular programs, though no instructional difference was revealed across racial/ethnic groups. Facing such difficulties, underrepresented minority students performed poorly in math and science compared to white and Asian students.

Gender differences were found largely in the psychological respect only. Relative to boys, girls showed high aspiration for education attainment in general, and girls did not lag behind boys in terms of effort in math and science learning. However, proportionally fewer girls than boys expressed motivation or personal interest in learning subjects related to S&E.

In contrast to underrepresented minority students who were disadvantaged by limited resources and opportunity, girls did not seem to suffer tremendously from limited learning opportunities. No gender difference was found regarding math and science curricula, and girls were more likely than boys to be placed in gifted/talented programs. The rates for participating in science-related enrichment activities were lower for girls than boys, but the difference was hardly attributable to limited opportunities. No substantial gender difference was found in school program offering and classroom instruction. Unremarkably, however, given the identified psychological disadvantage, girls' achievement levels in math and science were lower than boys'.

Logistic Regression Analysis

The descriptive analysis revealed racial/ethnic and gender differences relevant to preparation for postsecondary S&E education. These predictor variables were then used in a logistic regression analysis to further examine the relationships between S&E program entry and these variables. The specific goal of the regression analysis was to understand which factors are predictive of the group difference in S&E program entry.

S&E Majors and Related Data Selection Problem

The outcome measure in this analysis was enrollment in postsecondary S&E among high school students surveyed in the NELS:88 base year through third follow-up surveys. College major selection normally takes place in the early years of postsecondary schooling, though it varies in timing for individuals and institutions. Some students may make the choice as early as the first years of college, many do in their junior year. Institutions may have different requirements regarding selecting a major. In community colleges, the decision is normally made during an early stage of entrance, while in liberal arts colleges the choice may be made much later. NELS:88 data on major selection were gathered in the second year in college. Arguably, the data should represent a substantial portion of the cohort members' *initial* S&E program entry, though by no means cover the full range of program enrollment, which may include delayed major selection or even program change and program termination.

As discussed earlier, the postsecondary academic fields used to define S&E programs are as follows: engineering; earth, atmosphere, and ocean sciences; mathematical or computer sciences; physical sciences; and biological and agricultural sciences. A related issue in defining S&E majors with NELS:88 data was whether to include into the analysis respondents who did not enter postsecondary education after high school. A number of prior studies on S&E entrance have compared college students who majored in S&E to their peers who majored in other fields, whereas cohort members who did not enter college were excluded from analyses (e.g., Ware and Lee 1988). Making such retrospective contrasts between S&E majors and other majors is analytically convenient because it avoids the confounding issues of college entrance. It seems an easier approach to isolating factors that are responsible for academic field selection because those who did not enter college were not considered in the analysis. Using this approach on a broad, national scale, however, does not allow one to address the racial/ethnic and gender gaps existing in the overall population. It leaves unanswered questions as to how certain groups in the total population are underrepresented in getting into the S&E pipeline as a result of their lesser likelihood of entering college or even graduating from high school. Therefore, as explained in the Sample Design section, this analysis included the respondents who did not go on to college after high school, including the high school dropouts.

Predictor Variables

The regression analysis uses the same basic categories of variables discussed earlier: family environment and support, student behavior, and school factors. The specific variables used include a number of the variables used in the descriptive analysis and some additional variables that were specified as predictor variables after data editing, variable rescaling, and alternative model specification and testing. The variables are listed below and discussed in the following paragraphs (see appendix II for their descriptive statistics).

Family environment and support
- Parents' educational attainment (completed college)
- Parents' expectations for their child to attain college education
- Family financial support for students' college education

Student behavior
- Students' motivation to learn science
- Gaining in science learning
- Aspiring for science and technology jobs
- Gifted/advanced program placement
- Self-confidence in math learning
- Total math and science credits
- Advanced math and science credits

School factors
- Teachers' major or minor in math or in science
- Schools' science coursework requirements (3 or more years of science)

The three aspects of ***family environment and support*** relevant to students' postsecondary education are all available from the parent file. Parents' educational attainment was derived from measures of the education level of the student's father and mother. We created a dummy variable, coding it 1 for students whose father or mother had completed college education and 0 for those whose parents had not completed college. Parents' expectations for their child to attain college education was coded 1 for students whose parent(s) expected them to attend college and 0 for the other panel members. Family financial support for students' college education was also indicated by a binary variable, with 1 for those students whose parents reported they would provide some form of financial support and 0 for the rest of the students, including those who did not respond to the question as they were presumably different from the first group regarding family financial support.
To indicate different aspects of ***student behavior,*** we created five dummy variables and two continuous variables, which are sums of credits taken.

Students' motivation to learn science is indicated by items asking respondents their reasons for taking science courses in 10^{th} and 12^{th} grades. Those who responded "because I am interested in" were considered self-motivated (in contrast to those who responded "required by graduation standards," "advised by teachers" or other significant persons, or "assigned by schools," etc.). The resulting binary variable was coded 1 for self-motivated students and 0 for the rest of the students, including students who did not respond (i.e., missing cases) as it is reasonable to consider those students to be distinct from the self-motivated group. Gaining in science learning was coded 1 for students whose science proficiency level increased between 8th and 12th grades and 0 for those who either remained at the same level or dropped a level. Aspiring for science and technology jobs was coded 1 for students who, at the eighth grade, reported aspiring for the two occupations and coded 0 for students who failed to report so. Gifted/advanced program placement was coded 1 for students who participated in either or both of the two programs at any time from 8th through 12th grades and 0 for the rest of the students. Self-confidence in math learning was coded 1 for the students who, at 10th grade, claimed they "always do well in math" and 0 for those who did not say so.

Total math and science credits is the sum of all the credits in the two subjects from high school transcript records. Advanced math and science credits is the sum of the credits in precalculus, calculus, and physics from high school transcript records.

Many ***school factors*** (that is, school policies and conditions) were examined to identify predictors that were conceptually important in accounting for majoring in S&E, but only two were selected for analysis: teachers' majoring or minoring in math or in science and schools' science coursework requirements. The other variables, which included measures of school minority concentration, free or reduced-price lunch rates, school enrollment size, school sector (private versus public), and rural-urban locations, were important in explaining academic achievement and educational attainment in general, but do not relate to postsecondary S&E entrance, probably because they are too generic for explaining such a personal decision as choice of major.

The two variables selected for analysis were recoded as dummy variables. Teachers' major or minor in math or in science, drawing from the first and second follow-up teacher surveys, was linked to student data by recoding 1 for students with math or science teachers who majored or minored in either of the subjects and 0 for the other students. This relaxed definition of in-subject teaching is intended to reflect the close intellectual relationship between the two subjects. The second school variable was derived from the second follow-up school files, distinguishing students whose schools required 3 or more years of science coursework to graduate (coded 1) from students whose schools required otherwise (coded 0).

Missing cases, unless otherwise noted, were excluded from the analysis. We ran test procedures to examine if this was reasonable. In these tests, for each variable containing missing cases that numbered more than one percent of the total sample, the missing values were coded -1 and estimated. Since none of the resulting estimates indicated that missing cases were statistically significantly different from non-missing cases in relating to the outcome variables, we excluded the missing cases on each variable in the equations. This is shown in the tables by the varying number of cases (n's) across equations. (The n is different for each equation because the number of missing cases excluded from the analysis was different for each equation.) We then performed an additional test to examine whether such varying sample sizes affected the model estimation: we estimated the models with the "fully completed" data (i.e., the data that excluded missing cases on all the variables). The results revealed no substantial difference from the estimates generated by the analysis with varying number of cases. Appendix III tabulates the differences between the used cases and missing cases in the final modeling.

Analytical Approach

In the descriptive analysis, a large number of variables conceptually relevant to entry into postsecondary S&E education were investigated to examine their psychometric properties and empirical relationships with this outcome. Logistic regression techniques were then used in the equations because of the binary coded outcome variable. A series of initial tests was run to explore alternative equations that could yield reasonably good fit with the data. Particular attention was given to systematic testing of two-way interaction effects in order to detect peculiar joint effects of two predictors on majoring in S&E. The tests included interactions between student variables, between school variables, between school and student variables, and between school and family variables. The results revealed only one interaction term that was substantial: the gender/race/ethnicity interaction. This was included in the final equations (discussed in detail in the next section).

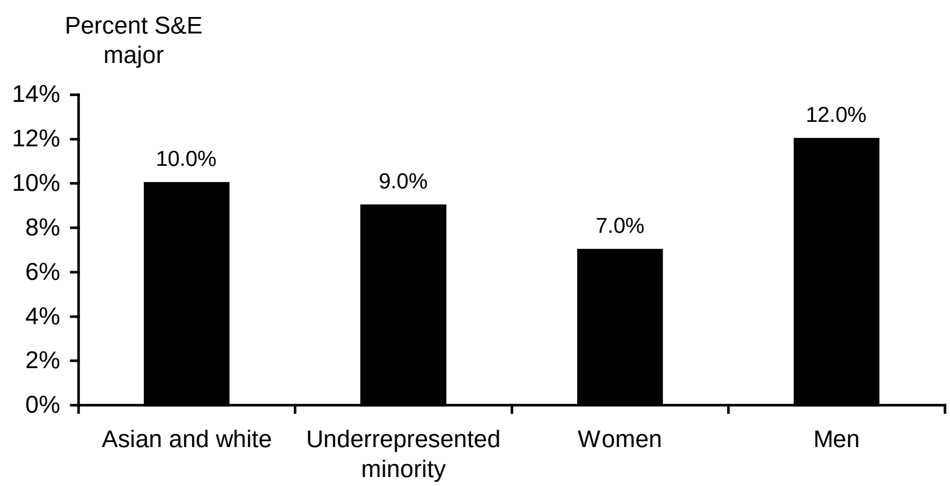
In the final analysis, a series of equations was specified to examine the racial/ethnic and gender gaps. The first equation simply demonstrates the existing racial/ethnic and gender gaps in S&E entrance. Subsequently family, behavior, and school predictors were entered into the equations to estimate how the two gaps might narrow or even disappear. While not strictly statistical, the rationale was that if a gap narrowed after controlling for the effects of factors that are *theoretically* responsible for the outcome, then the hypothesized role of these factors in reducing the gap could be supported by the data. Implications could be drawn for managing such factors in policymaking and program development.

Findings

The overall racial/ethnic and gender gaps in S&E entrance are shown in figure 2. The racial gap is very small, with rates of 10 percent for Asian and white students and 9 percent for underrepresented minorities, and the difference is not statistically significant at the $p < 0.05$ level. The overall gender gap is wide, with rates of 12 percent for men and 7 percent for women, and the difference is highly statistically significant ($p < 0.001$).

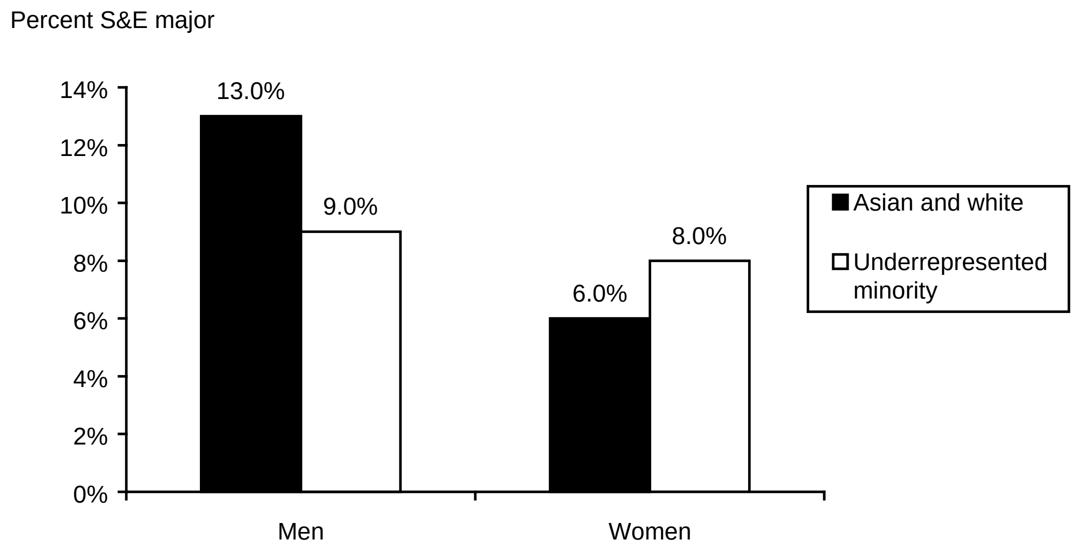
Breaking down data by both race/ethnicity and gender, the data reveal different patterns across the two variables. Among men, the S&E entrance rate for Asian and white men is 13 percent, compared with 9 percent for underrepresented minority men (see figure 3), a statistically significant gap. Among women, however, the rate is 6 percent for the Asians and whites and 8 percent for the underrepresented minorities, and the difference is not statistically significant. Apparently, a racial gap to the disadvantage of minority exists only among men, not among women. The same statistics also suggest that the gender gap differs across race/ethnicity. Among the Asian and white groups, the entry rate is 13 percent for men and 6 percent for women, a statistically significant gap; but among minorities, the rate is 9 percent for men and 8 percent for women, and the difference is not statistically significant. In short, the racial/ethnic gap only occurred among men and the gender gap mainly happened among the Asians and whites.

Figure 2.—Overall racial/ethnic and gender gaps in postsecondary S&E program entry



SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) “Base Year” through “Third Follow-up” panel data.

Figure 3.—Racial/ethnic and gender gaps in postsecondary S&E program entry: Three-way crosstabulation



SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88) "Base Year" through "Third Follow-up" panel data.

The results from a multiple logistic regression analysis are presented in table 32. Both the estimated logits (log-odds) and odds ratios are presented for the convenience of interpretation. The logit metrics indicate the linear additive effects of the predictor variables. The additive effects are translated into multiplicative effects when using odds ratio scales. While the logit seems abstract, the odds ratio is straightforward, referring to the ratio of the two conditional odds of the event; that is, majoring in S&E versus other outcomes after high school.

The gender–racial/ethnic interaction is apparent in the estimates in table 32. Estimates in equation 1 provide measures of racial/ethnic and gender gaps and a baseline for assessing the effects of predictor variables. White and Asian men serve as the reference group in this analysis. Equation 1 yields an intercept of -1.94 in logit, equivalent to a baseline odds of 0.14 or a probability of 0.13, as white and Asian men's *expected* likelihood of entering S&E programs. Controlling for race/ethnicity, women are less likely than men to enter S&E programs, as the coefficient -0.74 in logit indicates. Holding gender constant, underrepresented minorities are also less likely than Asians and whites to enroll in S&E programs, as shown in the estimated logit -0.38.

The estimate of the interaction term—which reveals the difference between minority women and the others—is 0.64 in logit and statistically significant, suggesting that minority women are more likely than the average of the rest to enter S&E programs. These estimates, compatible with the descriptive statistics shown in figure 3, indicate that a racial/ethnic gap only occurs among men and that the gender gap exists primarily among the Asian and white group.

Table 32.—Racial/ethnic and gender gaps in postsecondary S&E entry: Multiple logistic regression coefficient estimates (with odds ratio estimates in parentheses)

Predictor variables	Equation 1 Gender and race/ethnicity	Equation 2 Family environment and support	Equation 3 Student behavior	Equation 4 School factors
Gender (female)	*-0.74 (0.48)	*-0.75 (0.47)	*-0.63 (0.53)	*-0.62 (0.54)
Race/ethnicity (underrepresented minority)	*-0.38 (0.68)	-0.16 (0.86)	0.24 (1.27)	0.26 (1.29)
Gender/race/ethnicity interaction	*0.64 (1.90)	*0.66 (1.93)	0.60 (1.83)	0.38 (1.47)
Family environment and support				
Parents' educational attainment (college completion)		*0.52 (1.69)	0.05 (1.05)	0.02 (1.02)
Parents' expectations for their children to attain college education		*0.89 (2.43)	0.25 (1.28)	*0.32 (1.37)
Family financial support for students' college education		*0.26 (1.29)	0.17 (1.19)	0.11 (1.12)
Student behavior				
Students' motivation to learn science			*0.99 (2.70)	*1.01 (2.75)
Gaining in science learning			0.13 (1.14)	0.19 (1.21)
Aspiring for science/technology jobs			*0.53 (1.71)	*0.45 (1.56)
Gifted/advanced program placement			0.16 (1.17)	0.14 (1.15)
Self-confidence in math learning			*0.39 (1.47)	*0.22 (1.25)
Total math and science credits			*0.11	*0.15
Advanced math and science credits			*0.44	*0.44
School factors				
Teachers' major or minor in science or math				0.17 (1.18)
Schools' science coursework requirement (3 or more years)				-0.08 (0.92)
Intercept	*-1.94	*-2.70	*-3.83	*-4.15
Model Chi-square	*113.78	*427.16	*1223.98	*1,101.29
Degree of freedom	3	6	13	[1]16
Number of cases	13,117	12,922	10,274	8,733

* $p<0.05$

[1] Teachers' major or minor in science or math is a three-category variable with missing/not applicable cases coded –1; these cases numbered 5,050.

NOTE: The sample size n changed across equations due to listwise deleting of missing cases.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), "Base Year" through "Third Follow-Up" panel data, weighted with normalized panel weight F3PNLWT.

Racial Difference in S&E Enrollment

The regression analysis reveals a fairly consistent pattern in which the racial/ethnic gap diminishes as family environment and support, student behavior, and school factors are considered. This pattern is indicated by the change of the logistic regression coefficient associated with race/ethnicity from statistically significant in equation 1 to statistically insignificant in the subsequent three equations.

Equation 2 examines the relationship between family environment and support variables and S&E entry. The estimates for the three family variables are positive and statistically significant (with logistic coefficients of 0.52, 0.89, and 0.26, respectively), suggesting that, holding race/ethnicity and gender constant, students would be more likely to enter S&E if their parents had a college education and expected their child to have a college education, and their families could provide some financial support for college. Note that as the three variables enter the equation, the logistic coefficient associated with race/ethnicity becomes smaller in magnitude (-0.16) and is no longer statistically significant. This finding implies that when comparing students with these similar family characteristics, the racial/ethnic gap in S&E entry tends to disappear. The gender gap, however, remains substantial (-0.75 in logit estimate).

Equation 3 includes a set of student behavior variables, which concentrate on students' academic preparation during their secondary schooling. Note that the overall model fit improves when these variables are entered, as indicated by the larger Chi square of 1223.98 (relative to that of 427.16 in equation 2). Students' psychological characteristics relating to math and science learning are evidently strong predictors of postsecondary S&E enrollment. Given the same race/ethnicity, gender, and family environment and support, the variables students' motivation to learn science, aspiring for science and technology jobs, and self-confidence in math learning are positively related to S&E entry, with logit estimates of 0.99, 0.53, and 0.39, respectively. S&E entry is also clearly related to the two measures of math and science credits, holding other conditions constant. Both total math and science credits and advanced math and science credits are found to be positive and statistically significant predictors of S&E enrollment, with coefficients of 0.11 and 0.44.

Gaining in science learning as indicated by the increasing proficiency level in NELS:88 science tests is not related to S&E entry, nor is the gifted or advanced program placement, as neither coefficient is statistically significant.

After including the student behavior variables, the racial/ethnic gap further changes from negative to positive (0.24 in logit), though not to statistically significant, and the gender gap also narrows, while remaining substantial (-0.63 in logit). Conspicuously, the gender/race/ethnicity interaction effect disappears after the student behavior variables are entered into the equation.

Moreover, the coefficients associated with parents' educational attainment and family financial support are reduced to virtually nil (not statistically significant logits of 0.05 and 0.17, respectively), and the coefficient for parents' expectations for their child to attain college education also becomes much smaller (0.25 in logit) and is not statistically significant.

These findings highlight the critical importance of students' secondary academic preparation in relation to postsecondary S&E enrollment. They show that once students' attitudes regarding math and science learning and their coursework in the two subjects are taken into account, the chance to enter S&E programs tends to approach equity for students of different racial/ethnic and socioeconomic backgrounds.

School variables are entered in equation 4. Teachers' having majored or minored in math or in science in their academic training is not a significant predictor of students' S&E entry (with a logit coefficient of 0.09). Neither is schools' science coursework requirement of 3 or more years (logit estimate -0.08). Including these two variables makes little difference to the estimates of other predictor variables or to the overall model goodness of fit.

Focusing on the Racial Gap among Male Students

Because minority women do not differ substantially from nonminority women in S&E entrance, it may help to closely look at the male students in order to ascertain the pattern in which the racial/ethnic gap changes in connection to other independent variables. The results of analyzing the subset of data for male students, generated from the same equations as those with the total sample data, are presented in table 33. The estimates from the four equations appear consistent with those from the total sample. Evidently, the racial/ethnic gap in majoring in S&E among men steadily closes when comparing students who had similar motivation, aspirations, and confidence regarding math and science; earned similar total and advanced credits in the subjects; and whose parents' educational attainment and expectation for their child's education are similar. Teachers' majoring or minoring in the two subjects and schools' graduation requirement for 3 years science coursework, however, are not related to the outcome.

Additional findings from this subsample analysis are noteworthy. First, the racial/ethnic gap shifts from -0.38 (see equation 1) to 0.30 in logit and becomes statistically insignificant (see equations 2, 3, and 4). This finding confirms the finding from the total sample analysis, suggesting that holding constant the three sets of predictor variables, underrepresented minority men could have the same chance as other male students to enter postsecondary S&E programs. Furthermore, among male students, S&E entry is related to students' gain in science learning during secondary school years. The logit estimate for this variable is 0.31 and is statistically significant at the $p<0.01$ level.

Table 33.—Racial/ethnic gap among male students in postsecondary S&E entry: Multiple logistic regression coefficient estimates (with odds ratio estimates in parentheses)

Predictor variables	Equation 1 Race/ethnicity	Equation 2 Family environment and support	Equation 3 Student behavior	Equation 4 School factors
Race/ethnicity (underrepresented minority)	*-0.38 (0.68)	-0.15 (0.86)	0.26 (1.30)	0.30 (1.35)
Family environment and support				
Parents' educational attainment (college completion)		*0.54 (1.72)	0.11 (1.12)	0.20 (1.22)
Parents' expectation for their child's college education		*0.92 (2.50)	*0.28 (1.32)	*0.36 (1.44)
Family financial support for students' college education		0.26 (1.30)	0.07 (1.07)	0.18 (1.19)
Student behavior				
Students' motivation to learn science			*0.84 (2.31)	*0.94 (2.56)
Gaining in science learning			*0.24 (1.27)	*0.31 (1.37)
Aspiring for science/technology jobs			*0.57 (1.78)	*0.42 (1.52)
Gifted/advanced program placement			0.18 (1.20)	0.12 (1.12)
Self-confidence in math learning			*0.29 (1.33)	*0.20 (1.22)
Total math and science credits			*0.16	*0.15
Advanced math and science credits			*0.36	*0.40
School factors				
Teachers' major or minor in science or math				0.16 (1.18)
Schools' science coursework requirement (3 or more years)				-0.03 (0.97)
Intercept	*-1.94	*-2.72	*-4.06	*-4.22
Model Chi-square	*15.68	*220.81	*685.33	*608.71
Degree of freedom	1	4	11	[1]14
Number of cases	6,360	6,270	4,985	4,208

* $p<0.05$

[1] Teachers' major or minor in science or in math is a three-category variable with missing/not applicable cases coded –1; these cases numbered 5,050.

NOTE: The sample size n changed across equations due to listwise deleting of missing cases.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), "Base Year" through "Third Follow-Up" panel data, weighted with normalized panel weight F3PNLWT.

Gender Difference in S&E Enrollment

Theoretically, the gender gap in S&E achievement and attainment was a result of psychological and sociocultural influences which discouraged women from reaching high in an area that has been traditionally dominated by men. Economic resources and material support were not a significant issue in dealing with the gender gap. The above analysis of the overall sample data found that a broad gender gap only narrowed to a limited extent after predictor variables were entered into the equations. In other words, those predictor variables did not account well for the low S&E entry among women. This finding led to questions as to whether there was some cultural value that backed girls' venture into S&E areas, or, alternatively, environmental factors that fostered girls' intellectual orientation in terms of postsecondary program choice. Perhaps there were unique joint effects among the family expectations, girls' academic preparation, and their school conditions. We tested a number of possible interaction effects to explore these questions.

We hypothesized that traditional values that emphasize marriage, family, and children, in contrast to "nontraditional" views that stress individual success and independence, might make a difference in female students' career choice. To derive a measure of such value orientations, we conducted a principal component analysis with 15 items from the third follow-up student file that assessed the respondents' perceived importance of life goals. The resulting two factors, stable with different extraction and rotation methods, were labeled "traditional value" and "nontraditional value," respectively, based on their high loading on specific items (see appendix IV for the data items and the loadings resulting from the factor analysis). When tested, only the factor labeled nontraditional value related to majoring in S&E among female students. Therefore, respondents' "nontraditional" value orientation in high school years and its interaction term with gender were tested to see how this value orientation specifically affects girls' S&E choice after high school.

The model specifications were largely the same as those for racial/ethnic gaps, only with an additional value orientation indicator and its interaction term with female. The results, however, do not support the hypothesized relation between S&E selection and value orientation: neither the estimates for the "nontraditional" value orientation nor its interaction term with female are statistically significant. To further focus on girls' family environment and support and behavior variables in connection to S&E entry, another analysis was conducted with NELS:88 data for Asian and white cohort members only, because the observed gender difference took place primarily in this group. Table 34 presents the results of the analysis. The model specifications are essentially the same as those in the overall panel data analysis, except that the race/ethnicity variable and the gender/race/ethnicity interaction term were removed.

The resulting estimate for virtually every predictor variable is similar to that in the overall panel data analysis. With the full model (equation 4), holding other conditions constant, parents' expectation for their child's college education is related to greater likelihood of S&E entry; students' motivation to learn science, aspiring for science or technology jobs, self-confidence in math learning, and both the total credits and the advanced credits in math and science, are positively related to S&E entry. The gender gap—indicated by the coefficient associated with the variable gender—tends to narrow upon entering behavior items, but to a fairly small extent (from -0.74 to -0.63 in log odds ratio), and it remains substantial and highly statistically significant. On the other hand, teachers' major or minor in math or science and schools' science coursework requirement, again, do not relate to postsecondary S&E entry. In short, the analysis of data for Asian and white students reveals no different pattern of gender gap from that found in the overall analysis.

Table 34.—Gender gap among Asian and white students in postsecondary S&E entry: Multiple logistic regression coefficient estimates (with odds ratio estimates in parentheses)

Predictor variables	Equation 1 Gender	Equation 2 Family environment and support	Equation 3 Student behavior	Equation 4 School factors
Gender (female)	*-0.74 (0.48)	*-0.76 (0.47)	*-0.64 (0.53)	*-0.63 (0.53)
Family environment and support				
Parents' educational attainment (college completion)		*0.49 (1.64)	-0.01 (0.99)	-0.01 (0.99)
Parents' expectation for their child's college education		*1.06 (2.89)	*0.37 (1.45)	*0.39 (1.48)
Family financial support for students' college education		*0.26 (1.30)	0.12 (1.13)	0.20 (1.22)
Student behavior				
Students' motivation to learn science			*1.03 (2.80)	*1.07 (2.91)
Gaining in science learning			0.16 (1.18)	0.22 (1.24)
Aspiring for science/technology jobs			*0.52 (1.69)	*0.38 (1.47)
Gifted/advanced program placement			0.09 (1.10)	0.12 (1.13)
Self-confidence in math learning			*0.30 (1.35)	*0.30 (1.35)
Total math and science credits			*0.14 (1.16)	*0.12 (1.13)
Advanced math and science credits			*0.41 (1.50)	*0.46 (1.58)
Nontraditional value				-0.00 (1.00)
Female*nontraditional value				0.13 (1.14)
School factors				
Teachers' major or minor in science or math				0.24 (1.28)
Schools' science coursework requirement (3 or more years)				-0.04 (0.96)
Intercept	*-1.94	*-2.80	*-4.02	*-4.10
Model Chi-square	*110.48	*419.78	*1,047.43	*882.33
Degree of freedom	1	4	11	[1]16
Number of cases	9,835	9,730	7,986	6,516

* p<0.05

[1] Teacher major in S&E is a three-category variable with missing/not applicable cases coded -1 and counted 5,050 cases.

NOTE: The sample size n changed across equations due to listwise deleting of missing cases.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), "Base Year" through "Third Follow-Up" panel data, weighted with normalized panel weight F3PNLWT.

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Chapter 4
Persistence and Attainment in the S&E Pipeline: An Analysis of BPS Data

Entering a postsecondary institution does not guarantee success in science and engineering (S&E) education. In struggling to complete the programs, underrepresented minority and female students are often confronted with more difficulties than other students. The analysis in this chapter seeks to further examine the issue by addressing two questions[5] with empirical data from the Beginning Postsecondary Students Longitudinal Study (BPS):

(1) Are there gaps in program persistence and in degree completion across race/ethnicity and gender?
(2) What are the factors—family, individual, or institution—that can help us understand the gaps in program completion and persistence?

The analysis concentrates on tracing a cohort of students who began their S&E education in their *first* postsecondary year. Because this cohort represents the majority of S&E students (87 percent), focusing on it allowed analysts to sort out the main flows in the pipeline while avoiding confounding issues related to those who began S&E programs later. A description of the gender and racial/ethnic differences in pipeline outcomes—including overall persistence and attainment by the end of college years—is provided. Multiple logistic regression analysis was used to explore underlying factors that may be related to such differences.

BPS Data

The Beginning Postsecondary Students (BPS) Longitudinal Study was implemented in 1992. BPS includes nontraditional (older) students as well as traditional students and is, therefore, representative of *all* beginning students in postsecondary education. (The nontraditional students—30 or older—however, are not included in this analysis.) Moreover, the BPS definition of postsecondary education is broad, encompassing postsecondary enrollment in activities that do not award credits/degrees as well as various degree-awarding programs. The first BPS cohort comprised students who began their postsecondary education in the 1989–90 academic year; this cohort was followed up in 1992 and 1994. (A second BPS cohort comprises students who started their postsecondary education in the 1995–96 academic year.)

[5] It would be interesting to examine the process of “pipeline leakage”—that is, students’ unsuccessful exit from S&E programs—differentiated by gender and race/ethnicity during each of the 5 years of postsecondary education. Unfortunately, BPS data for the S&E subgroup do not allow such an analysis because the small subgroup size makes statistical estimates unreliable when the leakage measure is broken down by year and gender or race/ethnicity.

Sample Design

BPS draws its cohort from the National Postsecondary Student Aid Study (NPSAS), an information system that regularly collects financial aid data on nationally representative cross-sectional samples of postsecondary students. The baseline sample for the first BPS cohort was taken from the National Postsecondary Student Aid Study of 1990 (NPSAS:90), which surveyed 60,000 undergraduate and graduate students enrolled at U.S. postsecondary institutions in the 50 states and the District of Columbia. The first BPS cohort was a follow-up study of 11,700 NPSAS:90 students (from 1,092 institutions) who met the selection criteria of being students beginning postsecondary education for the first time between July 1, 1989, and June 30, 1990. A review of NPSAS data revealed that 1,976 of these students had been improperly classified as first-time beginning students (FTBs), resulting in their exclusion from the BPS first follow-up in 1992. The final BPS-eligible sample contained 7,932 individuals. Among these FTBs, 6,520 were given full or partial interviews in the first follow-up; 1,394 did not respond.

In the second follow-up of this cohort in 1994, a working sample of 7,914 individuals was initially used. It consisted of the first follow-up eligible respondents, plus those nonrespondents for whom FTB status had yet to be determined. Only 7,132 sample members could be located. Of these, 6,786 members were interviewed, either fully or partially. Some of those interviewed (169) were determined to be non-FTBs, leaving 6,617 eligible FTBs who were either fully (5,926) or partially (691) interviewed in the second follow-up. (This analysis included 6,682 respondents younger than 30 who had completed at least partially one of the waves of the survey. For more information on nonresponse, see the Analytic Approach and appendix V.)

By spring 1994, the project had collected data for five academic years (1989–90, 1990–91, 1991–92, 1992–93, and 1993–94). Data items for academic years 1990–91 and 1992–93 were largely gathered retrospectively: the respondents were asked to recall their experiences in the years prior to the year of interview. (BPS uses computer-assisted telephone interviews.) This report used data from the base year and the two follow-ups but based analyses on different subsamples—those that could best address the proposed research questions (see later section on Analytical Approach).

Survey Components

BPS collects student data, postsecondary transcripts, and financial aid records covering the entire undergraduate period, providing complete information on progress and persistence in school.

Defining and Measuring Persistence and Attainment

Students in postsecondary education follow diverse pathways. In examining pipeline processes in a 5-year time frame, it is critically important to differentiate respondents who attempted 4-year bachelor's programs from others who studied shorter—typically 1- or 2-year—programs (Berkner, Cuccaro-Alamin, McCormick, and Bobbitt 1996). Students who enroll in 4-year programs the first year are likely to follow the route of college education although there are ample alternative processes, such as institution transfer, program subject switch, discontinued enrollment, and college dropout. Students attending shorter programs tend to complete a degree—or just earn certain credits—and then move on to study in bachelor's programs or enter the labor force.

It is essential to clearly define S&E pipeline persistence and attainment to explain such complicated experiences. This entailed conceptualizing *postsecondary* completion and persistence differently than is done in most studies. For example, an earlier publication using BPS data defined persistence and attainment in terms of degree attempted (the first degree or the highest degree) and institutions, but disregarded the subjects of study (Berkner et al. 1996). This study, however, defines persistence and attainment in reference to program subjects, namely, S&E versus other subjects. While dropping out of the postsecondary track by definition implies dropping out of S&E programs, persistence in and attainment of postsecondary education may not correspond to persistence and attainment in S&E. Thus, this report examines the following indicator of pipeline experience and outcomes.

S&E program enrollment: Using the definition of S&E fields which excludes social sciences and psychology, this group of binary variables distinguishes on a yearly basis students who enrolled in any S&E degree-awarding programs—including certificate, associate, and bachelor's—from students who enrolled in non-S&E programs.[6] The resulting yearly S&E enrollment rates reflect the proportions of S&E enrollees among the BPS respondents who are identified as enrolled in postsecondary education in each of the survey years. Respondents who were not enrolled in postsecondary education in a given year were thus excluded from the denominator. These rates are broken down by race/ethnicity and gender, and separately presented for the total BPS sample and for the subsample of respondents who attended 4-year institutions in a given year. The rates for respondents who attended shorter programs are not presented because this group's small sample size and resulting low cell frequencies make the estimates unreliable.

Overall pipeline outcomes: The outcomes project to a different population from that described by the S&E enrollment indicators. S&E enrollment rates

[6] The analysis dichotomizes the programs into S&E versus non-S&E because there are too few cases in some cells—specifically physical sciences and computer/mathematical sciences—to produce reliable estimates for enrollment in all relevant fields.

were calculated to project to the population of first-time postsecondary students younger than 30 in the total BPS sample (n=6,682); whereas S&E program outcomes are only pertinent to those respondents who had enrolled in S&E programs. Specifically in this analysis, the overall pipeline outcomes were estimated for the subgroup of first-year S&E students (n=859; i.e., 80 percent of all S&E students). The outcomes as of the end of the survey are measured by systematically examining four categories:

(1) ***completers***: respondents who started postsecondary education in S&E in academic year 1989–90 and who had completed one or more degrees including certificate, associate, and bachelor's *in S&E* by spring 1994 when BPS data collection ended;
(2) ***persisters***: respondents who started postsecondary education in S&E in academic year 1989–90 and who had not attained any degree in S&E but were still enrolled in S&E programs in spring 1994;
(3) ***dropouts***: respondents who started postsecondary education in S&E in academic year 1989–90 and who had not attained any degree in S&E and were not enrolled in postsecondary programs by spring 1994; and
(4) ***switchers***: respondents who started postsecondary education in S&E in academic year 1989–90 and who had not attained any degree in S&E and did not drop out of the postsecondary track but were not enrolled in S&E programs by spring 1994.

Note that the 4 categories are mutually exclusive and exhaustive in the sense that every case in the subsample of 859 respondents was located in 1 and only 1 of the categories.

Given the limited time span, later-year S&E students (i.e., those who enrolled in S&E *after* the first postsecondary year of BPS) were less likely or unable to complete the programs by the end of the survey and hence were not comparable with the first-year S&E group in outcomes measured within the time span—that is why the later-year S&E group is excluded from the overall outcomes analysis and multiple regression analysis, which both focus on the "final" outcomes *measured by the end of the 5-year span*.

Hispanics and African-Americans are separated in the crosstabulation of S&E enrollment by year by gender and race/ethnicity with the full BPS sample, but this could not be done in the rest of the analysis because the subsample sizes are too small to break down any further. Even using the full BPS sample, the numbers of American Indians are too low to produce reliable estimates. Therefore, the analysis compares whites and Asians with underrepresented minorities.

Predictor Variables

The BPS multiple regression analysis focused on S&E bachelor's degree completion by the end of the 5 years of the survey. Otherwise, the conceptual framework is similar to that used in the NELS:88 analysis. Family background, student behavior, and institution factors were considered in relation to S&E attainment across gender and race/ethnicity.[7] Women and underrepresented minorities share some concerns in dealing with the historically white male dominated S&E establishment, but women's experiences of S&E education could differ from underrepresented minorities' experiences. As suggested earlier, cultural values and self-confidence are crucial factors relating to the gender gap in S&E entry; financial or material support and academic preparation might be a lesser predictor of success for women. As for underrepresented minorities, education outcomes may hinge upon material resources to a greater extent than on attitudinal/psychological factors. This assumption called for testing different interaction terms in addition to estimating effects of common predictor variables. For gender gaps, the interactions could be gender and attitudinal/cultural/psychological factors; and for racial/ethnic gaps, race/ethnicity and financial support. The predictor variables are listed below and discussed in the following paragraphs.

Family environment and support
- Parents' educational attainment
- Family financial support

Student behavior
- Aspiration for advanced education
- Intellectual self-confidence
- Delayed college entry

Institution factors
- Control (public or private)
- Financial aid

Among ***family environment and support*** variables, parents' educational attainment is widely accepted as a significant factor related to children's educational attainment, though its effect on success in *specific subjects* is not clear. It is expressed by a binary variable, coded 1 for students whose parents (either mother or father) had 4 years or more of college education and 0 for those whose parents had less education. Respondents' reported dependence on the family was construed as a measure of family support for respondents' education since the item implied availability of family financial support to the

[7] "Minority student" was defined using the original racial indicators in the BPS data file, which were respondents' self-identification of Hispanic origin, white, African-American, American Indian or Alaskan Native, and Asian. A dichotomous variable was created, coded 1 for African-Americans, Hispanics, and American Indians and 0 for whites and Asians. "Gender" is also indicated by a binary variable, derived from the data file, coded 1 for women and 0 for men.

respondents. The variable was coded 1 for those who reported depending on the family in the first year of college and 0 for those who reported they did not. Family SES, a composite variable in the original data set, was not used in the analysis because it was found to have no relation to S&E degree completion.[8]

Student behavioral factors are represented by an array of indicators derived from the original BPS data items. Aspiration for advanced education is indicated by a binary variable coded 1 for students who reported an aspiration for graduate education and 0 for those who intended to complete their education at lower levels. It seemed reasonable to assume that respondents who aspired for advanced studies were more likely than the others to succeed in S&E fields. Self-confidence is measured with a binary variable about intellectual ability, coded 1 for respondents who claimed to be above average and 0 for those who reported to be average or below average and for those who did not respond to the item. To examine the hypothetical effect of self-confidence on women's success in S&E programs through multiple regression analysis, we constructed a cross-product term that would allow estimates of the interaction effect between self-confidence and gender. While other data on self-confidence are available from the BPS file, such as self-perceived academic, mathematical, and mechanical/technical abilities and social confidence, they did not correlate as well with the outcome variable (completion of S&E programs) as the variables mentioned above; therefore, they were not used in the final analysis.

This analysis also examined a group of individual risk factors hypothetically relevant to completion and persistence. Delayed entry into postsecondary education was identified as a negative predictor of degree completion. This dichotomous variable was coded 1 for respondents who began postsecondary education after at least a 1-year break since completion of high school and 0 for those who went to postsecondary education immediately following high school. Other potential risk measures such as single parenthood, number of children, and disabilities were examined and were found to be trivial in relating to S&E degree completion and were not specified in the final equation.

Postsecondary institutions attended by respondents in academic year 1989–90 were distinguished by the sector of control: public schools were assigned a value of 1 and private schools 0 (including both for-profit and not-for-profit institutions). Institution level (4-year colleges versus others) was not considered in equations because it implies different levels of attainment than the bachelor's degree.

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[8] BPS collected items on specific amount of money for college, but these items contained many missing values.

The *services* postsecondary institutions provide are an important issue when examining pipeline outcomes. In particular, service programs intended to help underrepresented groups must be examined to assess their impact on the attainment of the targeted groups. One such indicator is used in the analysis: financial aid. The financial aid provided by schools and underrepresented minority students' attainment is a key policy concern. The variable on financial aid received is binary, coded 1 for respondents who reported receiving any grant or loan during the years of survey, and 0 for the rest of respondents. Additionally, an interaction effect was estimated with a cross-product term for minority status and financial aid, which, in a multivariate equation, would explicate the relationships between this service and underrepresented minority students' degree completion.

Note that some predictor variables are summary measures across the years—meaning that they combine information from the same data items in different years of interview—while some are indicators of the first year. The shortcoming of such measurements is obvious: they might not accurately reflect the changing conditions of respondents' experiences over the 5 years. The problem stems from the available data: because there are many missing values in the follow-ups, it was simply not feasible to construct measures of the key concepts for *each* academic year. Nevertheless, as this is an exploratory study of S&E pipeline issues with BPS data, the available information warranted this analysis based on the subsamples of students who enrolled in S&E bachelor's programs in their first year of college.

Analytical Approach

Steps were taken in the data analysis to deepen research from the pattern of S&E enrollment in the BPS total sample (excluding respondents aged 30 or older) to the subsample of students who entered the S&E pipeline with the clearly defined goal of completing bachelor's degrees. Initially, the total BPS sample was used to give an overview of S&E enrollment distribution by gender and race/ethnicity across the 5 years of the data collection. Sample members who had enrolled in an S&E program in one of the 5 years were identified as S&E students on a yearly basis from the BPS sample members who enrolled in postsecondary education (excluding those who were not enrolled in postsecondary education in a given year). This step, termed "total sample analysis," relies upon descriptive statistics; it included 6,682 students who were younger than 30 and were interviewed in 1989 and in subsequent follow-ups.

The description of gender and racial/ethnic gaps in *overall pipeline outcomes* uses the subsample of 859 students enrolled in S&E programs in their first year of postsecondary education. This part of the analysis, called "first-year S&E subsample analysis," went through a series of crosstabulations to produce findings about the majority of S&E students in the cohort. (Students who started S&E enrollment in later years made up only 13 percent of the 1,075 students who had ever enrolled in S&E programs in any of the 5 years of the survey.) This approach offered the conceptual advantage of streamlining the diverse flows and twists of students' schooling, enabling analysts to convey a clear idea about the pipeline results by condensing the large amount of information about the many idiosyncratic pathways followed by individual students.

Finally, to determine key factors that related to attainment and persistence, data from a subsample were further extracted from the first-year S&E subsample for multiple logistic regression analysis and survival analysis. The subsample comprised the 676 students who enrolled in S&E *bachelor's degree* programs in their first year of college, called the "first-year S&E bachelor's subsample." Separating this subsample facilitated examination of program-differentiated conditions because 4-year bachelor's programs were significantly different from shorter programs (e.g., certificate or associate degree programs) in both process and outcomes. The S&E bachelor's subsample, representing students who set a relatively clear destination for S&E careers, contained a majority (approximately 60 percent) of the students who ever enrolled in S&E during the survey years. This analysis could best address questions about the typical pipeline experience, as 4-year bachelor's programs are the main source of S&E labor supply. (See appendix V for demographic characteristics of the three BPS subsamples used in the analysis.)

Using data for students who were first-year S&E majors sharpened the research focus on the pipeline mainstream. However, a caveat related to analysis based on extracted data should be noted. By definition, this approach ignores complex individual experiences such as those of students beginning their S&E enrollment in later college years. Further, selecting subgroups of beginning postsecondary students who had in the entry year selected S&E programs reduced the sample size for analysis. The resulting estimates in crosstabulation by gender and race/ethnicity and multiple regression analysis could sometimes be unreliable—these will be identified in the data presentation. However, no data for respondents who attended programs other than 4-year college and data for American Indians are presented because of such unreliable estimates. In tracing the dynamic processes and diverse conditions of postsecondary schooling, BPS involved in-depth research and detailed measures to cover alternative education paths experienced by respondents. However, the resulting data set contains a rather large amount of data with such problems as missing values, multiple response, and inconsistent responses. While such problems are inevitable in a general purpose survey, they posed challenges to this analysis because the small subsample of S&E students tended to be further reduced as a result of unusable data.

Weighting and Treatment of Missing Data

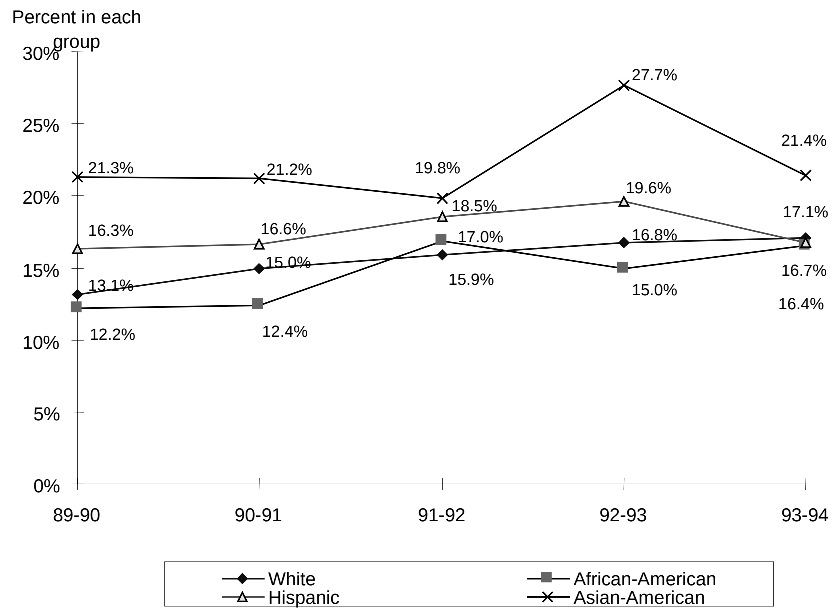
All of the statistical procedures were first tested with the software package SAS and then run with WesVar, a software package specifically designed for analyzing data of complex surveys that require adjustment for design effects (see Westat 1994). The final estimates were generated from procedures by WesVar with adjustments using the normalized panel weight (BPS94AWT), derived by dividing the original weight by its mean, and the replicate weights (BPS94W01–BPS94W35). For information on weighting procedures in BPS data analysis see Berkner et al. (1996). SUDAAN procedures identical to the WesVar procedures were also run because SUDAAN can produce odds ratio estimates that WesVar cannot.

Missing data were not imputed and were excluded from analysis, unless otherwise noted in the above description of coding procedures for specific variables. However, sample weighting should remedy bias resulting from unit nonresponse. (For descriptive statistics of the first-year S&E bachelor's subsample, see appendix IIB.)

Findings

Findings from BPS data on S&E enrollment show the following racial/ethnic and gender gaps in postsecondary S&E pipeline entry. Among African American students, 12 percent were enrolled in S&E programs in their first year of college, not substantially lower than whites' 13 percent; Hispanics had a higher rate of S&E enrollment than whites; and Asian-Americans had the highest rate, 21 percent (see figure 4). While the rates fluctuated over the years, by the end of the last year, the rates for African-Americans, Hispanics, and whites all came close to 17 percent. Only the rate for Asian-Americans remained higher (21 percent).

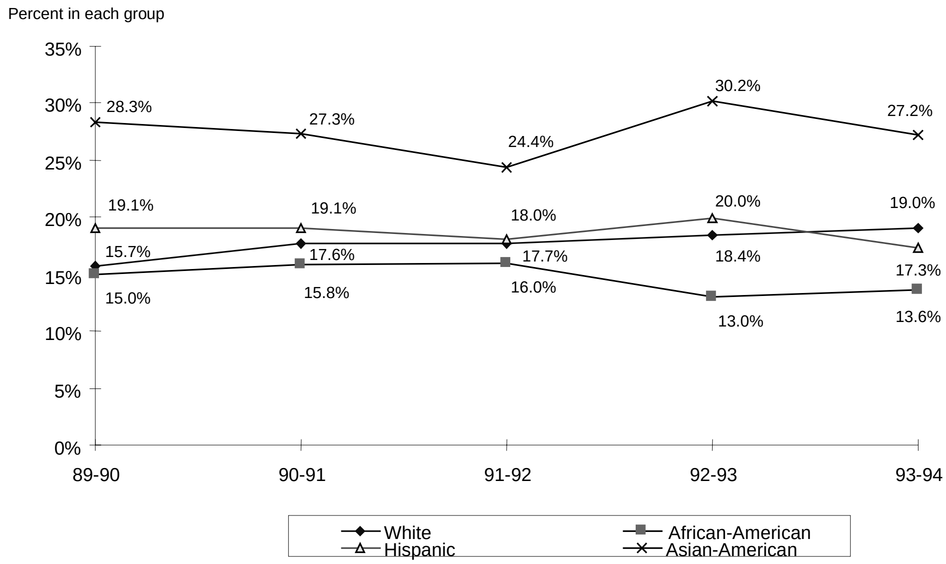
Figure 4.—Racial/ethnic differences in S&E enrollment by academic year: Total sample of BPS students



NOTE: Data from BPS total sample of 6,682 beginning postsecondary students.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

The racial/ethnic differences in S&E enrollment among students attending 4-year colleges are similar to those found in the total sample (figure 5). There is no large minority-white gap, except that Asian-Americans' enrollment was much higher than the rest over the years. Relative to whites, Hispanics rated slightly higher at the beginning year but slightly lower in the last year. The rate of African-Americans in S&E enrollment remained relatively low, though the gap is less than dramatic.

Figure 5.—Racial/ethnic differences in S&E enrollment by academic year: Students attending 4-year colleges

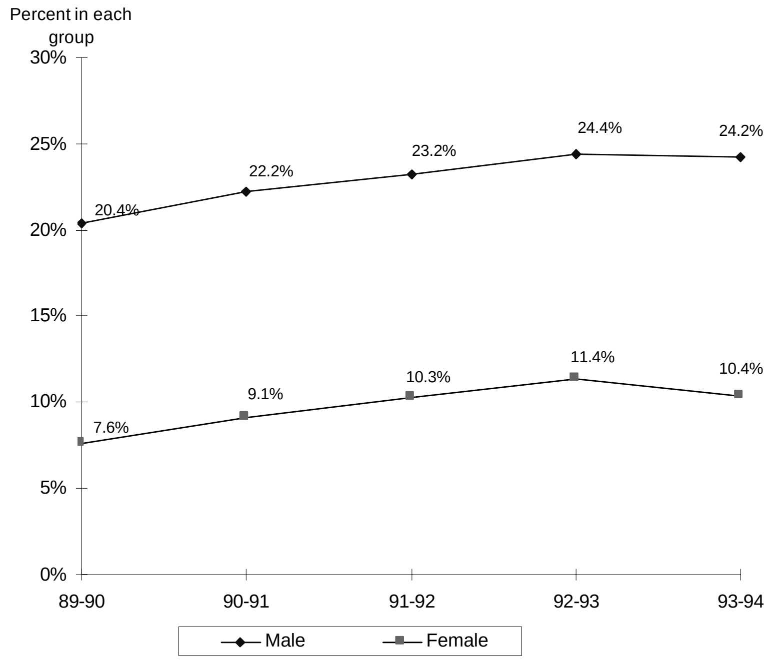


NOTE: Data from BPS total subsample of 4,346 students who attended 4-year colleges in Academic year 1989–90.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Women consistently enrolled in S&E programs at lower rates than men in the total BPS sample (figure 6). Compared with racial/ethnic gaps, the gender difference was wider—women's enrollment rate was less than a half of men's (7.6 percent and 20.4 percent, respectively) at the beginning year of the survey and the difference persisted at the end of the survey (10.4 percent versus 24.2 percent). The pattern was largely the same as found with data for respondents who enrolled in 4-year institutions (see figure 7).

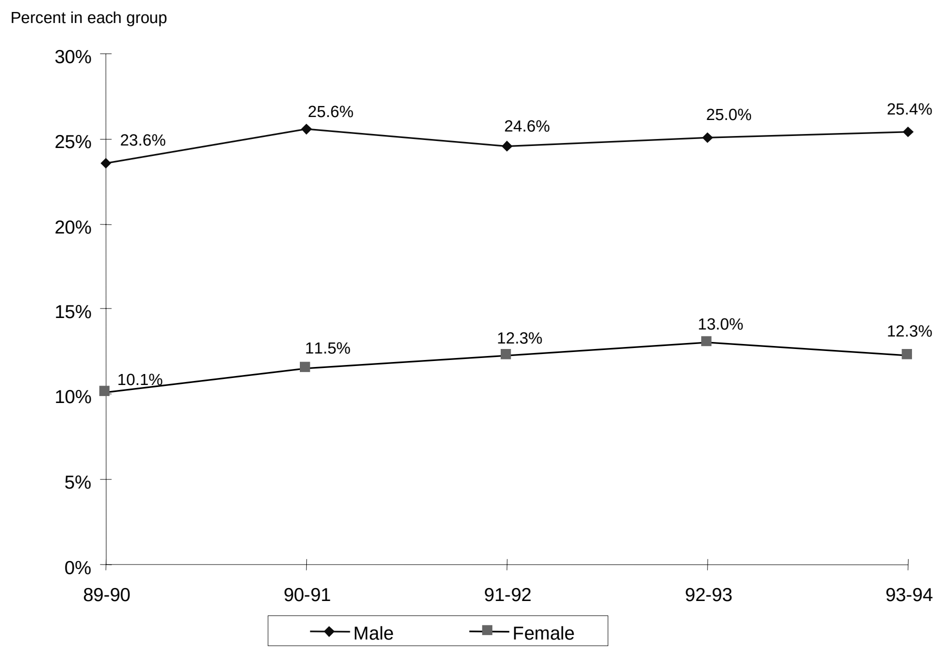
The differences of enrollment rates for race/ethnicity and gender were fairly stable across the 5 years—a typical time span for college years. Clearly, BPS data indicate that racial/ethnic difference in S&E *entry* is not very substantial. Asian-Americans continued to have high enrollment rates; the rest were fairly close to each other. However, the gender gap is salient, with women severely underrepresented in S&E entry. This result is consistent with the pattern found with NELS:88 data. This overview of S&E enrollment differences is meant merely to introduce readers to the large pattern of the S&E pipeline demographics. With vast heterogeneous postsecondary institutional and programmatic alternatives as well as individuals' choices of how to go through the system, readers are cautioned that this picture may be overly simplistic and requires detailed analysis.

Figure 6.—Gender differences in S&E enrollment by academic year: Total sample of BPS students



NOTE: Data from BPS total sample of 6,682 beginning postsecondary students.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Figure 7.—Gender differences in S&E enrollment by academic year: BPS students attending 4-year colleges



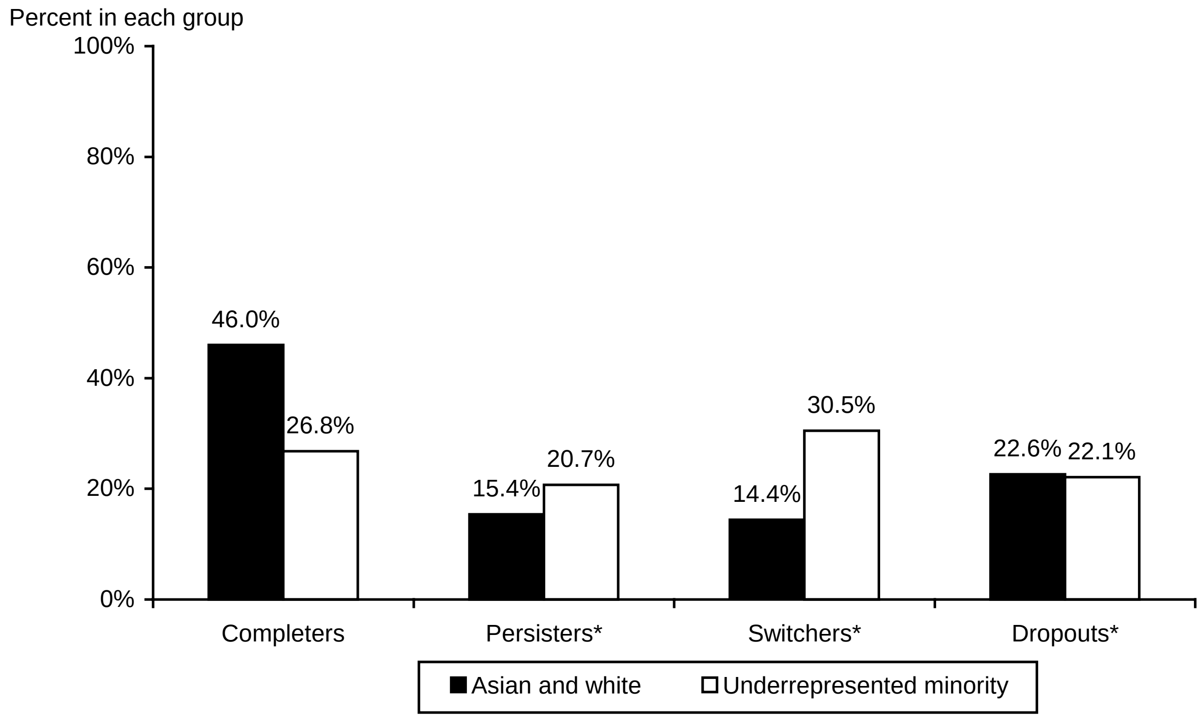
NOTE: Data from BPS total sample of 4,346 students who attended 4-year colleges in Academic year 1989–90.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Overall Pipeline Outcomes

Where did women and underrepresented minorities end up 5 years later? The answer came from data on the subsample of 859 students who entered the S&E pipeline in the first year of college. A student in this subsample would necessarily assume one of four outcomes 5 years later: a completer who had completed at least one S&E degree; a persister who had not completed a degree but was still in an S&E program; a switcher who had changed into a non-S&E program without finishing an S&E degree; or a dropout who was out of the postsecondary education track without completing any degrees (refer to the Defining and Measuring Persistence and Attainment section for detailed definitions).

Figures 8 and 9 present estimates from the first-year S&E student subsample analysis. Underrepresented minority students' fate differed considerably from that of whites and Asians (figure 8). Only 26.8 percent of underrepresented minorities completed one or more S&E programs, in contrast to more than 46 percent of whites and Asians. No statistically significant difference was found between the racial/ethnic groups in persistence rates, nor in college dropout rates. However, more underrepresented minorities (30.5 percent) had switched into non-S&E fields relative to whites and Asians (14.4 percent). These descriptive statistics seem to portray underrepresented minority S&E students as struggling in the system: they had difficulty attaining a degree in the desired S&E fields within a tight 5-year college calendar. Some of them had to switch to other fields to work out different programs.

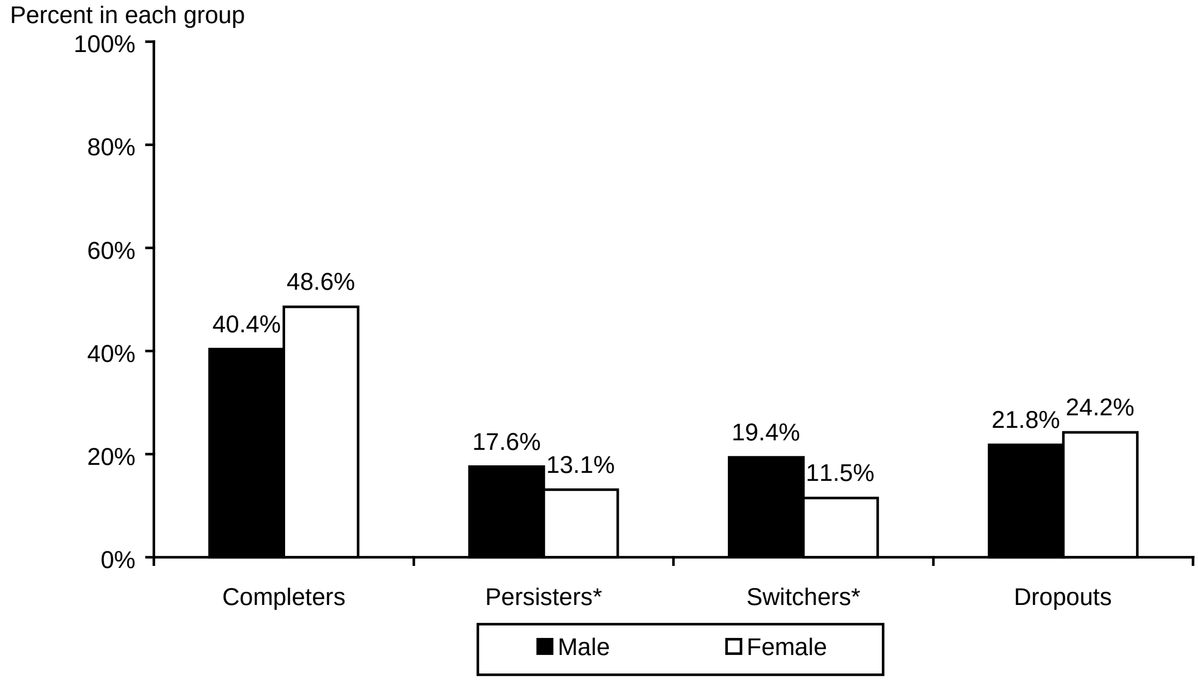
Figure 8.—Racial/ethnic differences in overall pipeline outcomes



* Estimates may be unreliable due to low cell frequencies for underrepresented minority persisters (n=25), switchers (n=22), and dropouts (n=29).
NOTE: Data from BPS subsample of 859 first-year S&E students. Group total may not add to 100 percent due to rounding errors.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Women in general did better than men once they were in the S&E pipeline (figure 9). Five years down the pipeline, close to half (48.6 percent) of the first-year female S&E students had completed a degree in S&E compared with 40.4 percent of the males. Women did differ from men in persistence (13.1 percent and 17.6 percent, respectively), but the difference is not statistically significant. Clearly women were less likely than men to change their S&E goals: only 11.5 percent of women were switchers, but 19.4 percent of men were. There seemed to be no gender difference in college dropout rates among first-year S&E students.

Figure 9.—Gender differences in overall pipeline outcomes



* Estimates may be unreliable due to low cell frequencies for female persisters (n=28) and switchers (n=21).
NOTE: Data from BPS subsample of 859 first-year S&E students. Group total may not add to 100 percent due to rounding errors.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Factors Related to Attainment and Persistence

Multiple logistic regression analysis was conducted to examine the factors theoretically important to S&E pipeline attainment and persistence. The findings from logistic regression procedures are presented in tables 35 and 36 (descriptive statistics for the S&E bachelor subsample used in this analysis are shown in appendix II). Equation 1 in table 35 estimates racial/ethnic and gender differences in completion of S&E bachelor's degrees. The equation serves as a base to examine the extent to which other predictor variables act to change the racial/ethnic and gender gaps. The intercept, -0.19 in estimated logit, is not statistically significant. In equation 1, it represents the likelihood of Asian and white males completing S&E degrees in the 5-year time frame and serves as the reference in racial/ethnic and gender comparison.

The estimated logit of -0.88 and odds ratio of 0.41 for underrepresented minorities are statistically significant, indicating that, holding gender constant, underrepresented minority students' likelihood of completing the degrees in the same time span is smaller than Asian and white students'. Further, the predicted logit for underrepresented minority men would be -1.07 (= -0.19 - 0.88). The statistically significant coefficient of 0.67 in logit or 1.96 in odds ratio for female indicate that women's likelihood of completing a degree is higher than men's, controlling for race/ethnicity. The predicted logit of degree completion for white women would be 0.48 (= -.19 + 0.67). Thus, the gender gap was in favor of women. Note that the interaction term of race/ethnicity and gender has been specified and tested in the initial modeling, which turned out to be not statistically significant, probably due to the small group size (43 unweighted cases) of underrepresented minority women among first-year S&E bachelor's students. Thus, the analysis does not include this term in subsequent equations.

Family environment and support variables are included into equation 2 of table 35. S&E degree completion is positively related to parents' college education and the family financial support that students depended on. Both coefficients, 0.58 and 0.99 in logit, were statistically significant, suggesting that respondents whose parents had an education of college-level or above or whose family provided dependable support were more likely to complete S&E degrees, other factors being equal.

Respondents' psychological and behavioral characteristics are considered in equation 3. Aspiring for advanced S&E studies and high self-confidence regarding intellectual abilities are positively and strongly related to degree completion (1.76 and 0.70 in logit, respectively). It is remarkable that the entry of these predictors into the equation substantially reduced the estimated effect size for parents' education and family support (for parents' education, the logit 0.58 in equation 2 is reduced to 0.30 and not statistically significant; for family support, 0.99 is reduced to 0.67). This finding seems to imply that aspiration and intellectual confidence could help mediate the difference in S&E educational attainment relating to family background. Delayed enrollment in college, however, is not related to degree completion as the coefficient is not statistically significant.

Equation 4 examines program and institutional factors. Receiving financial aid from school was found to be related to the likelihood of degree completion, as the estimate (0.48 in logit) is statistically significant. Degree completion is also related positively to attending a private institution (0.70 in logit). The two estimates suggest that, other conditions being similar, students receiving financial aid and attending private colleges have a mildly higher likelihood of completing S&E degrees.

To assess the changes in racial/ethnic and gender gaps across the equations, the estimates for underrepresented minority and female are shown in the equations in table 35. The racial gap indicated by the estimated regression coefficient seems fairly stable (from -0.88 to -0.80, -0.84, and -0.83) as increasingly more predictor variables are added. This differed from the expected pattern where including relevant explanatory variables would narrow the estimated gap. This finding hints that factors other than those in the equations need to be considered. In particular, academic preparation and effort may be crucial for underrepresented minorities' success. The gender gap that favored women also seems stable across equations with increasingly more predictor variables entered (ranging from 0.67 to 0.58).

Table 35.—Racial/ethnic and gender gaps in completion of S&E bachelor's degrees: Logistic regression coefficient estimates with data from the first year S&E bachelor's subsample (with odds ratio estimates in parentheses)

Predictor variables	Equation 1 Race/ethnicity and gender	Equation 2 Family environment and support	Equation 3 Student Behavior	Equation 4 Institutional Factors
Race/ethnicity (non-Asian minority)	*-0.88 (0.41)	*-0.80 (0.45)	*-0.84 (0.43)	*-0.83 (0.43)
Gender (female)	*0.67 (1.96)	*0.67 (1.95)	*0.62 (1.86)	*0.58 (1.80)
Family environment and support				
Parents' educational attainment		*0.58 (1.80)	0.30 (1.35)	*0.40 (1.49)
Family financial support		*0.99 (2.69)	*0.67 (1.96)	*0.61 (1.84)
Student behavior				
Aspiration for advanced S&E Study			*1.76 (5.81)	*1.68 (5.38)
Delayed college entry			-0.42 (0.65)	-0.41 (0.66)
Intellectual self-confidence			*0.70 (2.00)	*0.66 (1.93)
Institutional factors				
Financial aid				*0.48 (1.62)
Private institution				*0.70 (2.02)
Intercept	-0.19	*-1.44	*-2.49	*-2.92
Model Chi square	*25.93	*58.80	*167.98	*189.73
Degree of freedom	2	4	7	9
Number of cases	676	676	[1]664	[1]664

*p<0.05

[1] There were 12 missing cases on the variable "Aspiration for advanced S&E study."

SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Underrepresented minority and female students might face different obstacles going through the pipeline. Specifically, it was hypothesized that financial aid might be especially helpful in enabling underrepresented minority students to complete S&E degrees because these students are most prone to financial difficulties. On the other hand, self-confidence was theorized to be an important issue for women to succeed in S&E education. These concerns required statistical test of interaction effects. Table 36 presents findings regarding these interaction effects.

Equation 5 covers the interaction term of underrepresented minority by financial aid, representing potential differences in logit of S&E degree completion relating to financial aid received by underrepresented minority students. This interaction effect, however, is not found in the analysis as the estimate is not statistically significant.

The hypothesized interaction effect between gender and self-confidence is specified in equation 6 (table 36). The estimated effect is not statistically significant (-0.52 in logit). It indicates that female S&E students who self-reported higher than average intellectual abilities did not differ from other women in degree completion in 5 years. Thus, the data do not support the expected joint relationship between gender and self-confidence in connection to S&E degree completion.

Table 36.—Interaction effects: Racial/ethnic and gender gaps in completion of S&E bachelor's degrees: Logistic regression coefficient estimates with data from the first year S&E bachelor's subsample (with odds ratio estimates in parentheses)

Predictor variables	Equation 5 Minority by financial aid	Equation 6 Female by self-confidence
Race/ethnicity (non-Asian minority)	-0.52 (0.60)	*-0.80 (0.45)
Gender (female)	*0.59 (1.81)	*0.90 (2.45)
Family environment and support		
Parents' educational attainment	*0.40 (1.49)	*0.36 (1.44)
Family financial support	0.62 (1.86)	*0.62 (1.87)
Student behavior		
Aspiration for advanced S&E study	*1.71 (5.51)	*1.73 (5.64)
Delayed college entry	-0.40 (0.67)	-0.35 (0.71)
Intellectual self-confidence	*0.66 (1.94)	*0.85 (2.35)
Institutional factors		
Financial aid	*0.53 (1.70)	0.41 (1.51)
Private institution	*0.70 (2.02)	*0.68 (1.97)
Minority*Financial aid	-0.45 (0.64)	
Female*self-confidence		-0.52 (0.60)
Intercept	*-2.98	*-2.96
Model Chi square	*290.32	200.56
Degree of freedom	10	11
Number of cases	[1]664	[1]664

*p<0.05

[1] There were 12 missing cases on the variable "Aspiration for advanced S&E study."

SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

Summary

The analysis of BPS data yields important findings regarding minority and female students' status in and out of the S&E pipeline. As prior research has documented, underrepresented minority students are less successful in S&E educational persistence and attainment. As this analysis has shown, the problem was indicated with outcome measures of degree completion and switching out of S&E fields. Recall that the NELS:88 analysis suggests that the racial/ethnic gap was small compared with the gender gap in the S&E program entry. BPS data, however, demonstrate that minority students face greater difficulties *within* S&E programs.

Contrary to prior research, however, BPS data show that female students in S&E programs did not fall behind in the pipeline; they actually did better than male students in program switching and degree completion. Given the daunting social and academic obstacles facing women in S&E fields—traditionally a man's world—how should one explain the ironic success of women shown by data? Looking only at the available BPS data, it seems difficult to answer the question. But by reconciling the findings from NELS:88 and BPS analyses and linking these findings with broader research, a plausible, albeit speculative, interpretation could be advanced.

Analysis of NELS:88 data clearly shows that female high school students are much less likely to select S&E majors. The descriptive analysis of data for the BPS total sample also reveals evidence of severely low female enrollment in S&E programs. In striking contrast, women in recent years have been growing into a majority in overall postsecondary education. Female overrepresentation has been consistently found in postsecondary demographic studies as well as in NELS:88 and BPS data. With such a contrast, the low S&E enrollment by women implies that a very stringent selection mechanism might be at work in S&E program entry. The selection mechanism—either by women themselves or by institutional forces or by a joint effect of both—probably filters out all but a small group of highly resilient women for S&E programs. These women who enter S&E fields are likely to have strong family support, high expectation, healthy self-confidence, and solid academic preparation (see table 37 for some data on such differences). Consequently, women *in* the S&E pipeline do well relative to males.

The findings from this analysis may help expand the understanding of science and engineering education in relation to race/ethnicity and gender. For example, an earlier study with HS&B transcript data examined male and female students' paths through engineering programs—not including science programs—in college (Adelman 1998). This BPS analysis, looking at both gender and race/ethnicity, may help address broader concerns in education policymaking and program development because of the extensive descriptive material and demographic analyses. Because of differences in research issues, data sets, and purpose, these two studies overlap in some areas but their findings are hardly directly comparable. Nevertheless, it may be meaningful to look at the large patterns regarding gender difference in the two studies. Specifically, compatible findings include:

- relative to men, women in the programs are not poorly prepared, but they face difficulties of a largely psychocultural nature;
- relative to men, women *in* the programs do not perform poorly; and
- relative to men, women *in* the programs have strong family support to attain college education.

Further, the overall program outcomes (degree completion, migration, dropout, etc.) seem fairly consistent in the two reports (and another report cited by Adelman)—taking into consideration the differences in data sets, time span, and particularly program coverage (science and engineering vs. engineering).

One possibly inconsistent finding is that Adelman found a 20 percent gap in *engineering* program completion rates between men and women, whereas we found women in S&E programs were slightly higher in completion rates. However, Adelman's data only cover engineering programs where women tend to face the toughest institutional and cultural barriers; this study included the sciences (and engineering), especially life sciences where women tend to do better than in other fields. In light of this, it would be hard to say the two analyses really differ regarding this gender gap.

Table 37.—Racial/ethnic and gender differences in selected predictor variables: The first year S&E bachelor's subsample (n=676)

	Estimated percent in group	Standard error	Design effect
Aspiration for advanced studies			
Underrepresented minority	73.24	3.26	0.48
Asian and white	70.53	2.95	2.46
Female	77.80	2.42	0.76
Male	67.70	3.42	2.41
Dependent upon family support			
Underrepresented minority	80.98	2.67	0.41
Asian and white	86.94	1.75	1.59
Female	88.79	2.47	1.38
Male	84.78	1.99	1.38
Parents had college education			
Underrepresented minority	40.67	4.59	0.78
Asian and white	50.91	2.52	1.49
Female	50.18	3.39	1.03
Male	49.02	2.88	1.50
Intellectual confidence above average			
Underrepresented minority	47.54	4.23	0.64
Asian and white	47.83	2.26	1.20
Female	50.32	3.51	1.10
Male	46.60	2.76	1.39

SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Longitudinal Study.

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Appendix I: Crosswalk of Field Variables and Science/Math Codes for NELS:88 and BPS with a Modified National Science Foundation Definition of Science and Engineering Fields

	NSF	NELS:88		BPS
Variable		PSEFIRMJ		MAJ8990 MAJ9091 MAJ9192 MAJ9293 MAJ9394
Codes	[1]Modified NSF S&E (i.e., excludes 2 fields that are part of NSF S&E: Psychology Social sciences)	140–144	(engineering)	7 (engineering)
		260–263	(biological sci)	3 (biological sci)
		270–271	(mathematics)	5 (mathematics)
		400–403	(physical sci)	4 (physical sci)
		20	(agric sci)	
		30–31	(nat res/forest)	
		110–112	(computer sci)	6 (computer/info sci)
		301–303	(interdisc sci)	

[1] Health sciences, engineering/science technical, and agricultural business/production are also not included because they are not considered S&E fields by NSF.

NOTE: Agricultural sciences, natural resources, and interdisciplinary science fields were included where available or identifiable. For example, agriculture could not be identified in BPS because it is collapsed into code 12, which covers other technical/professional fields.

Appendix II: Descriptive Statistics of Variables used in the NELS:88 and BPS Regression Analyses

A: Descriptive Statistics of Variables Used in Multiple Logistic Regression Analysis of NELS:88 Data (BY–F3 transcript panel data)

Variables	Code, scale and labels	Unweighted number of cases	Percentage or mean (sd)
S&E major	0=not S&E major	11,756	89.62
	1=major S&E	1,361	10.38
Sex	0=male	6,360	48.49
	1=female	6,757	51.51
Race	0=Asian and white	9,835	74.98
	1=black, Hispanic, and American Indian	3,282	25.02
Sex*race	0=others	11,374	86.71
	1=female black, Hispanic, American Indian	1,743	13.29
Parents' college education	0=no	9,498	72.41
	1=college or more	3,596	27.41
	-1=missing	23	.18
Parents' expectation for child's college education	0=no	6,990	53.27
	1=college or more	5,939	45.28
	-1=missing	188	1.43
Family financial support for college	0=no	2,710	20.66
	1=yes	10,407	79.34
Motivated to learn science	0=other reasons or missing	11,436	87.18
	1=because of personal interest	1,681	12.82
Gain in science learning	0=no gain in 8th–12th grade	8,786	66.98
	1=gained	4,331	33.02
Aspiring for science/technology jobs	0=not for science/tech jobs or missing	11,555	88.09
	1=aspire for science/tech jobs	1,562	11.91
Gifted/advanced programs	0=never in 8th–12th grade	8,560	65.26
	1=at least once in	2,755	21.00
	-1=missing	1,802	13.74
Self-confidence in math	0=didn't do well in math	6,396	48.76
	1=always/mostly do well	5,424	41.35
	-1=missing	1,297	9.89

A: Descriptive Statistics of Variables Used in Multiple Logistic Regression Analysis of NELS:88 Data (BY–F3 transcript panel data)—Continued

Variables	Code, scale and labels	Unweighted number of cases	Percentage or mean (sd)
Teach major in S&M	0=no	2,499	19.05
	1=major/minor in math or science	5,568	42.45
	-1=legitmate skip/missing	5,050	38.50
School requirement of 3 years of science	0=require less than 3 years	7,825	59.66
	1=require 3 or more years	2,595	19.78
	-1=legitmate skip/missing	2,697	20.56
Total M&S coursework	0 to 17.00	11,315	5.65 (2.19)
Advanced M&S coursework	0 to 5.10	11,315	0.51 (0.88)
Nontraditional value (factor score)	-2.37 to 2.48	11515	0.00 (0.79)
Sex*Nontraditional value	-2.37 to 2.37	11,511	-.03 (0.58)

NOTE: N represents weighted sample size by normalized panel weight F3PNLWT.
SOURCE: National Education Longitudinal Study of 1988 (NELS:88), “Base Year” through “Third Follow-Up” panel data.

B: Descriptive Statistics of Variables Used in Multiple Logistic Regression Analysis of BPS Data (subsample of students enrolled in bachelor S&E programs in the first year of college (n=676)[1]

Variables	Code and Label	Unweighted N	Percentage
Complete a S&E bachelor's degree	(0) Not complete	273	43.1
	(1) (1) Complete	403	56.9
Race/ethnicity	(0) Asian and white	589	86.7
	(1) Underrepresented minority	90	13.3
Gender	(0) Male	452	66.9
	(1) Female	224	33.1
Receive financial aid	(0) Received no financial aid	178	26.3
	(1) Receive some financial aid	498	73.67
Aspire for advanced S&E study	(0) For a bachelor or lower degree	161	23.8
	(1) For an advanced degree	503	74.4
	(-1) Nonresponse	12	1.8
Intellectual confidence	(0) Intellectual self-confidence on average or below	316	46.7
	(1) Intellectual self-confidence above average	360	53.3
Control	(0) Public institution	293	43.3
	(1) Private institution	383	56.7
Delayed college entry	(0) Not delayed college entry	635	93.9
	(1) Delay college entry	41	6.1
Dependent upon family support	(0) Independent on family support	66	9.8
	(1) Dependent on family support	610	90.2
Parents educational Attainment	(0) Parents had no college education	233	34.5
	(1) Parents had some college education	443	65.5
Minority*financial aid	(0) No	604	89.4
	(1) Yes	72	10.7
Female*intellectual confidence	(0) No	566	83.7
	(1) Yes	110	16.3

[1] Missing cases were not included.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students (BPS) Longitudinal Study.

Appendix III: Demographic Characteristics for Subgroup with Missing Value on One or More Variables and Subgroup without any Missing Cases: the NELS:88 BY–F3 Panel Data

	Unweighted number of cases	Underrepresented minorities (percent)	Female (percent)	Parents with college education[1] (percent)
Subgroup with missing values on one or more variables	8,090	29.31	51.42	24.97
Subgroup without missing values on any variable	5,027	18.12	51.66	31.35
Total BY–F3 Panel sample	13,117	25.02	51.51	27.41

[1] There are 23 missing cases on this variable.

NOTE: N represents weighted sample size by normalized panel weight F3PNLWT.

SOURCE: National Education Longitudinal Study of 1988 (NELS:88) “Base Year” through “Third Follow-Up” panel data.

Appendix IV: NELS:88 Data Items and Factor Loadings for Creating the Value-Orientation Scale

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Factor Method: Principal Components

                 Final Communality Estimates: Total = 8.879130
Prerotation Method: Varimax
Orthogonal Transformation Matrix

                                         1          2

                               1      0.82041    0.57178
                               2     -0.57178    0.82041

                              Rotated Factor Pattern

               FACTOR1    FACTOR2

    F2S40B       77|        20        IMPORTANT FINDING RIGHT PERSON TO MARRY
    F2S40H       75|        12        IMPORTANT LIVING NEAR PARENTS, FRIENDS
    F2S40K       73|        14        IMPORTANT HAVING CHILDREN
    F2S40F       69|        28        IMPORTANT TO HELP OTHERS IN COMMUNITY
    F2S40G       69|        31        GIVE OWN CHILDREN BETTER OPPORTUNITIES
    F2S40A       69|        45        IMPORTANT BEING SUCCESSFUL IN LINE WORK
    F2S40D       68|        33        IMPORTANT HAVING STRONG FRIENDSHIPS
    F2S40E       68|        44        IMPORTANT TO BE ABLE TO FIND STEADY WORK
    F2S40O       67|        44        IMPORTANT GETTING GOOD EDUCATION
    F2S40J       55|        41        WORKING TO CORRECT ECONOMIC INEQUALITES
    F2S40L       54|        49        IMPORTANT HAVING LEISURE TIME
    F2S40I       15         82|       IMPORTANT GETTING AWAY FROM THIS AREA
    F2S40M       17         82|       IMPORTANT GETTING AWAY FROM PARENTS
    F2S40C       44         54|       IMPORTANT HAVING LOTS OF MONEY
    F2S40N       52         53|       IMPORTANT BEING EXPERT IN FIELD

NOTE: Printed values are multiplied by 100 and rounded to the nearest integer.
      Values greater than 0.544032 have been flagged by an '*'.

                       Variance explained by each factor

                                 FACTOR1   FACTOR2
                                5.603801  3.275329

                 Final Communality Estimates: Total = 8.879130
```

Appendix V: Demographic Characteristics of the Three BPS Subsamples Used in the Analysis (numbers in parentheses are for missing cases on a given variable)

	Unweighted N	Under-represented minorities unweighted percent	Female unweighted percent	Parents with college education unweighted percent	Mean age as of 12/31/89
Total BPS sample of students (age<30)	6,682	16.41 (15)	54.43 (15)	49.64 (183)	18.92
First-year S&E subsample	859	14.67 (0)	31.90 (0)	52.62 (28)	19.09
First-Year S&E bachelor's subsample	676	12.48 (0)	32.95 (0)	65.17 (7)	19.09

SOURCE: U.S. Department of Education, National Center for Education Statistics, Beginning Postsecondary Students (BPS) Longitudinal Study.