

Women in CS and Biology

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Abstract

Common departmental characteristics and practices in computer science and biology/life science are compared for 46 departments at 23 Virginia colleges and universities. The goal of this preliminary investigation is to provide additional evidence on how departmental factors can affect the retention of female students.

1 Introduction

Women are under-represented in some, but not all, scientific, mathematical, engineering, and technical (SMET) disciplines. The degree and distribution of this under-representation changes over time, with some disciplines improving their female participation rates to the point of equivalence with men in recent years. For example, as Figure 1 shows, Biology/Life Science (BLS) rose from 29% female Bachelors degrees in 1970-71 to 55% female Bachelors degrees in 1997-98 [12]. In contrast, the female percentage in computer science (CS) rose then fell. CS was the only major SMET discipline to show such a decline in female representation.

Disproportionate loss of women from undergraduate CS, (women switching out at higher rates than men), reduces the already low numbers of women in the discipline. Despite recent overall enrollment increases in CS and women's achievement of parity in internet use, the most current statistics available from the U.S. Department of Education (1997-98) show that the female percentage of CS Bachelors degrees continued fourteen years of almost unrelenting decline to its most recent low of 26.7%. (See Camp [3] for a more complete discussion of this trend.)

A comparison of gendered attrition rates (the difference between a department's male rates of leaving the major and female rates of leaving the major) shows that one reason BLS awards more of its Bachelors degrees to women is because it retains its female majors at comparable rates to men. In Virginia, the average CS department lost 9% more of its women than men to other majors [4]. As will be reported here, the average BLS departments in those Virginia institutions lost only 1% more women than men

between 1992 and 1997.

These observations suggest that the current low numbers of women in CS are not inevitable. If a discipline such as BLS, similar to CS in many ways, can increase its female participation rates, CS might also. By comparing departmental characteristics in BLS to those in CS, we may find evidence on which factors could increase the female participation rates in CS.

The similarities between these two disciplines include the following. They are both rapidly advancing and highly technical. They both have rigorous academic requirements that include courses in disciplines such as mathematics, chemistry, and physics. Both majors are closely tied with particular careers - many BLS students are pre-med. In both disciplines, lab work is necessary, and students are often expected to become familiar with new technology.

Given these similarities, a comparison of the two disciplines might uncover features that are related to the disciplines' different gender outcomes. This article compares certain characteristics and practices of CS and BLS departments. The selected characteristics and practices were those identified as significant by a study of CS alone. Comparing the two disciplines lends additional weight to findings that this set of factors could increase female participation rates in disciplines where they are under-represented.

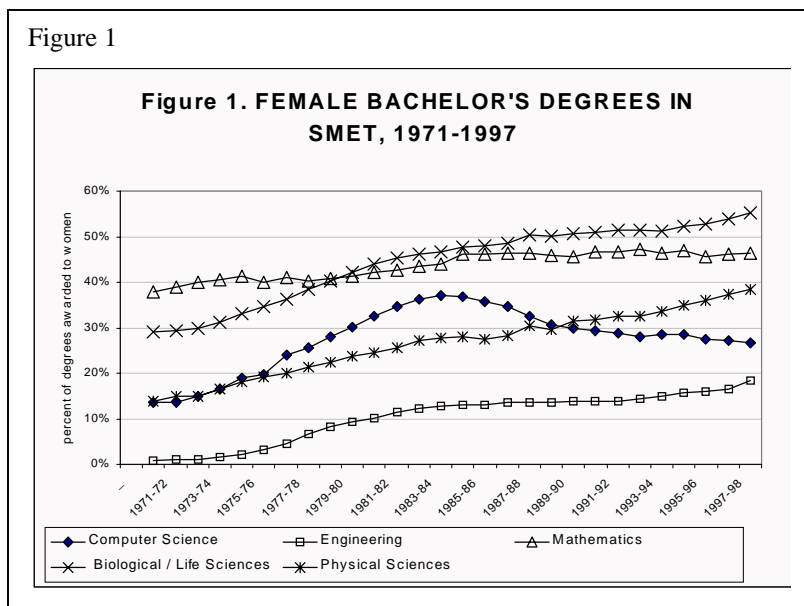
2 Background

Much effort has gone into identifying the reasons for low female participation in SMET disciplines, and numerous studies have focused specifically on the discipline of computer science [14, 2].

Some research suggests that the culture of computing can inhibit women's entrance and persistence in CS [9, 15, 7]. These reports generally describe the computing culture in single institutions and focus on the different experiences of male and female students. For example, Fisher, Margolis, and Miller detail the experiences of male and female CS and non-CS majors at Carnegie Mellon University [7].

Examinations of female recruitment and retention in different SMET disciplines have been made, however, they seldom explicitly compare discipline features and outcomes [13, 1, 6, 13, 11, 16]. Typically, these works relate student characteristics with student outcomes. Their findings include indications that environmental factors can influence outcomes for male and female students. For example, Astin and Astin found that having socially similar peers was a strong predictor of persistence in an SMET major [1], and

Figure 1



Seymour and Hewitt found that pedagogical practices affected student retention [11].

The current study builds on previous work by making an overt, quantitative comparison of CS with another discipline at the departmental level. The focus on departments is worthwhile because the characteristics and practices of departments influence their retention of women [4]. The comparison across disciplines is productive because it lends additional support for this assertion by demonstrating that certain factors may have a general influence over female retention in SMET disciplines.

3 Data and Measures

Because the unit of study for this research was academic departments, the data collection task was to describe participating departments. This task was accomplished with data from three sources. Quantitative data came from the State Council of Higher Education for Virginia (SCHEV) and from a survey of faculty and chairpersons in Virginia's CS and BLS departments. Qualitative data came from interviews conducted with faculty, chairpersons, and students at 5 Virginia CS departments.

SCHEV provided aggregate data on outcomes for declared CS and BLS majors. These data counted the number of students enrolled each year from Fall 1992 until Fall 1997 at the 23 colleges or universities that granted CS Bachelors degrees to both males and females in this time period. For each sex, the number of students who switched majors was divided by the number initially enrolled less those students who left the institution. Each department's average female rate for 1992-1997 was then subtracted from the average male rate for a gendered attrition rate. These departmental gendered attrition rates were then averaged by discipline to provide a statewide mean for CS and for BLS.

The survey of faculty and chairpersons was conducted in 1998. Two hundred ten faculty and 45 chairpersons

returned completed surveys for response rates of 65% and 90%, respectively. The overall survey response rate was a very respectable 68% so that every one of the 46 departments in the study was represented by at least one faculty member or chairperson.

This report deals with one aspect of a larger study that included over 80 theoretically and empirically derived variables. The variables considered in this paper are only those that both distinguished CS from BLS and associated with CS departments' gendered attrition rates in other portions of the analysis. These variables are: available same-sex peer support; faculty stability; faculty attitude toward female students; mentoring time and numbers; shared responsibility for student success; and the presence of female faculty. The complete set of variables considered may be obtained from the

author.

With the exception of available peer support and presence of female faculty, each of these variables was measured by a departments' average response to questions on either the faculty or chairperson survey. Presence of female faculty was measured as the percent of a discipline's departments that had at least one female faculty member. Available peer support was measured in two ways - with SCHEV data on the gender composition of student enrollment, and with faculty responses to a survey question about the gender composition of lower-level courses they recently taught. These data quantified the same-sex peer support available to female students.

Faculty stability was measured for each department with the chairpersons' responses to two questions. The first question determined turnover numbers - "Since 1990, approximately how many faculty have left the department for reasons other than retirement?" The second question determined the number of tenured faculty in the department - "How many of your department's faculty have full-time, tenured appointments?" Using the second piece of information as the basis of stable faculty size, the ratio of these two numbers represented the amount of instability in the faculty.

Faculty attitude toward female students was measured by an index constructed from questions about male and female student characteristics and the necessity of these characteristics for success in the major. The index measured faculty belief that one sex had an advantage on characteristics important to success in the major with scores ranging from a possible -70 (extreme male advantage on all characteristics) to 70 (extreme female advantage on all characteristics).

Mentoring time was measured according to a department's average faculty response to the question, "During the academic years between fall 1992 and spring 1997,

approximately how many hours per week did you usually spend mentoring undergraduates in your department?" Mentoring was defined as "recruiting individual students into professional activities; offering personalized advice to individual students; encouraging individual students; helping individual student establish careers."

Mentoring numbers refers to the number of female students faculty reported mentoring. This measure was affected by the number of enrolled women because departments with more women enrolled would have the option of mentoring more women. To overcome this limitation, an additional measure, female percent of students mentored relative to female percent of enrollment, was also considered.

The last variable reported here was shared responsibility for student success. This variable was one of several items measuring elements of faculty commitment to teaching undergraduates. Faculty rated their level of agreement on a 5-point scale with the statement, "The students and I shared responsibility for their success in the course."

4 Analysis and Results

This study compares the typical characteristics and practices of CS and BLS departments in all the Virginia institutions that awarded CS Bachelors degrees to men and women between 1992 and 1997. Because this entire population was studied, inferential statistics were not necessary. The data represent actual conditions in Virginia during the study period. For this reason, all results reported

are the direct comparison of discipline averages.

The average Virginia BLS department is larger than the average Virginia CS department. BLS typically has more students enrolled as majors, and women are in the majority. The average BLS classes are also larger than average CS classes. And BLS departments typically have more faculty than CS departments have, although on average, the faculty/student ratio is higher in BLS (17:1 for BLS versus 14:1 for CS.)

Table 1 lists both departmental and discipline average gendered attrition rates for CS and BLS. As stated in the introduction, CS lost female students to other majors at higher rates than it lost male students. BLS lost female students at a slightly higher rate than males. Thus, the gender gap in BLS was much smaller than in CS. The institutional correlation is a moderately strong 0.49 indicating that there is an institutional effect on the gender gap in attrition rates. However, the rates in CS are significantly higher than in BLS, and they vary more in CS (stddev = .14) than in BLS (stddev = .04).

Table 2 summarizes the average discipline results for the study variables. It shows first that, both based on the gender composition of declared majors and the gender composition of course enrollment, there are more same-sex peers available to help women in the average Virginia BLS department than there are in CS. Thus, this availability may be important to female retention in both disciplines. It is known that supportive relationships and help from classmates are essential for student success in CS [5, 1]. The discipline difference in availability of women to support each other may be one reason for the difference in gendered attrition rates.

The percentage of Virginia departments in both disciplines with women on their faculty was surprisingly high. The lack of female faculty in SMET has been long lamented because it deprives female students of role models. However, BLS still had more departments with women on the faculty than did CS. This discipline difference could be related to gendered attrition.

Likewise, on average, faculty instability was greater in CS than it was in BLS. Turnover on the faculty could have a negative impact on student retention for several reasons. For example, it could be explained as an indication of general problems in a department that cause both faculty and students to leave. The fact that female students leave at higher rates than males could be due to weaker attachment to the discipline. An alternative explanation is that faculty uncertainty, as evidenced by turnover, leads faculty to rely more on students like themselves (white male in most cases) to the detriment of female students.

The index of faculty attitude toward female students showed that both disciplines generally rated female students more highly than male students. However, the average BLS faculty thought women were much more suited to the study

Table 1

Departmental and Discipline Gendered Attrition Rates	
Computer Science	Biology/Life Science
-0.6	-0.09
-0.36	.
-0.31	-0.02
-0.19	-0.03
-0.19	0.01
-0.11	-0.06
-0.06	-0.01
-0.06	-0.02
-0.05	-0.01
-0.05	0.06
-0.04	0.02
-0.04	0
-0.04	-0.04
-0.03	-0.02
-0.02	0.02
-0.02	-0.05
-0.01	-0.02
-0.01	-0.02
0	0.02
0	0
0.01	0.05
0.03	0.02
0.05	-0.05
Discipline mean -0.09	Discipline mean -0.01

Table 2

Average CS and BLS Characteristics and Practices		
	CS	BLS
Available same-sex peer support for women:		
department gender composition	28% female	58% female
course gender composition	31% female	56% female
Percent of departments with female faculty	87%	96%
Faculty instability	30%	25%
Faculty attitude toward female students	7.67	20.21
Mentoring time per week	4.21 hours	5.98 hours
Mentoring numbers:		
number of female students mentored	7	18
relative female percent of students mentored	1.34	1.03
Shared responsibility for student success	4.05	4.17

of their discipline than did CS faculty. An examination of this result by sex of responding faculty showed that it was not due to a female faculty voting block in BLS. Both male and female faculty rated female students much higher than males in BLS, and to a lesser extent in CS. This feature of departments could affect female retention through the commonly-noted low female self-confidence [7,13]. Perhaps strong positive faculty assessment of female students' abilities can shore-up weak self-confidence.

Mentoring hours per week were almost 2 hours greater in the average BLS department than in CS, suggesting that the time faculty devoted to mentoring students could help retain women. This time was devoted to reaching more students, rather than spending more time with individual students because more students and a greater number of women were mentored in BLS than in CS. Calculating the average amount of time per student mentored showed that BLS students got about one minute more mentoring per student per week than did CS students.

However, the mentoring results were not straightforward. When the number of women available to be mentored was taken into consideration, a different picture emerged. The female percent of student mentored relative to the female percent of enrollment was greater in CS than in BLS. In other words, CS departments were more prone than BLS to mentoring women out of proportion to their enrollment. This practice might be a well-intentioned effort to improve female retention in departments that really need it, or it might be a practice with unintended negative effects caused by putting female students in the spotlight.

On average, faculty belief that they shared responsibility for student success was slightly greater in BLS than in CS. This indicator of faculty commitment to undergraduate teaching was one of several that measured the importance of teaching. Together with the fact that two-thirds of BLS, but only one half of CS faculty attended workshops to improve their teaching, there appeared to be slightly more evidence of commitment to teaching undergraduates in BLS than in CS.

5 Discussion

This comparison of CS and BLS provided additional evidence that certain departmental characteristics and

practices may affect the relative retention of undergraduate women. The factors investigated here had already been shown to distinguish among CS departments [5]. All but attitude toward female students were selected because they had statistically significant correlations with gendered attrition rates in CS departments. Attitude toward female students was selected because qualitative data suggested that it was related to gendered attrition rates in CS. The result of this investigation is a demonstration that these factors also distinguish to varying degrees between the disciplines of CS and BLS.

Gender composition of the average department in the discipline differed in the manner predicted by average gendered attrition rates. Women are a majority in BLS and a minority in CS. Among undergraduates, there are many more same-sex peers available to support women in BLS than there are in CS. Likewise, more BLS departments had women on their faculty than did CS departments. These gender-composition differences between CS and BLS in Virginia lend support for the conclusion that this factor is important to the equitable retention of women.

Faculty stability, attitudes toward female students and teaching, and mentoring behaviors were also shown to differ between CS and BLS. With the exception of relative female percent of student mentored, these factors all differed in the manner predicted by their discipline's relative retention of female students. Compared with CS, BLS generally had less faculty turnover and more favorable attitudes towards female students, spent more time mentoring students, and had faculty who felt a shared responsibility for student success. These findings lend support for the conclusion that women are retained at comparable rates to men when there is little turnover on the faculty; when faculty believed that their female students are well-suited to the discipline, and that faculty played an important role in student success; and when faculty devoted time to mentoring students. The lack of support from mentoring women relative to their representation in the department is currently being investigated in more detail.

The degree of influence each factor we considered has over gendered attrition rates may be small or large. Previous research that focused on CS alone showed the strength of their effects [5]. Here we note that in addition to distinguishing among CS departments, these factors might also distinguish among SMET disciplines.

The results reported here are only suggestive. The small number of departments studied and the restriction to one state limit our ability to make generalizations based on these findings. Further investigation with more disciplines and more institutions across the nation is underway.

Yet despite these caveats, these results are interesting because they indicate that the common character of a discipline – its gender composition; and its faculty stability, attitudes, and behaviors could affect its retention of female

students. For CS departments that wish to increase female participation in the discipline, these results argue for greater effort at recruitment of female students and faculty, limiting faculty turnover, focusing faculty on teaching and mentoring, and promoting positive attitudes toward female students.

6 Summary

Despite much discussion of the issue and changes in the pattern of women's computer experience, female students continue to comprise a declining proportion of undergraduate computer science majors. To broaden our thinking about methods for increasing female representation, this article reported the results of a comparison of CS with BLS departments in the state of Virginia. This preliminary investigation suggests that gender composition of faculty and students, and faculty stability, attitudes, and mentoring may all affect the retention of female students at comparable rates to men.

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