A Six-Year Longitudinal Study of Undergraduate Women in Engineering and Science*

SUZANNE G. BRAINARD
Women in Engineering, College of Engineering
University of Washington

LINDA CARLIN
Department of Psychology
University of Washington

ABSTRACT

In 1991, the Women in Engineering (WIE) Initiative at the University of Washington was funded by the Alfred P. Sloan Foundation to conduct a longitudinal study of undergraduate women pursuing degrees in science or engineering. Cohorts of approximately 100 students have been added to the study each year, for a current total of 672 participants. The objectives are: (a) to determine an accurate measure of retention by tracking individual students through their science and engineering academic careers; (b) to examine factors affecting retention of women in science and engineering; and (c) to evaluate the effectiveness of WIE's programs targeted at increasing enrollment and retention of women in science and engineering. These programs include interventions primarily during the freshman and sophomore years, which are critical attrition points. The results of this study are reported annually to the Dean of Engineering and related departments for consideration in policy formulation. Annual results of the study have shown consistent patterns of persistence factors and barriers for these high-achieving women; most notably a significant drop in academic self-confidence during their freshman year in college. In addition, individual tracking of these women has shown a retention that is much higher than the estimated national average for engineering and science students.

I. INTRODUCTION

Undergraduate engineering enrollments in the United States reached an all-time high of 406,144 students in 1983. By 1996, this figure had decreased to only 317,772 students. However, this decline in engineering enrollment was disproportionate between females and males. The enrollment of males declined 25% from 1983 to 1996 (341,495 to 256,013), while the enrollment of females declined only 4% during the same period of time (64,649 to 61,759) and has actually increased almost every year since 1989. However, it still has not returned to the 1983 peak level.

On the other hand, undergraduate engineering degrees granted in the U.S. have steadily declined from 77,892 in 1985 to 65,091 in 1997. While most of this decrease is reflected in the male population, women reached a peak in 1997 with 12,160 (18.7%) degrees granted. Although the percentages of degrees granted to women continued to increase from 1985 to 1997, there were several fluctuations between 1987 and 1993 where the total number of degrees granted to women was well below 11,000.[1] It appears that national efforts to increase the participation of women in engineering are having an impact on retention rates. Thus, it is important to examine both the number and percent of degrees granted to women, for often the percentages mask what is actually happening.

Current national retention rate estimates for women, calculated as the ratio of students who complete an engineering program to the number of incoming freshmen four years earlier, are slightly below 60%.[2] Similarly calculated retention rates of female engineering students at the University of Washington in 1991, obtained from the Registrar's Office prior to the initiation of the present study, were about 55%. This aggregate retention calculation fails to account for students who transfer into engineering after the freshman year, resulting in an inflated retention rate. A more accurate retention rate can only be determined by tracking individual students from the beginning to completion of a program.

At the University of Washington, about 4000 freshmen (50% are female) are enrolled annually. During their freshman year, all students planning to pursue a degree in science or engineering are enrolled in the College of Arts and Sciences. Most students do not enter the College of Engineering or science departments until their junior year. It is only at the beginning of their junior year that students can be tracked individually by their college or department and more accurate persistence rates determined. Thus, there is no tracking of students who switch degree programs or who transfer to the University during their first two years.

The inadequacy and inconsistency of collection and maintenance of evaluation and retention data is a national problem and was identified in 1988 by the National Research Council (NRC) as a major hindrance to projecting future manpower needs as well as identifying problem areas in the pipeline. The NRC established a committee to investigate ways to improve this process both at the federal and institutional levels. Although mandates can be put in place for federal agencies, it is more difficult to do so for educational institutions. Collecting longitudinal data and maintaining tracking systems on all registered students is complicated and expensive. As a result, only a handful of institutions have implemented such systems, since most do not have an incentive to bear the cost.

The Women in Engineering Initiative (WIE) at the University of Washington was established in 1988 with the mission of increas-

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ing enrollment and retention of women pursuing degrees in engineering, primarily through a network of support programs for students. In 1991, supported by a grant from the Alfred P. Sloan Foundation, WIE began a longitudinal study of undergraduate women pursuing degrees in science or engineering. The study has three primary goals, the first of which is to obtain a more accurate measure of retention of females pursuing science and engineering (S&E) degrees by tracking individual students until they graduate.[3]

To date, WIE is able to report retention rates for women in S&E based on individual tracking of 672 women who have participated in the study over a span of six years. There are currently no comparison data available on retention rates for men in S&E, or women pursuing other degrees. To further investigate factors specifically related to the retention of women in S&E, the current study may eventually be expanded to include individual tracking of students in these groups.

The importance of determining accurate retention rates is related to the influx of women and other minority groups into the job market. Despite the growing proportion of these groups in the general workforce, they are underrepresented in the fields of science and engineering. For example, although women make up 46% of the total labor force, they comprise only 31% of the science professions (excluding social science) and only 8% of the engineering professions.[4] As the demographics of the workforce continue to change, a lack of technical education and experience in this growing portion of the workforce would prove detrimental to our increasingly technology-oriented society.[5]

A second goal of the study is to determine what factors influence the persistence of women in S&E degree programs. Early research investigating the underrepresentation of women in technical fields focused on ability. However, Seymour and Hewitt, in their benchmark 1994 study comparing students persisting in S&E undergraduate degree programs with those who chose to switch to another field of study, or drop out of college altogether, found that there were no real differences in the factors of high school preparation, ability, or effort expended in their coursework between students who remain and those who switch.[6] Although these results applied to both male and female undergraduates, they have been confirmed for women by other studies of female S&E undergraduates.[7,8]

Seymour and Hewitt identify two categories of students who switch out of S&E programs: students who become bored or disappointed with the S&E curriculum, and students who feel forced to leave due to a loss of academic self-confidence in a competitive environment.[9] Seymour and Hewitt's findings place many women and students of color in this second category.

These findings are supported by an earlier study of young women in high school who tended to suffer from a loss of perceived academic competence.[10] While only males of low competence dropped out of math and science courses, females of high competence were often also dropping out. These young women had experienced a loss of self-confidence prior to any exhibited loss of performance in their math and science classes. Therefore, it was not lack of academic ability that diverted these young women from continuing in math and science, but a lack of self-confidence.

The establishment and successful continuation of women in engineering programs at several universities[11] is an acknowledgment of the theory that, given support and opportunity, women can not only survive, but thrive in a traditionally male-dominated field.

The third goal of the study is to evaluate the impact of WIE programs on retention rates of women pursuing S&E undergraduate degrees at the University of Washington.

In summary, in order to have a better picture of how well female S&E students are faring, the goals of WIE's retention program and longitudinal study are:

- to determine a more accurate measure of retention by tracking individual students through their science and engineering academic careers
- to examine the factors affecting retention of females in science and engineering
- to evaluate the effectiveness of WIE's programs targeted at increasing recruitment and retention of women pursuing degrees in science and engineering.

The results of this study are reported annually to the Dean of Engineering and related departments for consideration in policy formulation.[12,13] Results of the first six years of the study suggest that the program has had a significant impact on increasing retention rates of female students pursuing degrees in both science and engineering. The data reported in this paper are the most current from this ongoing longitudinal study.[14]

II. Method

A. Instrument Design and Data Gathering

Six instruments have been designed to gather information: the Annual Freshman Interest Survey, Freshman Initial Interview Form, Freshman Follow-up Interview Form, Sophomore Follow-up Questionnaire, Junior Follow-up Questionnaire, and Senior Follow-up Questionnaire.

The Annual Freshman Interest Survey is mailed in August of each year to all incoming female freshmen at the University of Washington to determine how many are interested in pursuing degrees in science or engineering. Although early response rates in the first three years of the study were low, averaging 11%, the most recent three years' survey response rates have doubled to 22% of the approximately 2000 surveys sent out each year.

Of those responding to the survey, approximately 100 students interested in engineering and 25 students interested in science are selected to participate in the study.* Using a structured interview form, an initial, personal interview is conducted with each student at the WIE Study Center during the Autumn Quarter. A second, follow-up interview is conducted either in person or over the telephone during the Spring Quarter. Sophomores, juniors, and seniors are sent (via email) an annual follow-up questionnaire. Students not responding to the annual questionnaire are tracked by their registration status in the University Registrar's student database.

Reviewed and approved by the University of Washington Human Rights Committee, the structured interview forms are used to ensure that the students' rights of confidentiality and safety are honored and the same information is gathered on each student. The following information is gathered: demographic information;

* At least 70% of the approximately 100-150 female students who enter engineering each year respond to the survey. It would appear that these students are representative of the population. We have found that students expressing an interest in both science and engineering are less likely to persist than those who are only interested in engineering. The reasons for this are unclear, but perhaps a student who initially declares an interest in both is less committed to a specific major, and therefore, less likely to persist.

education and professional background; academic interests; amount of family, peer and financial support; confidence level; and perceptions of campus climate and quality of teaching. Students participating in the study must sign a release form consenting to participate.

B. Tracking System

The WIE tracking system provides a mechanism for measuring retention rates, monitoring student participation in activities, and analyzing data each year. Utilizing the SPSS statistical package, data from the tracking system are analyzed:

- to determine retention rates
- to identify individual problems potentially leading to changing majors or dropping out of science and engineering
- to analyze trends and patterns of barriers that tend to influence the retention of entering female freshmen
- to provide a mechanism for accountability in measuring the effectiveness of the WIE's efforts to increase the retention rates of female freshmen.

C. Interventions

A series of interventions (or contact points) are implemented by personal contact with each student throughout her academic career at the University of Washington, focusing primarily on the freshman and sophomore years, when students are not yet accepted into their respective departments and are at the greatest risk of switching out of science and engineering. These contact points involve academic and social support. Students are interviewed to discuss their academic goals, make plans for the future, and participate in activities with a community of peers. The contact points include personal interviews, an orientation session, peer tutoring, peer mentoring, and quarterly seminars and events. WIE also offers an engineering mentoring program that matches students with professionals working in their field of interest. This program, now in its seventh year, has had great success in providing students with "real-world" experience, as well as improving their self-confidence in their academic challenges.[15]

III. Analyses and Results

A. Freshman Interest Survey

Since 1991, the annual Freshman Interest Survey has been mailed to six consecutive cohorts of all incoming first-year female students at the beginning of Autumn Quarter. Table 1 summarizes the response rates of students to the survey and the number of students forming each cohort.

	Year Began	Initial Interest Surveys Response Rate (Returned/Sent)	Students Interested in S&E	Students Interviewed (Initial Cohort Size)	1997 Status
Cohort 1	1991	7% (150/2100)	110	92	Graduated
Cohort 2	1992	14% (358/2525)	332	107	5th Year or Graduated
Cohort 3	1993	11% (200/1900)	183	103	Senior
Cohort 4	1994	24% (512/2100)	483	125	Junior
Cohort 5	1995	22% (474/2118)	394	127	Sophomore
Cohort 6	1996	23% (485/2126)	427	118	Freshmen

Table 1. Response rates to the freshman interest survey.

B. Persistence in Engineering

The student responses to the interviews show that there are a number of common factors influencing a student's decision to persist in engineering or science, to switch to another major, or to drop out of school altogether. Tables 2-5 summarize the factors that have shown, based on chi-square analyses, a significant correlation (based on an exploratory study alpha level of $p < 0.1$) with persistence in engineering or science. These factors are then ranked according to their relative importance as a predictive factor of persistence, based on a stepwise logistic regression analysis model using persistence as the dependent variable. Persistence factors of 5th- and 6th-year students could not be calculated because persistence rates for both cohorts 1 and 2 in their 5th year were 100%, and only one of the two remaining 6th-year students from cohort 1 responded to the survey.

In the first two years of preparation for entering an engineering or science department, students at the University of Washington are required to take technical core courses, which include a series in math, physics and chemistry. The primary factors which seem to help these women decide to continue in S&E beyond their freshman year in college are interest in their math and science courses, being able to work independently, a positive influence of faculty, career opportunities, and the presence of WIE (table 2). Interestingly, many students who rated WIE as a persistence factor did not actually participate in any WIE programs, reflecting the support that the mere presence of a program like WIE appears to have for some students. Newly emerging persistence factors this year for freshman students were positive ratings of the quality of their math instruction, involvement in the Society of Women Engineers (SWE), and feeling supported by their mothers.

By the end of the sophomore year, the primary factor related to persistence continues to be the student's experience in math and science classes (table 3). In addition, committing to an engineering or science degree by registering as a pre-engineering or pre-science student (as indicated by their registration status), and gaining acceptance into a department become major factors in persistence. The positive influence of an advisor and working during the school year are also consistently related to persistence. Participation in SWE and internships and co-ops emerged as persistence factors this year, suggesting that students are becoming more actively involved in preparing for their careers.

By the junior year, most students have been accepted into a department, reflected by registration status as a predictor of persistence (table 4). Other persistence factors include the positive influence of a mentor and math and science courses, and participation in conferences and events. A new factor for juniors this year, but consistent with the freshmen and sophomore findings, is participation in SWE.

Consistent with past years, persistence factors for seniors include a positive influence of science classes, seeing an academic advisor, and participation in conferences and events. New factors emerging this year are a positive influence of engineering classes and teaching quality.

C. Perceived Barriers to Persistence

For those women who do choose to remain in engineering and science, there are a number of barriers to persistence frequently perceived at each stage of their education. The most frequently report-

Variables	χ^2	χ^2 p-value	Logistic Regression p-value
Enjoy science classes	29.90	.000	.000
Enjoy math classes	27.11	.000	.010
Participation in WIE	11.92	.103	.053
Career opportunities	24.99	.002	.061
Society of Women Engineers	8.16	.086	.150
Positive influence of mother	17.01	.030	.210
Quality of math instruction	15.31	.009	.321
Positive influence of Faculty/TAs	15.07	.001	.685
No problem working independently	15.67	.074	.812

*N=466; due to refinements to the questionnaire, not all students responded to all questions

*Table 2. Persistence factors in science and engineering at the end of the freshman year, cohorts 1-6.**

Variables	χ^2	χ^2 p-value	Logistic Regression p-value
Influence of math & science classes	36.13	.000	.005
Registration status	42.17	.000	.020
Acceptance into the department	8.10	.017	.057
Positive influence of internship/co-op	8.29	.141	.097
Working during the school year	7.56	.023	.145
Positive indluence of an advisor	16.21	.013	.396
Society of Women Engineers	9.25	.055	.940

*N=369; due to refinements to the questionnaire, not all students responded to all questions

*Table 3. Persistence factors in science and engineering a the sophomore year, cohorts 1-5.**

Variables	χ^2	χ^2 p-value	Logistic Regression p-value
Society of Women Engineers	9.72	.137	.264
Registration status	11.30	.010	.481
Positive influence of a mentor	7.19	.126	.535
Influence of math & science classes	17.74	.001	.694
Acceptance into the department	3.05	.081	.703
Participation in conferences & events	8.38	.079	.758

*N=284; due to refinements to the questionnaire, not all students responded to all questions

*Table 4. Persistence factors in science and engineering a the junior year, cohorts 1-4.**

Variables	χ^2	χ^2 p-value	Logistic Regression p-value
Seeing an academic advisor	3.17	.075	.031
Influence of science classes	5.76	.124	.088
Influence of engineering classes	6.22	.101	.500
Teaching quality	9.48	.050	.558
Participation in conferences & events	8.69	.069	.602

* N=174; due to refinements to the questionnaire, not all students responded to all questions

*Table 5. Persistence factors in science and engineering a the senior year, cohorts 1-3.**

ed barriers are summarized by year in school in table 6. Because of ongoing refinements to the annual interviews and questionnaires, not all questions were asked of all cohorts. Therefore, as shown in the column headings, the response rates represent only those students who responded to these questions, rather than the entire study population.

As in previous years, lack of self-confidence is consistently reported by at least one-fourth of the students in each year of school. A disturbing trend in this finding is that, rather than becoming more confident in their abilities as they make their way through college, the proportion of women reporting lack of self-confidence nearly doubles by the senior year. Because this trend is a key focus of this study, it will be discussed in more detail in the next section of this paper. Similarly disturbing trends are found for feeling isolated and losing interest. The proportion of students reporting feeling intimidated also increases to over 41% by the junior year, and then drops to about one-fourth of the students in the senior year.

Approximately 20% (a 5-10% decrease from last year) of the freshmen, sophomores and juniors report that they feel no barriers to persisting in their engineering or science education. Surprisingly, by the time they are 4th- and 5th-year seniors, almost all of the remaining women in our study, many of whom had earlier reported perceiving no barriers to their academic progress, report at least some barriers. In addition to the barriers reported in table 6, these 4th- and 5th-year seniors report feeling discouraged by low grades (45.0%), and complain about poor teaching (54.1%) and unapproachable faculty (37.9%). Financial problems continue to be a concern for about 20-30% of students throughout college.

D. Level of Confidence

Levels of self-confidence in academic achievement in S&E are measured each year on the basis of responses to questions asking the students to rate themselves as math and science students compared with their peers on a 1-5 Likert-type scale. As in previous years, most of these women intending to major in engineering or science begin with a very high level of self-confidence in their abilities in math and science (mean scores: math=4.01; science=3.98). However, both of these levels of self-confidence drop significantly ($p < .001$) over the course of their first year (mean scores: math=3.37; science=3.52). Figure 1 illustrates this significant drop.

Students who do maintain a high level of self-confidence in the freshman year report enjoyment of math and science classes, a high rating of instruction in math and science classes, and participation in WIE.

By the end of the sophomore year, overall self-confidence levels begin to increase slightly from the general decline in the freshman year. High self-confidence scores at this point are significantly correlated with level of interest in choice of major, a high rating of instruction in math and science classes, a positive influence of math and science classes and faculty/TAs (teaching assistants), and persistence.

The continued increase in confidence at the end of the junior year reflects having been accepted into a department. In addition, self-confidence is significantly correlated with a positive influence of math and science classes and faculty/TAs, interest in coursework, and persistence.

High levels of self-confidence for 4th- and 5th-year seniors are significantly correlated to a high rating of instruction in math and science classes, a positive influence of math classes and an advisor, participation in student professional societies and WIE seminars, and feeling

prepared for a career and that educational expectations were met. The students who maintain a high level of math and science self-confidence through graduation in S&E as a group had higher initial levels of self-confidence (initial math=4.47 compared to 4.01; initial science=4.24 compared to 3.98). It should be noted, however, that the overall levels of self-confidence, even for these exceptional students, never return to the original high level of entering freshman students.

E. Retention

One of the primary goals of this study is to calculate accurate retention rates of women in S&E. The retention rates reported in table 7 are the first accurate calculations based on tracking individual women throughout their college career. With no intervention in place, it would be expected that these rates would fall below the over-inflated estimated rate of 55% reported by the University Registrar. The results of this study indicate that the retention rates of women in engineering and science at the University of Washington have increased substantially, to more than 72% in most cases, since the inception of the WIE Undergraduate Retention Program.

An analysis of incremental retention rates reveals patterns of switching out of S&E. As shown in table 8, most women who leave S&E do so during their sophomore year. This switching coincides with the time when most students find out if they have been accepted into a department, as well as the point of lowest academic self-confidence that was shown in table 1. For those women who remain in S&E beyond their sophomore year, retention rates are very high.

F. Switching Out of Engineering and Science

A total of 40 of students from all six cohorts switched out of S&E or dropped out of college altogether this year. The majority (80%) of these students were freshmen and sophomores. Only six juniors, one senior, none of the 5th-year seniors, and one 6th-year senior switched or left the University without graduating. This significant increase in the retention rate at the junior and senior years is expected, since

- these students have persevered through the hurdles of the lower-level prerequisite courses and acceptance in their department at the end of their sophomore year
- the cost of switching, in terms of lost time and effort, increases as time goes on.

The most frequent reasons given for switching are summarized in table 9. Responses from all cohorts over the six years of the study have been fairly consistent: loss of interest in engineering and science, other majors appear more interesting, and discouragement by conceptual difficulties and perception of low grades. This discouragement corresponds to the drop in self-confidence over the course of the freshman year. Note that the responses in table 9 do not reflect the entire 187 students who have switched or dropped out, but only the 142 students who responded to the survey at the point of switching or leaving the University of Washington.

Barrier	Freshmen (n=561)	Sophomores (n=291)	Juniors (n=144)	Seniors (n=137)	5th Year (n=35)	Average
Lack of self-confidence	23.0%	26.8%	26.4%	44.5%	48.6%	33.9%
Not being accepted into department	29.4%	33.2%	9.7%	N/A	N/A	32.8%
Feeling intimidated	22.6%	35.7%	41.7%	19.0%	25.7%	28.4%
Isolation	7.6%	13.4%	8.3%	51.8%	45.7%	25.4%
Financial problems	17.8%	23.6%	25.7%	30.7%	28.6%	25.3%
Lack of interest	12.6%	18.2%	17.4%	38.0%	31.4%	23.5%
None	22.8%	17.9%	22.2%	2.9%	8.6%	14.9%

Table 6. Most frequently reported perceived barriers.

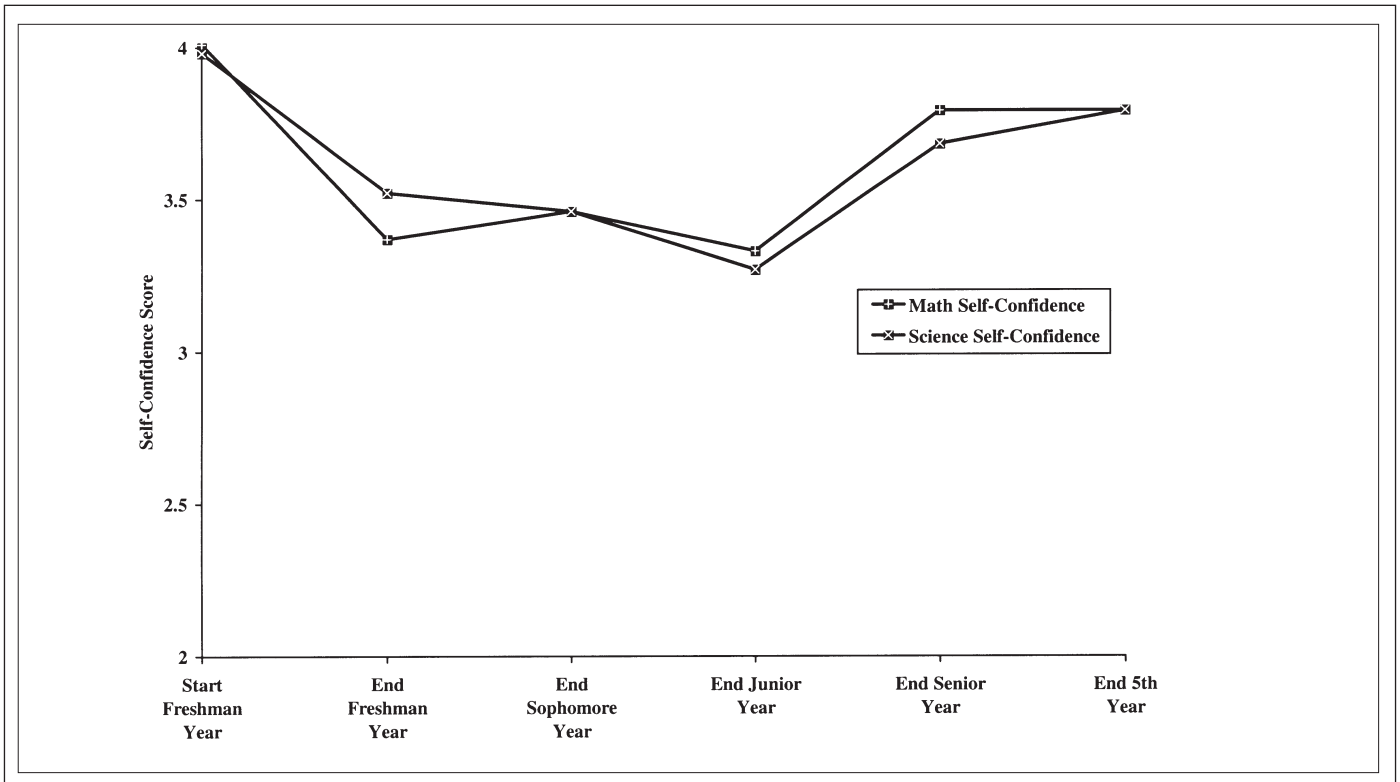

Figure 1. Main levels of self-confidence by year.

Cohort	Current Status	Original N	Still in S&E	%
1	Graduated	92	65	71%
2	End 5th year or graduated	107	78	73%
3	End senior year or graduated	103	61	59%
4	End junior year	125	81	65%
5	End sophomore year	127	93	73%
6	End freshman year	118	107	91%

Table 7. Retention rates of female students in science and engineering at the UW.

Cohort	Freshman year	Sophomore	Junior	Senior	5th Year	6th Year
1	97%	84%	97%	95%	100%	94%
2	93%	89%	94%	94%	100%	
3	87%	83%	83%	98%		
4	80%	87%	93%			
5	90%	82%				
6	91%					

Table 8. Incremental retention by year in school.

Reasons	Freshman year (n=59)	Sophomores (n=58)	Juniors (n=17)	Seniors (n=8)	5th Year (n=0)
Other majors more interesting	37%	41%	41%	50%	N/A
Lost interest in S&E	56%	60%	59%	63%	N/A
Conceptual difficulties	37%	45%	44%	38%	N/A
Discouraged by low grades	41%	60%	47%	50%	N/A
Rewards not worth the effort	34%	18%	19%	38%	N/A
Poor Teaching	27%	28%	81%	38%	N/A

Total N=142 students who responded to the annual questionnaire stating that they were switching out of science/engineering or dropping out of college altogether. Total does not include those 45 students who did not return the questionnaire when they left or changed majors.

Table 9. Most frequent reasons for not persisting in science and engineering.

A comparison of math and science self-confidence levels for women persisting in S&E or switching to another degree program is shown in figure 2. Women who switch at the end of their freshman year feel significantly less confident in science ($p<0.05$) than those who persist; however, there is no difference in levels of math confidence. Self-confidence scores are clearly divergent between persisters and switchers at the end of the sophomore year, with both scores significantly lower ($p<0.05$) for switchers. By the junior and senior years, only science self-confidence is significantly lower for switchers ($p<0.05$). Surprisingly, math self-confidence does not appear to be related to persistence for those women who switch in the later years of their education. It is more likely that women who switch in later years do so due to the alienating S&E educational climate.[16]

IV. Conclusion

In summary, there are several factors forming a general, consistent pattern describing the academic experiences influencing the decisions of women to persist in, or switch out of, degree programs in engineering and science.

- The women who enter the University of Washington with the intent to pursue a degree in engineering or science are highly-filtered achievers who start off with high levels of self-confidence in their academic abilities in math and science. These levels take a significant drop ($p< 0.001$) over the course of the first year, and although they slowly recover over the course of their four or more years in college (if they persist in S&E), they do not return to their original levels.
- Most women who switch out of engineering or science to another degree program do so in the first or sophomore year. The primary reasons they give for switching are losing interest in science/engineering, being attracted by another field, or being discouraged by academic difficulties and perception of low grades.
- Not surprisingly, the reasons for leaving are also the most frequently reported concerns, or "barriers" reported by women students who persist: fear of losing interest, intimidation, lack of self-confidence, poor advising, and not being accepted in their department. Although 20% of first-year students, sophomores and juniors reported no barriers, nearly all seniors reported at least one barrier.
- Women who are most likely to persist through the freshman year chose to pursue their major primarily because they enjoyed their science and math classes in high school, continue to enjoy those classes in college, and work well independently. In addition, they consider WIE and faculty to have a positive influence on them during their first year in college. New persistence factors emerging in this year's results are positive ratings of the quality of math instruction, involvement in SWE, and feeling supported by their mothers.
- In the sophomore year, persistence factors focus primarily on a positive relationship with an advisor, the influence of math and science classes, working, and gaining acceptance into a department. Participating in SWE and internships and co-ops also emerged as persistence factors this year.
- In the junior year, after most students have been accepted into a department, persistence factors shift to positive influence of a mentor, math and science classes, participation in conferences and events, and, for the first time, SWE.
- For seniors, persistence factors are a positive influence of science classes, seeing an academic advisor, and participation in conferences and events. New factors emerging this year were a positive influence of engineering classes and quality of instruction.
- Only science self-confidence levels are consistently lower for switchers than persisters. Math self-confidence is only significantly lower for those women who switch in their sophomore year; for those who switch in the first, junior, or senior year, there is no difference in math self-confidence.
- Despite differences in self-confidence, comparison at the time of switching showed no difference in actual performance, measured by GPA, between women who persist in S&E and women who switch to a non-science major.

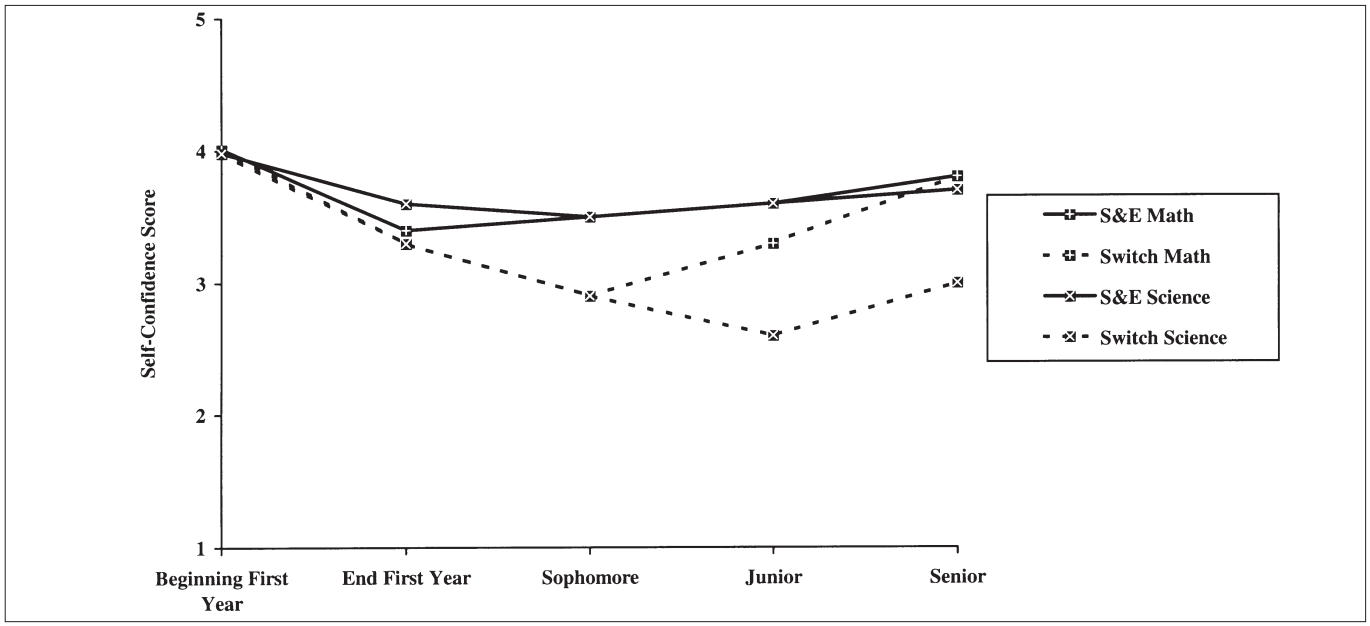

Figure 2. Academic self-confidence measures for women who remained in science and engineering vs. women who switched to another major.

- Students who maintain high levels of math and science self-confidence throughout college were likely to have had higher initial self-confidence levels. Continued high self-confidence is correlated with a number of other factors which have been shown to be related to persistence in S&E, such as higher levels of interest in coursework, positive relationships with faculty/TAs, involvement in student societies, seminars, conferences and events, participating in internships, and generally better preparation for a career.
- Overall retention rates for women participating in this study are consistently significantly higher than the estimated national average.

These findings suggest that factors other than ability play a major part in women's decisions to persist or switch from an engineering or science degree program. Maintaining a feeling of interest and involvement with coursework, and a sense of doing well academically, and finally the commitment that comes with acceptance into a department appear to be major influences for these women. In response to the finding that many students lose interest and change majors during the first two years when they take only prerequisite courses, some departments in the College of Engineering have instituted policy changes making it possible for students to begin the engineering curriculum in the sophomore year rather than the junior year. This policy will more than likely positively influence retention rates. The impact on retention of this and other changes in the curriculum will be examined as an ongoing part of the present study.

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