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RETAINING TOMORROW'S SCIENTISTS: EXPLORING THE FACTORS THAT KEEP MALE AND FEMALE COLLEGE STUDENTS INTERESTED IN SCIENCE CAREERS

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The underrepresentation of women in science and engineering is usually attributed to the experiences of young women during the elementary and secondary years. Although numerous studies document how women are lost from science during these critical years, it is also important to know what happens to the minority of women who, at the point of college entry, intend to pursue careers in the sciences. Using a national sample of 6,251 men and 9,268 women, this study examines college students' initial interest in scientific careers, the factors that influence science career choice during college, as well as how these factors may differ between men and women. Results indicate that variables traditionally used to predict science persistence (such as ability, self-concept, and preparation) have similar effects for both men and women. However, because this study incorporates an extensive array of variables that have not been included in previous research, a number of interesting differences emerge between men and women. Specifically, findings suggest that for men, the decision to abandon scientific career aspirations is driven by financial concerns, whereas women who decide not to persist toward scientific careers appear to be more concerned with the "social good" of their career choice.

INTRODUCTION

Considering that women constitute only 15% of the nation's scientists and engineers (National Science Foundation, 1988), it is not surprising that the underrepresentation of women in science, math, and engineering fields has been the focus of much research in recent decades. The relatively low participation rates of women in these fields has been attributed to a myriad of explanations, including innate ability, biology, elementary and secondary preparation, and sex-role socialization (Matyas, 1992; Oakes, 1990a; Vetter, 1989). However, even when many of these proposed factors have been controlled, women's likelihood of persisting in science fields during college is still below that of men's (Higher Education Research Institute, 1991).

What is needed, then, is an understanding of what additional factors may be inhibiting women's scientific aspirations. This study examines career choices among men and women who, as college freshmen, intended to pursue science careers, and incorporates an extensive array of data from a national, longitudinal survey of college students. The database includes information on students' personal and educational background, their differential college environments, as well as numerous behavioral

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and perceptual factors that influence career choice during college. Regression analyses explore how these personal and environmental factors shape students' likelihood of maintaining their commitment to careers in science, as well as how these factors may differ between men and women. Because this study explores many variables that have not been included in previous research, results provide some unique insights into how previously unexplored factors relate to college students' persistence in science.

BACKGROUND OF THE STUDY

Oakes (1990b) describes the underrepresentation of women in science as a reflection of their declining participation in science throughout the educational pipeline. In elementary school, girls and boys exhibit relatively equal math and science abilities, yet girls express less interest in these fields. By junior high school, achievement of girls and boys is still comparable within math and science courses, but girls are taking fewer of these courses than boys. By senior high school, women are taking significantly fewer courses in math and science than are men (Dearman & Plisko, 1981; Frieze & Hanusa, 1984; Matyas, 1985a, 1992). Lower levels of preparation inherently preclude many women from pursuing scientific fields in college, since high school math and science courses are usually prerequisites for college science programs (Brush, 1985; Oakes, 1990a, 1990b; Vetter, 1989).

Women's entry into science fields is also hindered by their exhibiting lower levels of academic and mathematical confidence than men (Frieze & Hanusa, 1984; Humphreys, 1984; MacCorquodale, 1984; Matyas, 1985a). Women's underestimation of their math abilities is of special importance for scientific career development. Even when women perform slightly better than men on tests of math ability, they express lower levels of math confidence than do men (Marsh, Smith, & Barnes, 1985; Sherman, 1983). The link between math confidence and science persistence is described by Ethington (1988), who provides evidence that math self-confidence is the most influential predictor of women's SAT math scores, as well as of their decision to pursue math and science fields in college. Due in part to a gender gap in math confidence, differences between men and women in math performance begin to appear by the end of high school, as is evidenced by women's lower math scores on the SAT and Achievement tests (Oakes, 1990b). Because performance on these standardized tests has been linked to women's entry into science fields (Matyas, 1985b; Peng & Jaffe, 1979), the importance of math confidence and preparation is emphasized even further.

Other factors that may inhibit women's choice of a career in science are the status differentials between men and women in science fields. Women earn less than men at every level within science careers (Cole, 1981; Humphreys, 1984), and women scientists in higher education are not promoted as fast as men, even when research productivity is controlled (Bayer & Astin, 1975). Thus, in addition to facing fewer financial opportunities in science than men, female college students inherently encounter fewer role models and have fewer opportunities for same-sex mentoring than do men.

Finally, societal pressures force women, more than men, to choose between

family and career (Frieze & Hanusa, 1984; Peng & Jaffe, 1979). Even though [illegible] tyas (1985b) found that except during child bearing and early child rearing, family responsibilities did not have a negative effect on women's science career attainment and productivity, many women may nevertheless perceive that a career in science will interfere with their family responsibilities.

For these reasons, it is understandable that by the time women come to college, their interest in science is well below that of men's. Among college freshmen in 1990, 24% of men, and only 7% of women, reported that they would major in biological science, physical science, or engineering (Dey, Astin, & Korn, 1991). Although small by comparison, this 7% of women represents those who apparently were not discouraged from science during the precollege years. Despite personal and societal forces, these women have chosen to enter a field in which they are clearly the minority. What effect will the college experience have on these women's scientific aspirations? Will this small minority of women remain interested science after four more years in the science pipeline?

OBJECTIVES

This study explores the factors related to persistence toward science careers for those students who, as freshmen, planned on pursuing careers in the sciences. Specifically, the study explores the relationship between men's and women's background characteristics, their college experiences, and their persistence toward careers in science. If aspects of the college environment can be linked to men's and women's persistence in science, perhaps we can gain an understanding of how educational programs, pedagogical techniques, peer group characteristics, and student involvement may differentially impact the career goals of men and women who are initially interested in science.

For the purposes of this study, science careers are defined as those occupations which utilize knowledge of engineering and the natural and physical sciences, and include: engineer, research scientist, statistician, conservationist/forester, and college teachers with final majors in biological science, physical science, or engineering. Science-practitioner occupations (i.e., physicians and dentists) are not included as "science" fields in this study, primarily because the gender gap in aspirations for practitioner fields has disappeared in recent decades, whereas the gender gap in other scientific fields has remained (Dey et al., 1991).

METHODS

Sample

The data in this study are drawn from the Cooperative Institutional Research Program (CIRP) 1985 Freshman Survey and 1989 Follow-Up Survey, which are sponsored by the American Council on Education and the UCLA Higher Education Research Institute (HERI). These data, collected as part of a recent national survey of college students, include information from over 27,000 college freshmen who were followed up four years after college entry, and incorporate information acquired directly from

institutions, as well as from 19 other data sources, including the 1989–1990 HERI Faculty Survey and the 1989 HERI Registrar's Survey. Additionally, a "maximum contribution" limit was imposed on institutions so as to prevent any institution from contributing more than 1% to the final sample. A complete description of sampling and weighting procedures is provided in HERI (1991).

Because this study is concerned primarily with the career aspirations of degree-bound college students, the original sample of 27,000 is reduced to 15,519 students "retain d" in 392 four-year colleges and universities. To qualify as "retained," students must meet at least one of three conditions of college retention: (1) have completed college with at least a bachelor's degree, (2) be currently enrolled in college and aspire to obtain a bachelor's degree, or (3) plan to enroll in college in 1989 and aspire to a bachelor's degree. Therefore, all students in this study have started college with science career goals, and have either maintained their interest in science, or are headed toward the bachelor's degree with alternative career plans.

Research Methods

This study employs the "input-environment-outcome" (I-E-O) methodological framework, which examines the impact of various college environments and experiences on student outcomes, after controlling for students' precollege characteristics and experiences. Implementation of this model requires that the effects of "input" characteristics, such as students' high school science preparation, be controlled so that one can measure the effect of the college "environment" on any number of cognitive or affective "outcomes" (Astin, 1991).

First, cross-tabular analyses were conducted to describe the persistence rates of women and men toward careers in the sciences, including persistence rates within specific major fields, and ultimate career aspirations of defectors from science. Next, blocked stepwise regression analysis, including 330 independent variables, was utilized separately for women and men in order to explore which input or environmental characteristics contribute to men's and women's decision whether to persist toward a career in the sciences. In accordance, with the I-E-O model, variables were blocked according to the temporal sequence in which they may have had an effect on students' career decisions four years after college entry.

Because the use of such a large number of variables is unusual, and perhaps unconventional for regression analysis, it is important to explain the rationale for this technique. The primary aim of this article is to explore the factors related to science career persistence, not to test a particular persistence model. Given that studies relying only on traditional predictors of persistence (grades, preparation, test scores, etc.) explain only a small proportion of the variance in persistence, it becomes ever more important to include variables that were not available in previous studies. For this reason, the present study capitalizes on an extensive database in an attempt to expand our notion of how college students maintain or abandon their initial career aspirations.

Variables

The dependent variable used in this study is "persistence versus defection" of science career aspirations. An individual is defined as a "persister" in a science career field

if that individual aspires toward a career in the sciences [illegible] (1985) and also aspires toward any one of the science career fields four years later (1989). An individual is defined as a "defector" if that individual aspires toward a career in a science field in 1985 and aspires toward any other career field in 1989.

Input Variables. In order to best understand the effects of various college environments on students' career decisions, the characteristics of students at the time of college entry must be controlled. These "input" or "background" characteristics are included in regression analyses in two groups. The first block of background characteristics includes: race, citizenship, parents' careers, parents' education, family income, religion, SAT scores, high school academic information, high school activities, reasons for coming to college, degree aspirations, life goals, views, personality types, and expectations about college. The second block of input characteristics includes students' intended major choice. Major choice is not included in the same block with the other input variables because while initial major choice is a characteristic of the student at the point of college entry, major choice also serves to define the environment to which the student is exposed during college. Hence, major choice may be seen as a bridge between input and environmental blocks.

Environmental Variables. The environmental variables employed in this study are grouped into four blocks: (1) living arrangements during college and financial aid sources, (2) curricular measures and characteristics of the peer and faculty environments, (3) institutional characteristics, including type and control, percent of degrees awarded in each academic field, expenditures, and enrollment characteristics, and (4) involvement measures/intermediate outcomes. The last environmental block has been named "intermediate outcomes" (Astin, 1991) because the variables in this block can be interpreted as both college environments or college outcomes. Intermediate outcomes include courses taken during college, experiences and activities during college, as well as the hours per week that students engaged in various pursuits. Because we cannot be sure that a correlation between any intermediate outcome and the dependent variable implies a causal relationship (since both are measured on the follow-up questionnaire), interpretation of the "effects" of intermediate outcomes is necessarily tenuous. For instance, while exposure to the college environment may lead a student to engage in a particular activity, the very involvement in that activity exposes the student to a different aspect of the college environment, which in turn may influence the student's development on an outcome measure. However, it is hoped that the blocking of the regression variables will allow us to have controlled for students' tendencies to engage in particular activities, so that any remaining correlation between these activities and the dependent variable might denote an "effect." (Interested readers may contact the author for a complete list of variables and coding schemes, as well as means, standard deviations, and correlation matrices for men and women.)

RESULTS AND ANALYSIS

Table 1 describes the proportions of male and female freshmen who aspire toward careers in science, as well as the corresponding rates of persistence within these career choices. The table displays a gap between men's and women's interest in

Table 1. The Pipeline in the Sciences for Men and Women

	All students		Men		Women	
	N	%	*N*	%	*N*	%
Total	15,519	100.0	6,251	100.0	9,268	100.0
1985 career choice: science	1,877	12.1	1,285	20.6	592	6.4
Science persisters	724	4.6	516	8.3	208	2.2
		(38.6)		(40.2)		(35.1)
Science defectors	1,153	7.5	769	12.3	384	4.1
		(61.4)		(59.8)		(64.9)

Note: Percentages in parentheses are based on the number indicating a science career choice in 1985.

science careers, as well as a loss of both men and women from science during college. Although 12.1% of the entire sample show an initial interest in science careers, only slightly over one-third of these students actually maintain their science career aspirations by the end of college.

It is important, however, to understand whether these persistence rates differ between women and men. Table 1 shows that the percentage of men and women with an initial interest in science careers is strikingly different. While 20.6% of male college students aspire toward careers in the sciences, only 6.4% of women share these career goals at the time of college entry. Therefore, much of the reason that engineers and scientists are predominantly male is simply that fewer women enter college with science as a career goal. Given the importance of college preparation for science careers, many women exclude themselves from these fields simply because of a lack of interest and/or preparation in science at the point of college entry.

Also described in Table 1 are the persistence rates among men and women who express an initial aspiration toward the sciences. Interestingly, women appear to persist toward science careers at only a slightly lower rate (35.1%) than men (40.2%). Yet, given that women enter college with much less interest in science than men, this nearly equal persistence rate in college does not facilitate balancing the number of male and female scientists and engineers in the workforce.

Perhaps some of the difference between men's and women's persistence in the sciences is due to their choice of college major. What majors are chosen by students with an initial interest in science? Does the choice of major affect students' likelihood of maintaining science career aspirations? Table 2 describes the most common major choices of students who express an initial interest in science and engineering. Al-

Table 2. Choice of Major Field for Students with Science Career Aspirations

	Percent choosing major		Rate of persistence of science career aspirations	
Initial choice of major	Men (*N* = 1,288)	Women (*N* = 592)	Men	Women
Biological sciences	6.7	20.6	43.0	27.0
Physical sciences	12.0	18.4	44.2	31.2
Engineering	70.7	51.9	40.2	41.4
Nonscience	9.7	7.1	33.6	31.0

Table 3. Career Choices Most Often Cited by Science Career Defectors

1989 career choice	Percent choosing career	
	Men (N = 769)	Women (N = 384)
Business or accounting	25.5	20.6
Military	6.7	3.6
Lawyer	4.0	2.9
Education	3.6	12.5
Undecided	3.5	3.6
Science-practitioner[a]	3.1	6.7
Other	7.7	14.1

[a]Science-practitioner includes the following careers: physician, dentist, veterinarian, pharmacist, optometrist, and clinical psychologist.

though engineering is the most popular major for both men and women, men are much more concentrated in this field than are women. Women, on the other hand, exhibit a slightly greater interest in the physical and biological sciences than do men.

By looking at persistence rates of science career aspirations within these fields, we can see whether major choice itself is a factor in retaining students for science careers. Men majoring in biological sciences, physical sciences, and engineering experience very similar science career persistence rates (43.0%, 44.2%, and 40.2%, respectively). Women, on the other hand, exhibit very different persistence patterns depending on their field of study. The highest rate of persistence toward science careers for women occurs in engineering (41.4%), followed by physical sciences (31.2%), and biological sciences (27.0%). Women's persistence appears to be affected more strongly by choice of major than it is for men, with engineering departments facilitating the highest rates of persistence for women.

Next, given the large percentage of students who shift their career plans away from the sciences, it is important to know what fields these "defectors" are planning to enter. Table 3 describes the 1989 career choices most often cited by students who abandon science career interests during college. For both men and women who defected from sciences, the most popular career choice four years later is business or accounting; one-fourth of male defectors and one-fifth of female defectors choose business fields. Aside from the "other" career category, the military is the next most popular career option for male defectors (6.7%), whereas education is the next most popular career choice for women (12.5%). A greater percentage of male than female defectors indicate an interest in law, whereas a greater percentage of women than men change their career plans to scientist-practitioner. In general, of students who shift their career focus away from scientific research, men are attracted to business, the military, and law, while women are attracted to business, education, and medicine.

It is important to note that in some cases, the term "defector" does not necessarily imply that an individual is abandoning science altogether. For example, some individuals may shift their career choice from scientific research to teaching, yet intend to *teach* science; others may shift from scientific research to medicine. While such individuals are clearly not defecting from science, they are shifting their atten-

Table 4. Input Variables Associated with Persistence Toward Science Careers

Variable	Men		Women	
	Beta after inputs	Final beta	Beta after inputs	Final beta
Positively associated:				
High school GPA	.10	.06	.17	.01
Self-rating: math ability	.21	.12	.09	.02
Father's career: engineer	.06	.05	.07	.02
Reason for going to college: Parental expectations	.11	.10		
Mother's career: research scientist	.07	.05		
U.S. citizen	.07	.09		
Goal: be successful in own business			.13	.17
Mother's career: college teacher			.13	.08
Years of physical science in H.S.			.10	.04
Major choice: engineering			.12	.11
Negatively associated:				
Goal: raise a Family	−.07	−.03	−.12	−.05
Self-rating: popularity	−.09	−.06		
Parents' income	−.11	−.10		
Goal: be successful in own business	−.08	−.04		
Expect to change career choice	−.07	−.04		
Self-rating: writing ability	−.08	−.02		
Expect to change major field			−.14	−.12
Goal: help others in difficulty			−.05	−.02
Number of personality types			−.11	−.11
R^2	13.0%		14.4%	

Note: Beta coefficients represent standardized regression coefficients and are shown if the variable entered the regression equation for that group.

tion away from a focus on scientific research. Unfortunately, it is impossible to know from these data the extent to which individuals plan to incorporate science into their nonscience careers.

Regression Analyses

The results of regression analyses may help to shed light on the factors associated with students' decisions to remain in or leave the sciences. Regression analyses were performed separately for women and men, and explain approximately 40% of the variance in the career decisions within each group. However, while the variables which enter the regression equations (significant at the .01 level) account for the same proportion of variance in persistence, the actual items that are significant in the regressions are somewhat different for men and women.

Input Measures. Input measures account for a relatively equal proportion of the variance among the male and female samples: 13.0% among men, and 14.4% among women. Table 4 describes the input variables that enter regression equations for each group. Four variables have similar effects on both men's and women's career decisions. High school grades and self-rating in math ability each have pos-

itive effects on men's and women's persistence toward science careers, suggesting that students who are high achievers or who have confidence in their math abilities are more likely to maintain their science ambitions during college.

Having a father who is an engineer is also positively associated with persistence for both men and women. Fathers who are engineers may provide at least two major functions in helping their children stay interested in science careers. First, these fathers may act as role models and/or mentors for their children, and second, children of engineers may feel an added pressure to persist toward a science career, as if they are expected to follow in their fathers' footsteps. Regardless of how this variable affects students emotionally, having a father who is an engineer does increase a student's chance of persisting in the sciences.

For both men and women, the goal of raising a family is negatively related to persistence toward science careers. Perhaps realizing the intense time commitment that science and engineering careers demand, as well as the time that might need to be spent in graduate programs, students who place a high priority on raising a family become less attracted to science and engineering careers.

Interestingly, one measure was positively associated with persistence for women (beta after inputs = .13), but negatively associated for men (beta after inputs = −.08): hoping to be successful in one's own business. Why this variable would have opposite effects on men and women suggests that these two groups might be interpreting their career and business opportunities much differently. For men, science and engineering may represent fields that offer relatively few financial incentive for hard work. Men who value financial success might be turned away from science and engineering, believing that their skills and abilities will be more highly rewarded through business ventures. Women, on the other hand, might believe that they will have a better chance of succeeding in business if they can gain entry through first proving themselves in the scientific community.

A large number of input measures were found to be significant for either men or women, but not both. For men, citing "parents wanted me to go" as a reason for attending college is positively associated with persisting toward a career in the sciences. This finding suggests that specifically for men, parental pressure is a strong influence on the decision to attend college, and has a direct effect on students' commitment to a science career.

Similar to the effect of having a father who is an engineer, having a mother who is a research scientist has a unique effect on men's science persistence. Interestingly, this measure does not have a significant effect on women. Given the importance often placed on providing female role models for women, it is surprising that having a mother who is a research scientist apparently does not directly promote women's persistence toward science careers.

Next, findings reveal that among students with an initial interest in science careers, those who are U.S. citizens are more likely to persist than noncitizens. What this finding suggests is that while foreign students may be more likely to report an *initial* interest in science, they are actually less likely to maintain that interest after four years of college. In other words, the factors that influence many foreign students to pursue science careers (family pressures to achieve in science, fewer language barriers in scientific fields, etc.) may become less important during the college years, when these students might improve their language skills, become more aware of the

various career opportunities available to them, and therefore shift away from science as a career choice.

A number of negative predictors of persistence were found among men, but not women. The strongest negative predictor of persistence for men is family income; male students with higher family incomes are less likely to persist toward careers in science. Perhaps these students have less incentive to become scientists or engineers, believing that such careers might actually lower their standard of living. Instead, as we have seen, such men might opt for careers that offer greater monetary rewards, such as in business or law.

Another input variable with a negative effect on men's persistence is expecting to change career choice during college. This finding is likely an artifact of the study, as students who exhibit career ambivalence upon entry to college are clearly less likely to maintain their career interests after four years.

Men's self-rating on popularity is also negatively related to persistence toward science careers. It may be that socially confident men are less attracted to science fields because they subscribe to the stereotype of scientists and engineers as "loners" or "antisocial."

The final input variable to have an effect only for men is self-rating of writing ability. Men who have less confidence in their writing ability are more likely to persist toward a career in science. Perhaps men with low confidence in their writing skills feel more comfortable in quantitative fields, which generally demand less extensive written composition than is required in nonscience fields.

For women only, three input variables are positively related to science persistence (in addition to striving for business success, discussed earlier): having a mother who is a college teacher, the number of years of physical science taken in high school, and majoring in engineering. Women who persist in science are those with female role models, early science preparation, and an early commitment to a science field. The positive effect of majoring in engineering is consistent with results reported in Table 2, and suggests that majoring in engineering does indeed have a uniquely strong effect on women's persistence toward careers in the sciences.

Among the input variables negatively related to women's persistence in the sciences, three seem to be particularly revealing. First, the strongest negative effect for women is the expectation to change their major field during college. As with men's expectations to change career choice, this variable suggests that women who are initially unsure about their choice of major are more likely to change their career choice as well, whereas women who commit early to a science major are more likely to maintain their decision for a career in science.

Second, placing higher priority on helping others in difficulty is negatively associated with science career persistence for women. Although much of scientific research is designed specifically to improve the human condition, traditional stereotypes of science may cause many altruistic women to perceive a weak connection between helping others and scientific pursuits. This finding is consistent with the finding that, among science career defectors, larger proportions of women than men are choosing careers in education and medicine, careers that are based on the notion of "helping others."

A third interesting finding for women is that those who exhibit a diverse set of personality characteristics are less likely to persist toward a science career. The

personality types used in this study are the following factors developed by Astin (1993): leader, status striver, scholar, artist, hedonist, social activist, and uncommitted. While most students qualify for two or three of these types, those with a diverse set of personality traits qualify for as many as five or six types. Therefore, this finding suggests that women with strong and diverse interests and views are more likely to be attracted away from science and engineering careers.

Environmental Measures. The inclusion of environmental variables raises the R^2 to 21.2% for men (an addition of 8.2% from the input block), and 16.0% for women (an addition of 1.6% from inputs). It appears that the effect of the college environment on science persistence is stronger for men than it is for women.

Table 5 describes environmental characteristics affecting men's and women's persistence toward science careers. The environmental variable most strongly associated with men's and women's persistence (and in fact the only environment affecting women) is the proportion of students at an institution holding jobs. A high score on this factor means that the student attends an institution in which many of his or her peers hold jobs and/or work full time while attending school. That this variable would have the strongest effect on both men's and women's science career persistence is at first a curious result. However, upon inspection of the environmental characteristics that are highly correlated ($r > .20$) with this variable, it appears that the effect of having a large number of working peers is actually a proxy for the *type* of institution in which many students hold outside jobs: a commuter school. For example, environmental characteristics positively correlated with the number of peers holding jobs include: living at home, percent of students receiving need-based financial aid, faculty perception of poor student relations, percentage of total bachelor's degrees awarded in education, and student-faculty ratio. Characteristics negatively associated with the peer outside work measure include: living on campus, peer intellectual self-esteem, peer socioeconomic status (SES) (as defined by parents' income and education levels), science preparation of the student body, institutional emphasis on resources and reputation, percentage of total bachelor's degrees awarded in history, political science, and social science, and institutional selectivity (defined by the mean SAT scores of the freshmen class).

Thus, being at an institution with a large number of students holding jobs actually represents being in a large, less selective, low-SES, commuter school. One reason that this type of institution has a positive effect on persistence toward science careers could be that it provides few distractions for students interested in science. First, these schools are not highly selective, thus students' confidence in science may be maintained more than at institutions with larger numbers of highly able science students. Also, these schools do not have large social science, political science, and history departments that might attract students away from the sciences. Finally, because students attending these schools are more likely to live at home, their main interaction with peers will be within their courses. Thus, the peer environment of science students at commuter schools are other students interested in science, a factor that may help to retain student interest in science as a career.

The remaining environmental variables with effects on persistence are significant only for the male population. First, receiving financial assistance from parents or a college loan is positively associated with men's persistence toward science careers. This suggests that among men preparing for science careers, those with greater

Table 5. Environmental Variables Associated with Persistence Toward Science Careers

Variable	Men		Women	
	Beta after inputs	Final beta	Beta after inputs	Final beta
Positively associated:				
Peer mean: outside work	.17	.15	.14	.16
Aid source: parents or family	.10	.04		
Aid source: other college loan	.08	.05		
Major-dominated G.E.	.09	.06		
Negatively associated:				
Distance from home to college	−.09	−.03		
Percent of faculty teaching in general ed.	−.05	−.09		
Faculty perception: competition among students	−.06	−.11		
R^2	21.2%		16.0%	

Note: Beta coefficients represent standardized regression coefficients and are shown if the variable entered the regression equation for that group.

financial assistance may be less likely to work during college, and thus have more time to devote to the demands of a science major.

Second, having a major-dominated general education program also has a positive effect on men's science persistence. A major-dominated program is defined as one in which required general education courses are determined primarily by the student's major department (Hurtado, Dey, & Astin, 1991). For men preparing for careers in science, a major-dominated curriculum probably acts to reinforce their science interests, and poses less of a distraction than general education programs that require many courses to be taken outside the major. Consistent with this finding is the negative effect of the percentage of faculty teaching general education courses. Again, this suggests that students are less likely to maintain their science interests when they are taking greater numbers of nonscience courses.

Two additional environmental variables have a negative effect on men's persistence toward science careers. First, male students who attend colleges farther from their homes are less likely to maintain an initial career interest in science. It may be that men who relocate to attend college are more likely to rethink their career plans, since living away from home provides students with new experiences and opportunities, many of which may attract the male science student away from his initial aspirations.

Second, being in a more competitive environment is negatively associated with men's persistence toward a science career. Regardless of their actual ability, men faced with competitive science programs may begin to doubt their scientific abilities and rethink their career plans, believing that they are no longer the "best" in science, as they may have been in high school.

Involvement Measures. After controlling for the effects of input and environmental measures, the relationship between student involvement and persistence in science can be examined. As stated earlier, involvement measures (intermediate outcomes) may be viewed as both environments and outcomes, thus cautious interpretation of "effects" must be observed.

Table 6. Involvement Variables Associated with Persistence Toward Science Careers

Variable	Men		Women	
	Beta after inputs	Final beta	Beta after inputs	Final beta
Positively associated:				
No. of cience courses taken	.34	.28	.36	.26
Hours per week: studying or homework	.11	.08		
Reason for career choice: work is interesting	.04	.09		
Reason for career choice: satisfies parents' hopes	.05	.08		
Worked on professor's research			.21	.16
No. of math/numerical courses taken			.22	.12
Negatively associated:				
Took a multiple-choice exam	−.25	−.17	−.23	−.17
Reason for career choice: enjoy working with people in field	−.13	−.13	−.22	−.14
No. of writing skills courses	−.21	−.13		
Had paper critiqued by instructor	−.24	−.13		
Received personal/psych. counseling	−.11	−.08		
Hours per week: volunteer work	−.11	−.08		
Took an essay exam			−.26	−.16
Held part-time job off-campus			−.11	−.15
R^2	41.0%		40.1%	

Note: Beta coefficients represent standardized regression coefficients and are shown if the variable entered the regression equation for that group.

Inclusion of involvement variables brings the R^2 to 41.0% for men (an addition of 19.8% from the environment block), and 40.1% for women (an addition of 24.1% from environments). Measures of involvement are apparently more strongly associated with persistence for women than they are for men.

Involvement measures associated with persistence of men's and women's science aspirations are described in Table 6. Three measures have similar relationships for men and women: the number of science courses taken (+), having taken a multiple-choice exam (−), and choosing a career because people in the field are enjoyable to work with (−). The first two measures are more likely the result of persisting in science, rather than the cause. For example, students persisting in science are more likely to take more science courses, and within these courses, exams are more likely to be problem solving than multiple choice. The negative effect of choosing a career because people in the field are enjoyable to work with suggests that those students who choose their careers based on the quality of their working relationships are less likely to pursue science careers. Once again, it seems that students may be influenced by the persistent stereotype of science as a cold and lonely pursuit.

A number of involvement measures have effects associated with either women or men, but not both. Five of these are related specifically to women's persistence in the sciences. Working on a professor's research project and the number of math courses taken in college are uniquely predictive of women's persistence. While these factors may simply be the result of science persistence, rather than the cause, the

fact that they enter the regression for women, but not for men, suggests that these findings represent more than mere artifacts of persistence in science. For instance, given the male-dominated and often impersonal nature of science fields, getting hands-on research experience, as well as guidance from a professor, may be invaluable in retaining women within science. Similarly, taking a greater number of math courses has a unique positive effect on women. Perhaps the fact that women college students have lower confidence in math than men (Sax, 1994) explains why a greater exposure to math in college significantly increases women's, but not men's, likelihood of persisting toward a career in science.

Holding a part-time job off-campus is negatively associated with women's persistence in the sciences. This finding speaks to the time commitment required to succeed in the sciences. Women who spend more time working off-campus have less time to devote to the demands of college science programs. This finding also suggests that among women with an initial interest in science, those whose financial situations require them to work are more likely to choose a nonscience career four years later.

Additionally, having taken an essay exam is negatively related to science career persistence for women. Because taking essay exams is more likely to occur in non-science courses, this finding probably refers to students who have defected from science early in college, and are thus taking courses that are more likely to require essay examinations.

Seven involvement measures are associated specifically with men's persistence toward science careers. Not surprisingly, the number of hours per week spent studying is positively related to persistence. This finding merely reinforces the notion that science fields demand that students spend greater amounts of time studying or doing homework.

Two variables positively associated with men's persistence are related to the reason why they made their particular career choice. Choosing a career because the work is interesting is a positive factor for retaining students in science, therefore suggesting that those who truly enjoy science are more likely to persist. Interestingly, making a career choice based on parents' expectations is also positively related to persistence for men. This finding is consistent with the results of the input block, which suggested that men who persist in science were more likely to go to college because their parents wanted them to. Clearly, parents' expectations have a unique effect on men's educational and career goals.

The amount of time spent volunteering was also found to be negatively related to science persistence. As with all involvement measures, it is unclear whether volunteering has a causal negative effect on persistence. While the amount of time required for science during college may preclude students from engaging in volunteer activities, it is also possible that students who spend more time volunteering are more likely to be drawn to other fields.

Receiving personal or psychological counseling is also negatively related to persistence for men. Due to the high levels of competition and high expectations within the sciences, many science students cope with a high degree of stress. Perhaps those who are less able to cope with the pressure of the sciences (those who are more likely to defect) are more likely to seek counseling. This does not imply that persisters do not experience high stress levels; rather, persisters may be less likely to seek counseling to deal with their stress.

Finally, the number of writing skills courses and having a paper critiqued by an instructor are both negatively related to persistence toward science careers for men. As with a number of other variables, these findings are likely the result, not the cause, of defection from the sciences.

DISCUSSION

Given the large number of variables associated with science career persistence for men and women, what generalizations can be made? While the specific variables entering the regressions for men and women differ, some common themes emerge for the two groups. Overall, these common themes represent nothing surprising: Students with an early commitment to science and greater amounts of science preparation before college are more likely to maintain an interest in science during college. Having a parent whose career involves science or scientific inquiry generally increases one's chance of persisting in science in college. While in college, students who are more focused on their course work and on the demands of science are more likely to maintain their science interests than students who have diverse interests and capabilities. Similarly, students who commit much of their time to nonacademic pursuits (outside jobs, volunteering, etc.) are less likely to persist toward science careers. Therefore, as one might expect, students who enter college more prepared and focused, and with fewer outside interests or demands, are more likely to persist toward careers in science.

However, what appear to be more interesting findings are those based on *differences* in factors related to men and women's persistence in science. Men who defect from science careers might do so because of expectations of a relative lack of financial reward in science fields. Wanting to be successful in business and choosing careers in business and law are more strongly associated with men's defection from science than women's. In fact, desiring business success was associated with science *persistence* for women! Further, desiring to help others in difficulty decreases the likelihood of women's, but not men's, persistence toward science careers. Consequently, women defectors are more likely than men to choose careers in education or medicine.

These differences suggest that women and men have different motivations guiding their choice of a career: Men appear to be more concerned with the monetary aspect of a career, while women are apparently more concerned with the "social good" of their career choice. Perhaps these findings represent the different ways in which women and men are socialized, and how their life opportunities are presented to them. It is therefore important for future research to examine further the motivations guiding career choice, especially for science careers. Perhaps men and women perceive careers differently, or perhaps they merely perceive their opportunities differently. Research on this topic should explore the following issues: How does students' understanding of specific careers and of career opportunities change during the college years? At what point during college do students lose interest in science? Is the field itself a "turn-off," or does college provide new opportunities that students had not previously considered?

Although the content of science and engineering programs demands a concen-

trated time commitment from students, findings from this study suggest that if science departments are to keep students interested in science, they should work to become more flexible for students with diverse interests and needs. First, science programs should make special efforts to retain students who show an initial interest in science, but who may not yet be fully committed to their science aspirations. Tobias (1992) refers to such students as the "second tier"—those who are interested in science, but who are often lost from the field due to the competitive nature of introductory science courses. As suggested by Rosser (1990), such students will benefit from lectures or visits by diverse types of scientists who can serve as role models by proving that a career in science does not necessarily preclude one from having a family or pursuing other interests and talents.

Second, science departments may be able to retain greater numbers of capable women and men by fostering more cooperative and inclusive learning environments (group problem solving and experiments, nonsexist language and textbooks), rather than promoting an isolating, competitive atmosphere among students. Third, this study reaffirms Rosser's (1990) suggestion that greater numbers of women would be retained in science if assignments and experiments focused more often on social concerns, rather than focusing on issues generated by the military. Finally, by procuring funds to hire undergraduates to assist with research projects, institutions can help retain those students whose outside jobs may otherwise leave them little time and energy for the science curriculum.

Recommendations such as these are certainly nothing new—they have been suggested in numerous other reports and studies in the past decade (see Frieze & Hanusa, 1984; Higher Education Research Institute, 1991; Matyas, 1985a, 1985b, 1992; National Science Foundation, 1988; Oakes, 1990a, 1990b; Rosser, 1990; Tobias, 1992). Future studies on how and why students leave the sciences will likely produce many of these same suggestions; clearly the problem is well understood. Perhaps at this point, it is time to aim the research and educational agenda directly at the *implementation* of these recommendations. At the same time, it is also important to challenge the persistent stereotype of science careers as cold, alienating, competitive, and detached from the immediate needs of society. Instead, the image of science needs to highlight the collaboration among scientists, the growing diversity within the scientific community, and the strong connection between scientific research and social good. If students can begin to *perceive* the life of the scientist as interesting, exciting, and welcoming, and if college science programs work to match that perception, many creative and multitalented individuals may opt to remain in the scientific community.

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