

# UCLA

## UCLA Previously Published Works

**Title**

Undergraduate Science Majors: Gender Differences in Who Goes to Graduate School

**Permalink**

<https://escholarship.org/uc/item/951147p3>

**Journal**

The Review of Higher Education, 24(2)

**ISSN**

0162-5748

**Author**

Sax, Linda J

**Publication Date**

2001

**DOI**

10.1353/rhe.2000.0030

Peer reviewed



Project  
**MUSE**<sup>®</sup>

*Today's Research. Tomorrow's Inspiration.*

---

## **Undergraduate Science Majors: Gender Differences in Who Goes to Graduate School**

Sax, Linda J., 1967-

The Review of Higher Education, Volume 24, Number 2, Winter 2001, pp. 153-172 (Article)

Published by The Johns Hopkins University Press



 For additional information about this article

<http://muse.jhu.edu/journals/rhe/summary/v024/24.2sax.html>

*The Review of Higher Education*

Winter 2001, Volume 24, No. 2, pp. 153–172

Copyright © 2001 Association for the Study of Higher Education

All Rights Reserved (ISSN 0162-5748)

# Undergraduate Science Majors: Gender Differences in Who Goes to Graduate School

*Linda J. Sax*

In the past thirty years, the number of science, math, and engineering (SME)<sup>1</sup> bachelor's, master's, and doctoral degrees awarded to women has increased by 106%, 150%, and 267%, respectively (National Science Foundation, 1995). Although the gender gap has certainly narrowed in these past decades, women have not yet achieved parity. Currently, women are underrepresented among SME degree recipients at all levels, particularly at the graduate level, earning 35% of bachelor's degrees, 26% of master's degrees, and 24% of doctoral degrees (calculated from NSF, 1999, data).

Numerous studies have addressed women's underrepresentation in science, providing many answers to such questions as: Why are young girls

---

Linda J. Sax is Assistant Professor in Residence and Director of the Cooperative Institutional Research Program for the Higher Education Research Institute at UCLA. The data collection was funded by the National Science Foundation, the Ford Foundation, and the Exxon Education Foundation. Funding for analysis in this study was provided by the Alfred P. Sloan Foundation. An earlier version of this paper was presented at the annual meeting of the Association for the Study of Higher Education, April 1996, in Memphis, Tennessee. The author gratefully acknowledges the assistance of Sharon Joyce and Marisol Arredondo with data collection and analysis. Address queries to her at 3039 Moore Hall, UCLA, Los Angeles, CA 90095-1521; telephone: (310) 825-1925; fax: (310) 206-2228; e-mail: LSAX@UCLA.EDU.

<sup>1</sup>SME fields include engineering; physical sciences; earth, atmospheric, and ocean sciences; mathematics and computer science; and biological science.

less interested in science than boys are? What factors discourage women from taking more math and science courses in high school? What types of women choose to major in SME fields in college? And among them, who persists toward the bachelor's degree?

However, fewer studies address the question of persistence in science after the undergraduate years. In some ways, this question is more difficult to answer. Certainly, a student with a bachelor's degree in physics who ultimately earns a physics doctorate can be considered an SME persister. And an engineer-turned-artist can probably be considered a nonpersister in SME. However, what about the undergraduate math major who becomes a junior high school algebra teacher? Or the biology major who becomes a heart surgeon? Certainly these individuals have not abandoned SME fields entirely. For this reason, any study of persistence in SME beyond the undergraduate years must be particularly careful with definitions.

This study defines persistence in SME as the pursuit of a graduate degree in an SME field. This definition purposefully focuses on the development of the talent pool of academic scientists, engineers, and other scientific researchers. More specifically, this study focuses on how predictors of enrollment in SME graduate programs differ between men and women. Although there is no consensus as to whether there is an economic "need" for more research scientists (National Academy of Sciences, 1995), certainly the development of this talent pool should be mindful of equity.

### FACTORS INFLUENCING WOMEN'S INTEREST IN SCIENCE

A significant body of literature has explored women's interest and participation in science throughout elementary, secondary, and higher education (e.g., Frieze & Hanusa, 1984; Higher Education Research Institute, 1992; Matyas, 1985; Oakes, 1990; Rosser, 1990; Seymour & Hewitt, 1994; Sonnert, 1995). Such work has identified several sources of influence on women's decisions to enroll in SME courses or major in SME fields. The most oft-cited explanations for women's lack of participation in SME can be summarized as follows:

1. Lack of early preparation. In junior high and high school, women's interest in math and science declines, and they take significantly fewer math and science courses than men. This differential course-taking prevents many women from majoring in science in college.

2. Lack of parental encouragement. For the most part, parents continue to discourage daughters from pursuing majors and careers in science.

3. Concerns about balancing career with family. Many women resist the pursuit of science because they perceive an SME career as incompatible with raising a family. In fact, research has shown that women's science career attainment and productivity tend to be compromised during child-

bearing and early child-rearing years. This period for most women occurs during the crucial early stages of their career.

4. Negative perceptions about the life of a scientist. Also influencing women's disinterest in science is an image of science careers as lonely, excessively demanding, and relatively unconnected to the improvement of society.

5. Limited access to role models and mentors. Due to the under representation of women in scientific careers, women students encounter fewer potential role models and same-sex mentors than men do.

6. Unwelcoming pedagogy in science. Compared with other faculty, science faculty are less likely to employ teaching styles preferred by women, such as class discussions, cooperative learning techniques, and student-selected topics, and are more likely to rely on lecturing and to enforce competitive grading practices. (See Colbeck, Cabrera, & Terenzini, this issue.)

Despite the abundance of research on factors accounting for women's underrepresentation in science throughout K-12 and undergraduate education, comparatively little is known about the factors affecting women's and men's persistence in science after the undergraduate years.

The issue of post-college commitment to science was addressed by Rayman and Brett (1995), who monitored the early career paths of women who had earned bachelor's degrees in science at a women's college. While their study supported the importance of early math and science preparation, as well as advice and encouragement from significant others (e.g., parents, teachers), some surprising findings did emerge. Most notably, two of the most often-cited predictors of science persistence—grades and self-esteem—did not predict persistence in science after the undergraduate years. Rayman and Brett caution that the generalizability of these findings may be limited, as their sample came from a particular women's college. Further, by including only women, that study could not report the extent to which personal and environmental influences on the pursuit of science careers differ between men and women. Thus, while the Rayman and Brett study was an important first step in understanding women's post-college pursuit of science careers, its conclusions invite more study.

In an earlier study (Sax, 1994a), I also addressed students' long-term interest in science by examining gender differences in the persistence of scientific career aspirations during four years of college. In addition to traditional predictors of science persistence (e.g., greater science preparation and a stronger commitment to scientific inquiry), that study showed that persistence in science could also be determined by students' desires for and motivations about their intended career. In this realm interesting gender differences emerged. For example, the expected likelihood of monetary or status rewards influenced men's career decisions, while women's career decisions were driven by the perceived "social good" of their career choice.

Although that study examined students' intentions to pursue scientific careers after the undergraduate years, the four-year time frame did not allow an examination of which students actually enrolled in SME graduate programs.

### OBJECTIVES

This study expands our understanding of women in science by examining the factors that predict enrollment in SME graduate programs among men and women who have earned SME bachelors' degrees. Based on a longitudinal study of 12,000 students from the 1985 freshman class who were followed-up four and nine years after entering college, this research examines how SME graduate school enrollment is influenced by women's and men's backgrounds, pre-college educational experiences, and undergraduate environments and experiences. As Hollenshead, Wenzel, Lazarus, and Nair (1996) note, longitudinal, multi-institutional studies on women enrolling in SME graduate programs have been noticeably absent from the research.

### METHODS

#### *Data Source and Sample*

I drew my data from a national, longitudinal study of college students conducted at three time points over a nine-year period: 1985, 1989, and 1994. These data were collected as part of the Cooperative Institutional Research Program (CIRP), which is sponsored by the American Council on Education and the Higher Education Research Institute (HERI) at the University of California, Los Angeles. The CIRP annually collects a broad array of information from entering first-year college students using the Student Information Form (SIF), which is designed as a pretest for longitudinal assessments of the impact of college on students. I drew my data from the 1985 SIF administered to first-year students, the 1989 Four-Year Follow-Up Survey, and the 1994 Nine-Year Follow-Up Survey.

The first year and follow-up surveys are ideally suited for science pipeline issues. First, the data are longitudinal, making it possible to measure student change and development directly rather than attempting to infer it from cross-sectional data. Secondly, these three data sets are multi-institutional. Collecting data from a diverse set of undergraduate institutions makes it possible to estimate generalizable institutional effects on student outcomes.

*The Student Information Form.* The Student Information Form (SIF) was distributed to campuses in the spring and summer of 1985 for distribution to college freshmen prior to or during the first few weeks of fall classes. The

1985 SIF includes information on students' personal and demographic characteristics, high school experiences, expectations about college, values, life goals, self-concepts, and career aspirations. A total of 279,985 students at 546 participating colleges and universities completed the SIF.

*The 1989 Four-Year Follow-Up Survey.* In 1989, HERI conducted a longitudinal follow-up of the 1985 first-year students. The 1989 Follow-Up Survey includes information on students' college experiences and their perceptions of college, as well as post-tests of many of the items on the 1985 Freshman Survey. HERI received responses from approximately 27,000 students from over 300 colleges and universities (HERI, 1991). The National Science Foundation (NSF) and the Exxon Education Foundation provided funding for this follow-up.

*The 1994 Nine-Year Follow-Up Survey.* The Nine-Year Follow-Up Survey provides information on graduate school and early career experiences, as well as post-test data on many of the attitudinal and behavioral items appearing on the 1985 and 1989 surveys. The Exxon Education Foundation and Ford Foundation funded this follow up. The Nine-Year Follow-Up sample includes 17,783 students (7,423 men and 10,360 women) who entered 224 undergraduate institutions in 1985.

My study draws from a database of students who completed all three questionnaires (1985, 1989, and 1994)—a total of 12,376 students (5,019 men and 7,357 women) at 209 institutions. I limited my analyses to the 2,563 students (1,537 men and 1,026 women) from that sample who earned a bachelor's degree in an SME field, since they were the most likely to enroll in SME graduate programs.

## RESEARCH METHODS

This study uses the "input-environment-outcome" (I-E-O) research model employed previously in a number of longitudinal studies (Astin, 1991, 1993a; Sax, 1994a, 1994b, 1996). This methodological framework allows the researcher to examine the impact of various environments and experiences on individual outcomes, after controlling for preexisting differences among individuals. I used the I-E-O model to analyze the impact of college on enrollment in SME graduate programs, controlling for students' pre-college (input) characteristics, such as high school grades and career aspirations.

First, descriptive analyses examine the rates of graduate school attendance (both SME and non-SME) separately for men and women from four undergraduate SME fields: biological sciences, engineering, physical sciences, and math/computer sciences. These analyses are important to highlight differences in graduate school enrollment patterns among students who come from different undergraduate SME fields.

I next conducted multivariate analyses in two stages. First, I conducted blocked stepwise regression analyses utilizing all variables separately for men and women to explore which student background characteristics and undergraduate environments and experiences predict enrollment in SME graduate programs. In light of the large number of independent variables (47) included in these preliminary analyses, I set tolerance protection at .30 to guard against potential problems resulting from multicollinearity. Based on the results of these exploratory regressions, I conducted a second set of regression analyses using only the independent variables that added significantly to the prediction of SME graduate enrollment for either the male or female subsample. To compare men to women, these analyses included identical blocks of variables that were force-entered into the regression equations for each group. (The coding scheme for these variables appears in Appendix A.)

### *Variables*

The dependent variable used in this study is enrollment in an SME graduate program. SME programs include the biological sciences, engineering, the physical sciences, and mathematical and computer sciences. Graduate enrollment information is based on students' self-reported current or most recent graduate/professional school and major on the 1994 nine-year follow-up survey.

In accordance with the I-E-O model, I blocked independent variables in the temporal sequence in which they may have an effect on enrollment in SME graduate programs: (a) student input characteristics, (b) institutional characteristics, (c) undergraduate experiences, and (d) career and life goals.

Input characteristics (block 1) include student background measures, such as race, socioeconomic status, and parents' career. Inputs also include characteristics of the student before or at the point of college entry that may influence the post-college decision to enroll in an SME graduate program. These characteristics include SAT scores, high school grades, career aspirations, and high school science preparation. The input block also includes a set of six personality "typologies" based on students' self-concept, aspirations, personal goals, and behaviors: Scholar, Social Activist, Artist, Status Striver, Leader, and Hedonist. These typologies were derived from factor analyses of sixty items from the 1985 Freshman Survey (see Appendix B and Astin, 1993b, for additional details).

Measures of the college environment (block 2) include structural characteristics of undergraduate institutions (size, type, and control) as well as characteristics of the 1985 entering students at each college (calculated from institutional mean responses to first-year survey variables), such as peer scientific orientation.



Undergraduate experiences are included in block 3. These include measures of academic and nonacademic experiences, including grades earned, satisfaction with the major, time spent studying, interaction with students, and interaction with faculty.

Career and life goals are included in block 4. These include a set of nine possible reasons for pursuing one's intended career (e.g., because it pays well, because it is challenging, etc.), as well as two life goals found in previous research to predict SME persistence at the undergraduate level: desire to raise a family and desire to make a theoretical contribution to science (Sax, 1994a).

## RESULTS

Table 1 presents graduate school enrollment patterns (for the pursuit of either a master's degree or a Ph.D.) for students from each of the four undergraduate science fields. Among all SME undergraduates, a total of 25.9% of women and 32.6% of men ultimately enrolled in SME graduate programs. Students from engineering and the physical sciences are most likely to enroll in SME graduate programs, followed by students from the biological and mathematical/computer sciences. While there are no gender differences in the likelihood of enrollment in SME graduate programs among students from either the biological sciences or engineering, men from the physical and mathematical/computer sciences are more likely than women from those fields to pursue SME graduate education. The difference is most striking in math/computer sciences, with 30.0% of men pursuing SME graduate degrees, compared with 12.4% of women.

Of course, not all students who enroll in SME graduate programs intend to earn a Ph.D. While the Ph.D. is commonly sought by graduate students in the physical sciences (77.9%) and biological sciences (62.8%), only 31.4% of engineering graduate students reported that the Ph.D. was their goal. In the mathematical/computer sciences, there is equal interest in master's and doctoral degrees (47.1 and 46.6%, respectively).

Table 2 displays the graduate fields most commonly selected by SME undergraduates who attend graduate school. (Only percentages greater than 4.0 are displayed.) Among undergraduate biological science majors, medicine is the most commonly selected graduate field, particularly among men (52.0%, compared with 36.8% of women). After medicine, 19.9% of men and 25.7% of women choose biological science graduate programs. Other graduate fields selected by undergraduate biological science majors include education (both men and women) and business (men only).

Among students earning bachelors' degrees in engineering, the overwhelming choice of graduate major is engineering (54.2% of women, 57.2% of men). Other graduate fields selected by engineering undergraduates in-

**TABLE 1**  
**UNDERGRADUATE TO GRADUATE TRANSITION**  
 (Weighted <sup>a</sup> percentages)

<i>Undergraduate Major</i>	<i>Unweighted N</i>	<i>Percent Enrolling in SME Graduate Program</i>	<i>Percent Enrolling in Other Graduate Program</i>	<i>Percent Not Attending Graduate School</i>
<u>All SME majors</u>				
Women	1,026	25.9	40.6	33.5
Men	1,537	32.6	29.8	37.7
<u>Biological sciences<sup>b</sup></u>				
Women	465	17.2	43.1	39.7
Men	330	17.4	44.3	38.2
<u>Engineering<sup>c</sup></u>				
Women	218	32.2	17.4	50.3
Men	772	32.1	18.5	49.4
<u>Physical sciences<sup>d</sup></u>				
Women	126	28.0	23.8	48.3
Men	204	32.9	28.3	38.7
<u>Mathematical/Computer Sciences<sup>e</sup></u>				
Women	217	12.4	23.8	64.1
Men	231	30.0	16.7	53.2

<sup>a</sup>Responses are weighted to compensate for response bias and sampling bias within the sample of 12,376 respondents. Weighted counts approximate the results we would expect to receive if the nine-year follow-up survey was completed by the 1.5 million students enrolling as first-time, full-time students in the fall of 1985.

<sup>b</sup>Includes general biology, biochemistry/biophysics, botany, marine (life) science, microbiology/bacteriology, zoology, and other biological science.

<sup>c</sup>Includes aeronautical/astronautical, civil, chemical, electrical/electronic, industrial, mechanical, and other engineering.

<sup>d</sup>Includes astronomy, atmospheric science (including meteorology), chemistry, earth science, marine science (including oceanography), physics, and other physical science.

<sup>e</sup>Includes mathematics, statistics, and computer science.

clude business, medicine, math/computer science, and law. There is essentially no gender difference in the choice of graduate major among undergraduate engineers, with the exception of the somewhat greater interest in math/computer sciences among women.

Physical science undergraduates, particularly women, select a more diverse range of graduate majors than other SME undergraduates. While 48.9% of men choose to major in the physical sciences in graduate school, only 28.6% of women do. Additional fields chosen by both men and women include medicine, engineering, and business, with women more likely than men to select each of these fields. Women, but not men, select biological

**TABLE 2**  
**MOST POPULAR GRADUATE MAJORS AMONG SME**  
**UNDERGRADUATES ATTENDING GRADUATE SCHOOL**  
 (Weighted <sup>a</sup> percentages)

<i>Undergraduate Major</i>	<i>Graduate Major Selected</i>	
	<i>Women (%)</i>	<i>Men (%)</i>
Biological science	Medicine/Vet. (36.8) Biological science (25.7) Education (6.2)	Medicine/Vet. (52.0) Biological science (19.9) Business (4.6) Education (4.5)
Engineering	Engineering (54.2) Business (17.2) Math/Comp. sciences (10.1) Medicine/Vet. (4.9) Law (4.8)	Engineering (57.2) Business (14.9) Medicine/Vet. (5.0) Law (4.9) Math/Comp. sciences (4.8)
Physical sciences	Physical sciences (28.6) Medicine/Vet. (18.2) Biological science (10.9) Engineering (10.8) Business (10.3) Pharmacy (5.5) Math/Comp. sciences (4.5)	Physical sciences (48.9) Medicine/Vet. (15.6) Education (13.2) Business (7.0) Engineering (5.0)
Math/Computer sciences	Education (31.3) Math/Comp. sciences (30.6) Business (24.8)	Math/Comp. sciences (57.6) Business (20.1) Engineering (6.6)

<sup>a</sup>Responses are weighted to compensate for response bias and sampling bias within the sample of 12,376 respondents. Weighted counts approximate the results we would expect to receive if the nine-year follow-up survey was completed by the 1.5 million students enrolling as first-time, full-time students in the fall of 1985.

sciences, pharmacy, and math/computer sciences. Interestingly, male physical science undergraduates are more likely than women to enroll in education graduate programs.

Among students majoring in mathematical/computer sciences as undergraduates, the most popular graduate majors for both men and women are math/computer science, education, and business; engineering is selected only by men. What is perhaps most striking is that among math/computer science undergraduates, far more men than women go into math/computer science graduate programs (57.6% of men versus 30.6% of women), while

**TABLE 3**  
**PREDICTING SME GRADUATE ENROLLMENT:**  
**REGRESSION RESULTS FOR WOMEN AND MEN**

Variable	Women		Men	
	<i>r</i>	<i>b</i> (Beta)	<i>r</i>	<i>b</i> (Beta)
<u>Input Characteristics</u>				
High school GPA	.12	.02 (.06)	.13	.00 (.01)
Student's probable career: science	.21	.15** (.16)	.14	.15** (.16)
Scholar typology	.11	.00 (.02)	.15	.01** (.08)
Social activist typology	-.09	-.02* (-.08)	-.01	.00 (.01)
Status striver typology	-.04	.00 (.03)	-.09	-.01* (-.06)
Race: nonwhite	-.01	-.03 (-.02)	-.10	.11** (-.07)
Father's career: science	.05	.03 (.03)	.08	.05 (.04)
		(R2 = .06)		(R2 = .07)
<u>Institutional Characteristics</u>				
Peer mean: scientific orientation	.15	.40** (.17)	.04	.17* (.07)
Four-year college	.03	.07* (.08)	-.02	.02 (.02)
Percent women students	-.04	.00 (.02)	.05	.00* (.07)
		(R2 = .09)		(R2 = .08)
<u>Undergraduate Experiences</u>				
Interaction with faculty	.14	.01** (.13)	.12	.01** (.08)
College GPA	.17	.04** (.10)	.24	.08** (.16)
Hours/week studying, homework	.12	.02 (.05)	.08	.02* (.05)
Hours/week socializing with friends	-.04	-.01 (-.03)	-.08	-.03** (-.08)
		(R2 = .13)		(R2 = .13)
<u>Career and Life Goals</u>				
Goal: raise a family	-.13	-.04** (-.09)	-.04	-.01 (-.02)
Goal: make theoretical contribution to science	.24	.11** (.24)	.22	.10** (.21)
Reason for career choice: enjoy working with people in the field	-.09	-.01 (-.02)	-.07	-.05** (-.10)

Reason for career choice: Work is interesting	.02	.00 (.00)	.08	.07** (.09)
Reason for career choice: Pays well	-.08	-.04** (-.09)	-.16	-.06** (-.11)
Reason for career choice: Work is challenging	.04	.00 (.00)	.00	-.05* (-.07)
Reason for career choice: Can make a contribution to society	-.04	-.04** (-.09)	.02	-.02 (-.04)
		(R2 = .20)		(R2 = .20)

\*p &lt; .05

\*\*p &lt; .01

significantly more women than men choose education (31.3% of women versus 5.0% of men).

### *Regression Analyses*

I conducted preliminary stepwise regression analyses separately for men and women using the full set of 47 independent variables. A total of 21 variables contributed significantly to the prediction of SME graduate enrollment for either group. To more adequately compare results for men and women, I then conducted regression analyses using only those 21 variables, which I forced into separate-gender equations in the four blocks specified earlier: input characteristics (7 variables), institutional characteristics (3 variables), undergraduate experiences (4 variables), and career and life goals (7 variables).

Table 3 provides final regression results for each group, including simple correlations, unstandardized and standardized regression coefficients, and the cumulative percentage of variance accounted for by the inclusion of each block of variables (R2). It is important to remember that because regression analyses include only students who earned a bachelor's degree in SME, variables significantly related to the dependent variable distinguish science majors who pursue SME graduate degrees from science majors who do not. This is, of course, quite a different question than asking which factors predict enrollment in SME graduate programs for all college students.

For both men and women, each of the four blocks of variables contributes significantly to predicting SME graduate enrollment. The full set of independent variables accounts for a total of 20% of the variance in the dependent variable. Further, among input characteristics (block 1), only one variable significantly predicts SME graduate enrollment for both men and women: first-year science career aspirations. This result is not surprising and simply highlights the importance of early career aspirations in students' ultimate career choice. For women, only one other input variable

contributes significantly to SME graduate enrollment: the negative effect of the Social Activist personality type. This finding suggests that undergraduate women science majors who are more strongly committed to effecting social change and to helping others in difficulty are less likely to pursue an SME graduate degree. This result is consistent with findings from earlier work that women who are more concerned with the “social good” of their career choice tend not to persist in science during the undergraduate years (Sax, 1994a).

Three input characteristics contribute significantly toward predicting SME graduate enrollment for men only. The first is the positive effect of the Scholar personality type, suggesting that male undergraduate science majors who are more academically ambitious and self-confident are more likely to enroll in SME graduate programs. Next is the negative effect of the Status Striver personality type. Apparently, among male undergraduate science majors, those who strive toward positions of authority, responsibility, and wealth are deterred from enrolling in SME graduate programs. This latter finding echoes previous research showing that men’s persistence in science at the undergraduate level is inhibited by the perception that science careers do not lead to high-status positions or financial success (Sax, 1994a). Finally, being nonwhite has a significant negative effect on the decision to enroll in SME graduate programs, a finding which certainly reflects the progressive underrepresentation of minority students at each step in the science pipeline.

Of the three institutional characteristics (block 2) that were included in the final analysis, only one significantly predicted SME graduate enrollment for both groups: the positive effect of the peer group’s orientation toward science. This variable represents the average level of interest in science among students in the same cohort at each undergraduate institution. Interestingly, the effects of this variable are more than twice as strong for women as they are for men, suggesting that a peer group that values science is particularly critical in promoting the scientific aspirations of women students. Similar findings have been reported for women’s persistence in science at the undergraduate level (HERI, 1992).

For women only, attendance at four-year colleges (as opposed to universities) promotes SME graduate enrollment. This result is in line with Bielby’s (1978) finding that women are more likely to pursue male-dominated fields if they attend liberal arts colleges.

A rather surprising result is the positive effect—for men only—of attending an undergraduate institution with a high proportion of women. One might expect that the percentage of women in the institution would have a positive effect on women’s pursuit of SME graduate degrees; instead, we find that only men are positively affected by this aspect of the environment. One possible explanation for this finding relates to the grades earned

in college, since it has been shown that men—but not women—earn higher grades in institutions enrolling greater numbers of women (Sax, 1996). It is possible that gender composition indirectly promotes men's interest in SME graduate programs through its effect on college grades. However, further analysis of the data in this study shows that this indirect effect accounts for some, but not all, of the effect of gender composition. Certainly, more research is needed to better understand the type of environment that is created when more women are enrolled at an institution.

Among undergraduate experiences (block 3), two positively predict SME graduate enrollment for both men and women: college grades and interaction with faculty. Clearly, undergraduate science majors who do well in their classes and spend time with faculty both in and out of the classroom will be more interested in pursuing graduate degrees in SME. In the case of faculty interaction, it may be that spending time with faculty (e.g., working on a professor's research project, assisting faculty in teaching a class, and being a guest in a professor's home) promotes interest in scientific careers by giving students a closer look at the life of academic scientists, while maximizing the opportunity for faculty to directly encourage students to attend graduate school. Other research does in fact show that interaction with faculty promotes students' interest in and commitment to a career in science (Astin, 1993b; Pascarella & Terenzini, 1991).

Two additional undergraduate experiences predict SME graduate school enrollment for men only: the positive effect of hours per week spent studying or doing homework, and the negative effect of hours per week spent socializing. The positive effects of doing homework are not surprising, and in fact are significant for women at the .07 level. The negative effects of socializing, however, are unique to men and are, in fact, quite interesting. This result certainly raises the question of direction of effect: Does the long-term commitment to a scientific career discourage men from spending more time socializing as undergraduates or does spending less time socializing keep these students focused on their SME aspirations? While the temporal order of these events cannot be firmly established from the data, it is certainly worth noting that the negative relationship between time spent socializing and the pursuit of SME graduate degrees does not emerge for women students.

Among variables in block 4, two serve as significant predictors of SME graduate enrollment for both men and women. The first is the positive effect of being committed to making a theoretical contribution to science. The importance of a commitment to science has been reported in other studies on science persistence (Sax, 1994a; Seymour & Hewitt, 1994; Sonnert, 1995). However, my study demonstrates that even among students who have already persisted toward an SME bachelor's degree (an achievement which itself symbolizes science commitment), the decision to pursue an SME

graduate degree is further influenced by a genuine commitment to science. Next, choosing a career because it pays well is negatively related to the decision to pursue SME graduate degrees. Clearly, science majors who are more concerned with the lucrative aspects of a career will be deterred from pursuing a graduate degree in science.

Two additional career and life goals are significant only for women. First, women SME majors are less likely to pursue a graduate degree in science if they place a high priority on raising a family. This finding is consistent with results reported in studies of undergraduate science persistence (Sax, 1994a; Seymour & Hewitt, 1994). Second, women are also less likely to pursue SME graduate degrees if their career decisions are based on the desire to "make a contribution to society." Like the effects of the Social Activist personality type reported in the input block, this finding suggests that women who are committed to making a social "contribution" are deterred from pursuing SME careers requiring graduate-level education.

Three variables in the final block are significant only in predicting men's SME graduate enrollment. First, men who choose a career because they believe people in the field would be enjoyable to work with are less likely to pursue an SME graduate degree. This finding echoes the earlier finding that men who spend more time socializing are less likely to enroll in SME graduate programs. Next, a somewhat contradictory set of findings emerges: Men who choose a career because they believe it would be "interesting" are more likely to pursue SME graduate degrees, while those who choose a career because they believe the work would be "challenging" are less likely to pursue these degrees. While the reasons for this finding are not immediately clear, one possibility is that these students equate "challenging" work with "difficult" work; those who perceive science careers as more difficult will choose not to pursue SME at the graduate level. Another possible interpretation is that non-SME careers present a welcome challenge to those men who have already completed undergraduate SME programs.

### *Limitations*

Although this study provides insight into men's and women's decisions to pursue SME at the graduate level, it also has some important limitations. First, the size of the sample does not permit an exploration of how the decision to attend graduate school varies across undergraduate SME majors. We do not know, for example, if the reasons to enroll in a graduate program in math differ from the reasons to enroll in an engineering graduate program. Second, this study does not explore SME persistence beyond the point of graduate school enrollment. It is vital to know whether men and women actually obtain the graduate degrees to which they aspire. Further, are there gender differences in the obstacles faced during the pursuit of SME graduate degrees? Finally, by relying only on quantitative data, this



study cannot report on the many other possible influences on students' graduate school choice. Given that the variables in this study account for only 20% of the variance in men's and women's SME graduate enrollment, future research should consider what other factors contribute to this decision and how such factors might differ by gender and major field.

### CONCLUSION

This study explored the student characteristics and undergraduate environments and experiences that lead men and women who have earned a bachelor's degree in science, mathematics, or engineering to enroll in SME graduate programs. It is important to remember that this study focuses on a particular form of persistence—toward a graduate degree in science, math, or engineering. Not pursuing an SME graduate degree does not necessarily indicate an abandonment of the science field. Among biological science undergraduates who attend graduate/professional school, more than half of men and more than one-third of women choose the field of medicine. Similarly, education is a popular graduate school major, particularly for women from undergraduate math/computer science programs. Given the continuing need for K-12 teachers with strong math/science backgrounds, it would be difficult to take the position that SME students who become educators have “abandoned” science. Indeed, one might argue that they will serve to better train the scientists and engineers of tomorrow.

Nevertheless, in understanding what does predict enrollment in SME graduate programs, several variables emerged as influential for both men and women. In particular, undergraduate science majors are more likely to continue the study of SME if they have a genuine commitment to scientific inquiry, an undergraduate peer environment that values science, and higher levels of academic involvement in college. The fact that these predictors have also emerged in previous research on science persistence at the undergraduate level (Sax, 1994a) reinforces their continued influence at the graduate level. Another important influence on both men's and women's career decisions is the desire to make money. Those who aspire to high-paying careers turn away from science, even if they have persisted in science through the undergraduate level.

Results also suggest some important gender differences in the factors predicting enrollment in SME graduate programs, most notably in students' motivations for their careers. Confirming what previous research on undergraduate SME persistence has shown, men and women have somewhat different motivations guiding their choice of a career. Driving many men away from the pursuit of SME graduate degrees are their desires for status and authority and their wish for employment in fields where they enjoy working with their colleagues. For women, the desires to influence social

change, make a contribution to society, and raise a family influence the decision not to continue with SME at the graduate level.

The policy implications of these results depend in part on how these gender differences are interpreted. Sonnert (1995) describes two different and somewhat competing interpretations for women's underrepresentation in science. The first and most common explanation is the "deficit model," which describes men and women as having the same basic goals, skills, and desires with respect to science. However, women are disadvantaged by structural obstacles, such as lower-status positions, lower pay, and limited access to key social and professional networks. Awareness of these structural obstacles reportedly deters many potential women scientists from pursuing a science career. Policy recommendations stemming from the deficit model usually promote greater access to such resources as fellowships, mentorships, internships, or specific programs designed to support women's participation in science.

The second and more controversial perspective is the "difference model," which suggests that, whether by genetics or socialization, men and women have inherently different preferences and aspirations. For example, women's less aggressive nature and greater sense of responsibility for the home and family are seen as discouraging them from pursuing a career in science. Policy recommendations emanating from the difference model would aim at changing the scientific profession itself, perhaps through efforts at "feminizing" the culture of science.

Although most policies designed to promote women's participation in science are consistent with the deficit model, results of this study suggest the importance of acknowledging inherent gender differences. Therefore, we must consider ways in which the climate in SME might be improved to be more welcoming for women.

First, how might science better retain those women who are interested in science but who find science incompatible with their interest in making a contribution to society? Clearly, K-12 and undergraduate education can better educate women (and ideally all students) about the many ways in which scientific work aims at improving society and the human condition, particularly in an era of rapidly expanding computer and biological technologies. Carefully placing students in internships and mentorships is also an important mechanism for exposing students to ways in which scientific research goes beyond the abstract and theoretical by addressing societal issues and needs.

Second, we must consider how science can be more accommodating for women who want to balance raising a family with a career in science. Even as undergraduates, women are seemingly aware of the challenges they will likely face attempting to build successful careers in science during their peak

childbearing years. To attract more talented women into science, the scientific workplace must become more sensitive to women's particular needs, including offering more flexible hours and child-care arrangements. Women on the academic tenure track should be given the option of stopping or slowing the tenure clock during childbearing and early child-rearing years. Although many men also face the challenge of balancing family with career, these policy changes are particularly important for women, since they continue to take on the lion's share of family responsibilities.

Nevertheless, educators and policy makers must also be realistic when encouraging women (and men) to pursue careers in science. The past decade has produced an oversupply of science Ph.D.s who aspire to faculty ranks, resulting in a rising percentage of young scientists who must settle for temporary appointments and nontenure track positions (National Research Council, 1998). Scientists today also face an increasingly competitive market for research funds, fueling even more frustration about the lack of financial rewards in science—a concern evident in the results of this study. In addition, women Ph.D.s in science continue to earn less than their male counterparts (Malcolm, George, & Van Horne, 1996). Therefore, while we must continue to strive toward equity and an improved climate for women in the sciences, we must also remember to caution prospective scientists about the realities of these fields.

## APPENDIX A

### VARIABLE DEFINITIONS AND CODING SCHEME

#### Dependent Variable

Enrolling in SME graduate program	Dichotomous: 1 = no, 2 = "yes"
<u>Input Characteristics (Block 1)</u>	Eight-point scale: 1 = "D" to 8 = "A or A+"
High school GPA	
Student's probable career: science	Includes college teacher, computer programmer or analyst, engineer, scientific researcher and statistician.
Scholar typology	Six-item factor scale (Appendix B)
Social activist typology	Four-item factor scale (Appendix B)
Status striver typology	Five-item factor scale (Appendix B)
Race: nonwhite	Dichotomous: 1 = no, 2 = "yes"
Father's career: science	Includes computer programmer or analyst, engineer, scientific researcher and statistician

#### Institutional Characteristics (Block 2)

Peer mean scientific orientation	Three-item factor scale (Appendix B)
----------------------------------	--------------------------------------

Percent women students Four-year college	Percent enrollment of women studies Dichotomous: 1 = no, 2 = "yes"
<u>Undergraduate Experiences (Block 3)</u>	
Interaction with faculty	Nine-item factor scale (Appendix B)
College GPA	Six-point scale; 1 = "C- or less," to 6 = "A"
Hours/week studying, homework	Eight-point scale: 1 = "none," to 8 = "over 20"
Hours/week socializing with friends	Eight-point scale: 1 = "none," to 8 = "over 20"
<u>Career and Life Goals (Block 4)</u>	
Goal: raise a family	Four-point scale: 1 = "not important", to 4 = "essential"
Goal: make theoretical contribution to science	Four-point scale: 1 = "not important", to 4 = "essential"
Reason for career choice: enjoy working with people in field	Four-point scale: 1 = "not important", to 4 = "essential"
Reason for career choice: work interesting	Four-point scale: 1 = "not important", is to 4 = "essential"
Reason for career choice: pays well	Four-point scale: 1 = "not important", to 4 = "essential"
Reason for career choice: work challenging	Four-point scale: 1 = "not important", is to 4 = "essential"
Reason for career choice: Can make a contribution to society	Four-point scale: 1 = "not important", to 4 = "essential"

## APPENDIX B

### ITEMS CONSTITUTING FACTOR SCALES

#### Scholar Typology

- Self-rated academic ability (self-rating)<sup>1</sup>
- Self-rated math ability (self-rating)<sup>1</sup>
- Intellectual self-confidence (self-rating)<sup>1</sup>
- Graduated high school with honors (expectation)<sup>2</sup>
- Elected to honor society (expectation)<sup>2</sup>
- Highest degree planned (aspiration)<sup>3</sup>

#### Social Activist Typology

- Influence political structure (life goal)<sup>4</sup>
- Influence social values (life goal)<sup>4</sup>
- Help others in difficulty (life goal)<sup>4</sup>
- Participation in community action program (life goal)<sup>4</sup>

#### Status Striver Typology

- Become authority in own field (life goal)<sup>4</sup>
- Obtain recognition from colleagues (life goal)<sup>4</sup>
- Have administrative responsibility (life goal)<sup>4</sup>

Be very well off financially (life goal)<sup>4</sup>  
 Be successful in own business (life goal)<sup>4</sup>

#### Peer Mean Scientific Orientation

Scientific researcher (career choice (yes/no))  
 College teacher (career choice (yes/no))  
 Make a theoretical contribution to science (life goal)<sup>4</sup>

#### Interaction with Faculty

Worked on professor's research (yes/no)  
 Assisted faculty in teaching class (yes/no)  
 Been guest in professor's home (yes/no)  
 Talk with faculty outside class (hours per week)<sup>5</sup>  
 Many opportunities for faculty-student socializing (opinion)<sup>6</sup>  
 Easy to see faculty outside office hours (opinion)<sup>6</sup>  
 Little contact between students and faculty (opinion)<sup>6</sup>  
 Opportunity to talk to professors (satisfaction)<sup>7</sup>  
 Contact with faculty/administration (satisfaction)<sup>7</sup>

NOTE: Detailed descriptions of factors are reported in Astin (1993b).

<sup>1</sup>Five-point scale: 1 = "lowest 10%," to 5 = "highest 10%"

<sup>2</sup>Four-point scale: 1 = "no chance," to 4 = "very good chance"

<sup>3</sup>Five-point scale: 1 = "no degree," 2 = "vocational certificate, associate's degree, or other,"  
 3 = "bachelor's degree or divinity degree (B.D. or M.Div)," 4 = "master's degree," 5 =  
 "doctorate degree (Ph.D., Ed.D, M.D., D.O., D.D.S., D.V.M., LL.B, or J.D.)"

<sup>4</sup>Four-point scale: 1 = "not important," to 4 = "essential"

<sup>5</sup>Eight-point scale: 1 = "none," to 8 = "over 20"

<sup>6</sup>Four-point scale: 1 = "disagree strongly," to 4 = "agree strongly"

<sup>7</sup>Four-point scale: 1 = "dissatisfied," to 4 = "very satisfied"

## REFERENCES

- Astin, A. W. (1991). *Assessment for excellence*. New York: Macmillan Publishing.
- Astin, A. W. (1993a). *What matters in college? Four critical years revisited*. San Francisco: Jossey-Bass.
- Astin, A. W. (1993b). An empirical typology of college students. *Journal of College Student Development*, 34, 36-46.
- Bielby, D. (1978). Career sex-atypicality and career involvement of college women: Baseline evidence from the 1960s. *Sociology of Education*, 51(1), 7-28.
- Frieze, I. H., & Hanusa, B. H. (1984). Women scientists: Overcoming barriers. *Advancements in Motivation and Achievement*, 2, 139-163.
- Higher Education Research Institute. (1991). *The American college student, 1989: National norms for 1985 and 1987 college freshmen*. Los Angeles: Higher Education Research Institute.
- Higher Education Research Institute. (1992). *Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences*. Los Angeles: Higher Education Research Institute, UCLA.

- Hollenshead, C. S., Wenzel, S. A., Lazarus, B. B., & Nair, I. (1996). The graduate experience in the sciences and engineering: Rethinking a gendered institution. In C. S. Davis, A. B. Ginorio, C. S. Hollenshead, B. B., Lazarus, P. M. Rayman, & Associates (Eds.), *The equity equation: Fostering the advancement of women in the sciences, mathematics, and engineering* (pp. 122-162). San Francisco: Jossey-Bass.
- Malcolm, S. M., George, Y. S., & Van Horne, V. V. (Eds.). (1996). *The effect of the changing policy climate on science, mathematics, and engineering (SME) diversity*. Washington, DC: American Association for the Advancement of Science.
- Matyas, M. L. (1985). Factors affecting female achievement and interest in science and scientific careers. In J. B. Kahle (Ed.), *Women in science: A report from the field* (pp. 77-101). Philadelphia: Falmer Press.
- National Academy of Sciences. (1995). *Reshaping the graduate education of scientists and engineers*. Washington, DC: National Academy Press.
- National Research Council (1998). *Trends in the early careers of life scientists*. Washington, DC: National Academy Press.
- National Science Foundation. (1995). *Science and engineering degrees: 1966-93*. (NSF 95-312). Arlington, VA: National Science Foundation.
- National Science Foundation. (1999). *Women, minorities, and persons with disabilities in science and engineering: 1998*. (NSF 99-87). Arlington, VA: National Science Foundation.
- Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. *Review of Research in Education*, 16, 153-222.
- Pascarella, E. T., and Terenzini, P. T. (1991). *How college affects students*. San Francisco: Jossey-Bass.
- Rayman, P., & Brett, B. (1995). Women science majors: What makes a difference in persistence after graduation? *Journal of Higher Education*, 66(4), 388-414.
- Rosser, S. V. (1990). *Female-friendly science: Applying women's studies methods and theories to attract students*. New York: Pergamon Press.
- Sax, L. J. (1994a). Retaining tomorrow's scientists: Exploring the factors that keep male and female students interested in science careers. *Journal of Women and Minorities in Science and Engineering*, 1(1), 45-61.
- Sax, L. J. (1994b). Mathematical self-concept: How college reinforces the gender gap. *Research in Higher Education*, 35(2), 141-166.
- Sax, L. J. (1996). The dynamics of tokenism: How college students are affected by the proportion of women in their major. *Research in Higher Education*, 37(3): 389-426.
- Seymour, E., & Hewitt, N. (1994). *Talking about leaving: Factors contributing to high attrition rates among science, mathematics, and engineering undergraduate majors*. Final Report to the Alfred P. Sloan Foundation. Boulder, CO: University of Colorado, Bureau of Sociological Research.
- Sonnert, G., with Holton, G. (1995). *Who succeeds in science? The gender dimension*. New Brunswick, NJ: Rutgers University Press.