Departmental Differences Can Point the Way to Improving Female Retention in Computer Science

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1. ABSTRACT

Departmental attrition data from one state show that the difference between male and female rates of undergraduate attrition from computer science varies by institution. This analysis suggests that departmental factors are important in attrition from CS. Some CS departments inhibit female persistence at the undergraduate level while other departments promote persistence. The observed variation encourages research that compares departmental characteristics such as structure and culture, and relates them to departmental outcomes. Shifting the research focus to departmental characteristics and outcomes will identify effective methods for retaining women.

1.1 Keywords

undergraduate education, gender, retention, attrition

2. INTRODUCTION

It is well recognized that women are underrepresented in computer science. Gender differences in interests, abilities, and personality characteristics have been implicated as reasons for this disparity. However, it has not been appreciated that computer science departments vary in the size of the gender gap in their attrition rates. Some computer science (CS) departments have no gender difference in their attrition rates, while others have dramatic differences between their male and female attrition rates. The implication of this variation across departments is that the environment – the CS department, can overcome gender differences that might contribute to female underrepresentation. This finding locates the power to improve female retention in the hands of educators.

3. ATTRITION FROM THE CS MAJOR

At the Bachelors level, female underrepresentation results from failures in both recruitment and retention. The number of female students recruited into computer science is low, and these low numbers are diminished further when attrition (non-persistence in the major) reduces the already thin ranks of women in the field. Although Scragg and Smith [1] identified ineffective recruitment as the primary cause of low female participation in CS, the reduction in numbers through female attrition is still a serious concern. Those women lost to CS through attrition are women with interest and ability who reached the college level, overcoming any deterrents to their participation in the field. Having overcome the hurdle of recruitment, computer science must find ways to retain these qualified women.

In computer science and other science, mathematics, and engineering (SME) fields, low female participation has most frequently been attributed to female disadvantages that stem from gender differences in

- computer interest, motivation, or experience [2, 3, 4, 5, 6]
- mathematical ability or academic preparation [7, 8, 9, 10]
- self-efficacy [11, 12]
- early socialization [13, 14].

Research also implicated the culture of computers and its particularly male character as a reason for low female participation [15, 16, 17, 18, 19]. And some studies of recruitment and retention in SME argued that environmental factors such as competition among students and pedagogical techniques affect female participation [20, 13]. A review of studies specifically focusing on undergraduate computer science is available in Howell [21].

In spite of these efforts, no adequate explanation of CS's gender disparity has been agreed upon. Research results are varied and conflicting [22, 23, 24, 25, 26, 27] so the reasons females leave computer science are still unclear. Meanwhile, female representation continues to decline.

New insights are needed to guide retention efforts. This paper documents that CS departments vary in their gendered attrition rates and suggests that comparative research on departmental characteristics and outcomes may provide useful new information on the necessary conditions for retaining equally high proportions of male and female CS majors.

4. DATA AND MEASURES

The State Council of Higher Education for Virginia provided aggregate data on outcomes for declared majors in computer science from Fall 1992 through Spring 1996. All 22 Virginia colleges or universities that granted CS Bachelors degrees to both males and females in this time period comprise the population for this study. Within each institution, sophomores, juniors, and seniors who were declared as CS majors in 1992, were tracked until 1996.

Unlike many other studies of attrition, this research includes only declared majors, and it is not based on a sample or a single institution. These differences offer some advantages and disadvantages. An advantage of using a population instead of a sample is that no inference is necessary. These data tell us exactly what the attrition from CS was in this Virginia cohort.

A disadvantage of basing this study on the population of Virginia institutions is that our analysis may not be generalizable to the United States as a whole. This concern can be reduced by comparing data from the state of Virginia with the nation as a whole. Figure 1 illustrates that the percentage of CS Bachelors degrees awarded to females in Virginia from 1985 through 1995 has generally been slightly higher than the national percentage and that it has followed a similar declining trend, although with more volatility. This comparison demonstrates that the conditions we observe in Virginia may be more favorable to females, but they are similar to national trends. Thus, the Virginia attrition data may offer some insight into female attrition from CS in the nation as a whole.
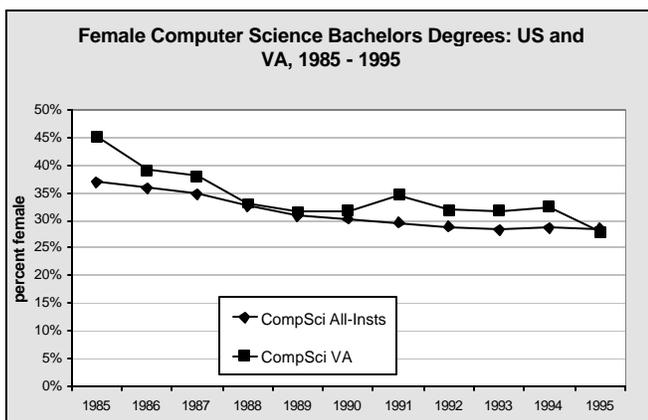

Figure 1.*

*Data from CASPAR [28].

An advantage of including only declared majors in this study is that it distinguishes attrition/retention from recruitment. Declared majors includes only those sophomores, juniors or seniors who formally declared their major, not incoming students or undecided students who have not yet taken this step. Students who have declared their major have some experience with their college environment before they declared. They have been exposed to the alternatives offered by higher education and their institution. These students are also likely to have taken a college course in their intended major, so they had a chance to test their ability and motivation against college standards to see if their initial intentions were realistic. Measuring the attrition of only declared majors makes it possible to focus in on the effects of departmental environment on student attrition.

Four attrition rates are calculated for each department – the overall rate, the male rate, the female rate, and the gendered attrition rate. The overall departmental attrition rate is measured as the percentage of all the sophomore, junior, and senior CS majors enrolled in a CS department in fall of 1992 who did not complete or continue to persist toward their Bachelors degree in that department by fall 1996. Only those students who switched to a different major at the same institution are considered part of the departmental attrition rate. To avoid confusion between factors that lead to switching major and those factors that lead to dropping out of college or transferring to another institution, students who eventually left the institution are excluded from consideration.

Male and female attrition rates are calculated separately in a similar fashion to departmental attrition rates. The original fall 1992 group less transfers and dropouts is the denominator and those who switched out of the major by 1996 are in the numerator.

Each department's female attrition rate is subtracted from its male attrition rate to obtain the department's gendered attrition rate, producing a positive number when there is less female attrition than male attrition. For some analyses the absolute value of the gendered attrition rate is used to measure the size of the gender gap between male and female attrition rates.

5. RESULTS AND ANALYSIS

By 1996, the average CS department in Virginia had lost 16 percent of the declared majors from its fall 1992 enrollment. Virginia's rate of attrition from CS was dramatically less than the 64 percent overall rate from a national sample of the 1987 – 1991 cohort [13]. The differences between the Virginia data and the national sample data are not surprising given that the national data included intended majors and tracked only entering freshmen. The Virginia statistics reported here are reduced by the inclusion of only declared majors, and by the inclusion of juniors and seniors with the sophomores being tracked. Including juniors and seniors lowers the attrition rate because with each successive year in a major, students are less likely to leave. A group that includes students with more experience will have a lower attrition rate than a group that includes only students new to the major. The VA statistics may also differ from the national statistics because the data cover different time frames, Virginia's being five years more recent.

On average, there was a 5% difference between male attrition (mean = 16%, or 12 male students) and female attrition (mean = 21%, or 7 female students). At these rates, had men and women been equally attracted to the CS major, attrition would have resulted in 5% fewer women CS graduates than men CS graduates.

However, this 5% difference in men's and women's average attrition rates is not the whole story. By considering only the average, we miss a subtle difference – that female attrition rates are more diverse than male attrition rates are. Female attrition ranged from 0 to 100%, with a variance of 6% and a standard deviation of 24%. Male attrition ranged from 0 to 43%, with a variance of 2% and a standard deviation of 13%. Contrary to the idea that there is something about being female that makes women less well suited to the study of computer science, there was no one "female" response to undergraduate computer science. Female attrition rates varied by department more so than male rates did.

As you would expect, the greater variation in female attrition rates produced variation in the gendered attrition rates because departments' gender gap increased or decreased with female attrition. This relationship between female attrition rate and gendered attrition rate is confirmed by comparing the correlations for male attrition and gendered attrition (r = .12) with female attrition and gendered attrition (r =.85). The size and direction of the gender gap in a department's attrition rate is strongly determined by how successful the department is at retaining its female students.
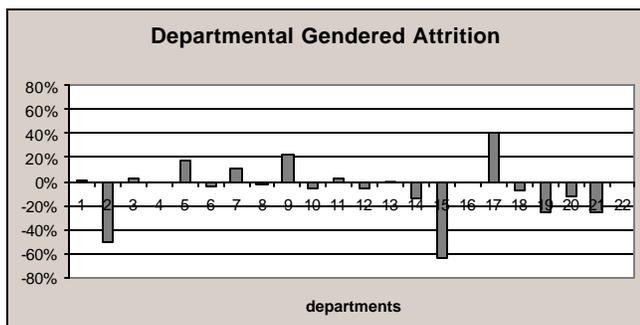

Departmental Gendered Attrition

Figure 2.

As discussed previously, much of the research explains the poor retention of females as an outcome of psychological or biological gender differences. These explanations would lead us to expect a fairly uniform gender gap in male and female attrition rates across departments with females always leaving at a higher rate than males. However, Figure 2 shows that the gender gap was not uniform. It ranged from 0 to a 64% difference between male and female attrition. The variance in gendered attrition was 5% and the standard deviation was 22%. This variation in gendered attrition rates across departments supports the notion that

departments contribute to differences in male and female persistence in CS.
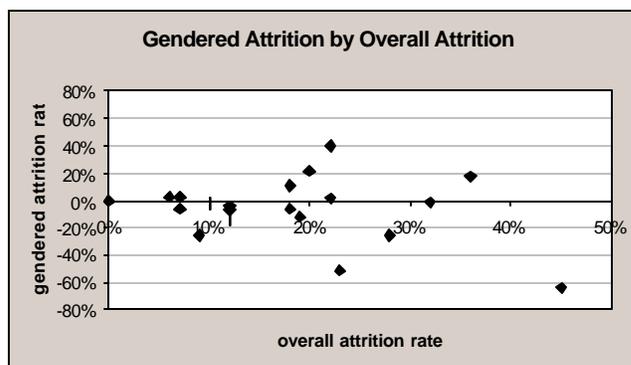

Gendered Attrition by Overall Attrition

Figure 3.

If departments contribute to differences in male-female attrition rates, could that contribution be simply a reflection of overall student attrition? Do the factors that cause some departments to lose a lot of students have a greater impact on females than on males? The answer to these questions is yes and no.

Departments with high overall attrition do tend to have larger gender gaps in their attrition rates (r = .64), but it may be either males or females who leave disproportionately. When gender is considered, the relationship between overall attrition and gendered attrition is much weaker (r = -.28). We can see the nature of this relationship more clearly in Figure 3, which shows the plot of departments' gendered attrition rate with the overall attrition rate. The eleven departments where overall attrition was 12% or less had gendered attrition rates that were either very small or negative leaving females at a slight disadvantage. In the seven departments where overall attrition was between 13 and 25%, males and females were about equally likely to leave at disproportionately high rates. And in the four remaining departments that had overall attrition above 25%, females were again more often the less persistent group. Thus CS departments that lost many students often lost a disproportionately high number of one sex. But it was not always the females who were disproportionately affected. Five out of eleven times, departments with more than 12% attrition lost a higher percentage of their male students. Based on these observations we can only conclude that the variation in departments' gendered attrition rates is more than a reflection of variation in overall departmental attrition.

6. DISCUSSION

As the education and training of computer scientists becomes more and more crucial to modern society's well-being, we are ever less able to tolerate the loss of interested women from the field. For example, the current shortage brought on by the Y2k problem shows that computer science needs more intelligent, well-trained people than the shrinking demographic pool of white males can provide.

The struggle to increase female participation in this important field will benefit from research that compares departments. This approach directs our attention toward environmental conditions that are under the control of higher educational institutions and puts a to-do list in our hands. Furthermore, the departmental focus encourages us to think about education and professional training as something more than a pipeline through which individual students pass with all their predetermined characteristics and abilities. Academic departments are not passive conduits. They affect the students that pass in, out, and through them. By studying these effects and the conditions that produce them, we gain the ability to retain more women in CS programs.

We have found that CS departments' gendered attrition rates varied across institutions. In other words, departments differed in the difference between their male and female attrition rates. This lack of a consistent difference demonstrates that gender characteristics such as early sex role socialization, mathematical achievement or ability, computer interests and attitudes, etc., are not sufficient to explain the disproportionate loss of women from computer science. It appears that environmental characteristics may overcome or exaggerate gender differences.

This finding suggests that comparisons of departmental characteristics and outcomes could lead to identification of the conditions under which females persist in computer science.

7. SUMMARY

This study has explored the relationship between departmental attrition and the disproportionate loss of female undergraduates from computer science. The observations of gendered attrition reported here are evidence that the college experience plays an important role in female underrepresentation in computer science. There is evidence that some computer science departments discourage female persistence at the undergraduate level while other departments promote persistence.

Research is underway to determine which departmental characteristics and practices contribute to greater retention of female students at the undergraduate level. Pedagogical techniques, access to opportunity, tokenism, and other environmental characteristics will be examined for their role in gendered attrition.

8. ACKNOWLEDGMENTS

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