# The Status of Women and Minorities in Academic Computer Science

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**The results of a survey concerning women and minority students and faculty in computer science during the years 1971 to 1975 are presented. Analysis of the data indicated that effective affirmative action programs for recruitment into graduate degree programs are needed to enlarge the number of women and minorities qualified for later employment in computer science. Also, possible discrimination in employment of women and minority graduate students was revealed.**

**Key Words and Phrases: discrimination against women, discrimination against minorities, graduate students, undergraduate students, academic employment, faculty, computer science degree programs, affirmative action, Title VII, Title IX**

**CR Categories: 1.52, 1.53, 2.2, 2.3**



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## 1. Introduction

Employment and admissions in academic computer science have been influenced during the past decade by the federal laws and regulations concerning sex and minority discrimination in educational institutions. These laws include Executive Order 11246, Title VII of the Civil Rights Act of 1964, the Equal Pay Act of 1963, and Title IX of the Education Amendments of 1972 [6]. A great deal of interest and discussion has revolved around the effectiveness of such regulations, and recent efforts have been undertaken to statistically evaluate their impact. Weber and Gilchrist [8] have reported on the status of women in the computer industry, and Arnst and Dooley [2] interviewed 30 women in the data processing field at a recent convention and reported on discrimination against women in that area. The following report is an examination of the status of women and minority faculty and students in computer science.

## 2. Survey Methodology

Data for the study were collected by means of a survey mailed to 440 computer science, engineering, and mathematics departments in colleges and universities throughout the United States. An attempt was made to contact all heads of departments which have computer science degree programs. Although a list of computer science Ph.D. degree granting departments is available, and all of these departments received questionnaires, there is currently no complete list of master's and undergraduate degree programs in computer science. Departments listed in the 1974–75 ACM Graduate Assistantship Directory in the Computer Sciences, as well as those listed on a University of Illinois Department of Computer Science information distribution list, were contacted in the search for all the master's and undergraduate degree programs.

A total of 265 questionnaires (60%) were returned. Of those returned, 91 respondents had a computer science undergraduate and/or graduate degree program and had sufficient records to supply at least some of the requested information. These 91 questionnaires form the database for the results given below. An additional 15 respondents had computer science degree programs but insufficient records to fill out the questionnaire, although 6 of these supplied lists of faculty members. Of the remaining respondents, 12 indicated that they had a computer science degree program in some stage of planning and development and 147 (55%) indicated having no degree program. 31 of the 60 known Ph.D. granting institutions responded. An examination of the Ph.D. granting institutions that returned questionnaires revealed representation from all ranges of the size, prestige, and geographical location spectra. A few very large Ph.D. granting departments did not respond, thus

possibly making the total numbers smaller than what might be expected in a representative sample.

In many places in this study, Pearson chi-square ($\chi^2$) tests of independence were used to compare distributions of male, female, and minority students, across years, degrees, and employment categories. However, since this test requires independent observations, and since some of the same students were presumably found in consecutive years (but only in enrollment and employment data), the following conservative approach was used for significance tests on these data. First, each $\chi^2$ value for the affected tables was divided by 2 (yielding $\chi_m^2$, or modified chi-square) on the assumption that the average student would only appear twice. Second, a probability level ($p$) of .01 was used in all cases to further reduce the probability of falsely rejecting a true null hypothesis.

For each $\chi^2$ statistic, a value of $C$ ($C^2 = \chi^2/(N + \chi^2)$ where $N$ = the total sample size) was also reported, in order to give some indication of the strength of the association between the variables. This measure has been criticized [4] on grounds that it is difficult to use it to compare two cross-classifications, and care should be taken in interpreting it.

## 3. Results

Enrollment, graduation, and employment (graduate students only) data were collected on students in computer science degree programs for the four academic years beginning with 1971–72. Data were also collected on faculty members. All students and faculty were classified as minority, women, or men for statistical analysis. A minority was defined to be any native born American, Spanish surnamed American, Oriental surnamed American, or black American. (See Alden [1] for a more detailed discussion of minority group composition.) It was assumed that a woman minority member was classified as a minority and was counted only once. Whenever appropriate, the total number of institutions responding in a particular category and the total number of students or faculty on which percentage figures were based, are included in the tables.

Most of the returned questionnaires contained some missing data. In the vast majority of cases, all data of a certain type or in a particular year was missing, indicating either that the data was not readily available (for example, many schools did not report marital status for their students) or perhaps that a program had just begun (for example, a program begun in 1973–74 would leave the 1971–72 and 1972–73 years blank). Blanks of this type were simply ignored. On the other hand, if a department reported some data for a particular year and degree (or form of employment) but omitted other similar data from the same year, the missing values were assumed to be zero. In most cases this assumption was undoubtably correct (i.e. a department reports three male Ph.D.s and one female Ph.D., but leaves the category for minority blank). However, there was no other uniform, objective way to treat the data. Although there was a reasonable number of such blanks, the authors do not feel that treating them as zeros had much effect on the relative results, and did serve to make use of all available data.

Table I. Students in Computer Science Bachelor's Programs.

| | No. of Insts. Resp. | Women No. | Women % | Minorities No. | Minorities % | Men No. | Men % |
|---|---|---|---|---|---|---|---|
| | | | | *Enrolled** | | | |
| 1971–72 | 48 | 437 | 17 | 197 | 7 | 2002 | 76 |
| 1972–73 | 54 | 855 | 21 | 240 | 6 | 2904 | 73 |
| 1973–74 | 62 | 943 | 21 | 348 | 8 | 3169 | 71 |
| 1974–75 | 73 | 1529 | 22 | 659 | 10 | 4740 | 68 |
| | | | | *Graduated*** | | | |
| 1971–72 | 45 | 117 | 15 | 22 | 3 | 621 | 82 |
| 1972–73 | 50 | 204 | 19 | 37 | 3 | 843 | 78 |
| 1973–74 | 57 | 228 | 19 | 56 | 5 | 946 | 77 |
| 1974–75 | 69 | 261 | 18 | 87 | 6 | 1095 | 76 |

* $\chi_m^2 = 43$ (significant with $p < .01$), $df = 6$, $C = .069$.

** $\chi^2 = 21$, $df = 6$.

Table II. Students in Computer Science Degree Granting Programs (1971/75).

| | No. of insts. resp.* | Total sample size | % women | % minorities |
|---|---|---|---|---|
| | | *Bachelors* | | |
| Enrolled | 48–73 | 18023 | 21 | 8 |
| Graduated | 45–69 | 4517 | 18 | 4 |
| | | *Masters* | | |
| Enrolled | 34–48 | 8035 | 17 | 9 |
| Graduated | 32–45 | 2358 | 15 | 9 |
| | | *Doctorates* | | |
| Enrolled | 25–31 | 2556 | 8 | 2 |
| Graduated | 22–28 | 381 | 7 | 3 |

* The numbers given here represent the range of institutions responding in the respective category over the four year period.

### Students

The first of three important results indicated by the data was that, except at the bachelor's level, there has been no increase in the percentage of women or minorities enrolled in or graduated from computer science degree programs during the four academic years covered by the study. The data showing the statistically significant[1] increases in enrollment of women and minorities and in graduation of minorities (separate $\chi^2$s were computed for men against women and men against minorities, and only the latter was significant[2]) at the bachelor's level in computer science programs are presented in Table I. Although these results (and some other discussed later) were statistically significant, the size of the increases was relatively small, on the order of 1% per year. Similar $\chi^2$ tests were performed for enrollment and graduation data at the masters and doctoral levels, and no differences were found across years. Also there were no differences in percentages of men, women, and minority graduate students employed as teaching assistants, research assistants, and fellows, across years. Thus, in all subsequent tables and analyses, data are totaled across the four academic years.

The second major finding from the student data was that there was a moderate, statistically significant decrease in the percentage of women enrolled in[3] and graduated from[4] computer science degree programs as the level of the degree rose (Table II). For example, while women received 18% of bachelor's degrees, they were awarded 15% of the master's degrees, and only 7% of the doctorates. Although similar levels of statistical significance were found for enrollment[5] and graduation[6] of minorities, more minorities appeared at the master's level than at either the bachelor's or doctorate. Also evident from Table II is the fact that women, and to a lesser extent minorities, were not enrolled in or graduated from computer science

[1] The phrase "statistically significant" is used in this paper to indicate that a statistical test has shown that the result is reliable (that is, has less than 1 chance in 100 of occurring by chance), but it does not imply that the result is sizable.

[2] $\chi^2 = 16$, $df = 3$, $p < .01$, $C = .066$.

[3] $\chi_m^2 = 141$, $df = 2$, $p < .01$, $C = .103$.

[4] $\chi^2 = 33$, $df = 2$, $p < .01$, $C = .070$.

[5] $\chi_m^2 = 71$, $df = 2$, $p < .01$, $C = .078$.

[6] $\chi^2 = 69$, $df = 2$, $p < .01$, $C = .106$.

degree programs in proportion to their representation in the population as a whole.

The final important result of the analysis of the student data was that minority, and to a lesser extent female, graduate students have been employed as teaching assistants, research assistants, and fellows in noticeably smaller percentages than their male counterparts (Table III). Also there were significantly different distributions among the three employment categories.[7] Women comprised approximately 15% of teaching assistants, 11% of research assistants, and 18% of fellows. Minorities accounted for 4% of teaching assistants, 6% of research assistants, and 9% of fellows.

Additional statistics of interest from the student data are presented in Table IV and Table V. Results indicated that a larger percentage of female graduate students were married and that a smaller percentage pursued academic careers when compared with the male students.

### Faculty

Faculty results are presented in Table VI, which gives the percentages of women and minorities in each of several ranks from professor to lecturer. The major result was that there was a considerably[8] larger percentage of women at the instructor/lecturer and assistant professor levels than at the more senior levels.

Table III. Employed Computer Science Graduate Students, 1971 through 1975 ($\chi_m^2$* = 24, $df$ = 2, $C$ = .067).

| | Women | Minority | Men |
|---|---|---|---|
| Total sample enrollment** | 1596 | 767 | 8228 |
| % employed | 28 | 22 | 33 |

* Significant at .01 level.
** These figures refer to students employed only as teaching assistants, research assistants or fellows.

Table IV. Marital Status of Computer Science Graduate Students, 1971 through 1975 ($\chi^2$ = 80, $df$ = 1, $p$ < .01, $C$ = .156).

| | Women | Men |
|---|---|---|
| Total sample size | 577 | 2634 |
| % married | 40 | 22 |

Table V. Computer Science Graduate Students Pursuing Academic Careers, 1971 through 1975 ($\chi^2$ = 12, $df$ = 1, $p$ < .01, $C$ = .045).

| | Women | Men |
|---|---|---|
| Total sample size | 2961 | 4836 |
| % academic | 25 | 31 |

Table VI. Faculty in Computer Science Degree Granting Programs (1974-75).

| | Full Professor | Associate Professor | Assistant Professor | Instructor/ Lecturer | Full time faculty* | Part-time faculty |
|---|---|---|---|---|---|---|
| Total sample size | 167 | 165 | 211 | 58 | 733 | 36 |
| % women | 2 | 2 | 7 | 26 | 7 | 3 |
| % minorities | 2 | 6 | 3 | 7 | 4 | 5 |

* This total includes full-time faculty other than those listed here whose titles were not given by respondents to the questionnaire.

## 4. Discussion and Conclusions

### Affirmative Action

The major results from the survey clearly indicate that if women are going to be represented in graduate computer science programs and ultimately on computer science faculties, in percentages similar to those found in undergraduate school, affirmative action programs[9] must be implemented in graduate schools. This statement is also true for minorities, but only at the Ph.D. level. The absence of any significant increases (over the four year period studied) in enrollments or graduations at the master's and doctoral levels strongly suggests that no effective efforts have been undertaken to recruit women into the field. The encouraging increase in enrollment at the bachelor's level does imply that the supply of qualified undergraduates able to pursue graduate studies will be greater in coming years, but an increased supply is no assurance of increased applications or admissions. The substantial decrease in percentages of women (enrolled and graduated) as the level of the degree increased supported this observation. From a recent survey of approximately 25,000 undergraduates, El-Khawas and Bisconti [3] have also concluded that women, even though they receive substantially higher grades than men in undergraduate courses, were less likely to go on to graduate school and had lower career aspirations than men. Thus the results of this study and those of the study of El-Khawas and Bisconti both indicate that though an increasing number of qualified women with bachelor's degrees in computer science exist, affirmative action recruitment efforts are required to encourage their entrance into graduate programs.

This indication of the need for an affirmative action supply plan to increase the numbers of women and minorities qualified for academic employment in computer science was also previously stated in a more general context by the Carnegie Council on Policy Studies in Higher Education [5]. The Council investigated federal affirmative action programs on the nation's campuses, and recommended enlarging the supply of women and minority members. It also recommended that a plan to increase numbers of women and minorities qualified for academic employment should be prepared as a major component of the affirmative action plans of institutions with graduate schools.[10] Supply plans of this nature are currently not necessarily required by federal law, since Title IX of the Education Amendments of 1972 is written so that the requirement for affirmative action may be enforced only after discrimination is proven.

There were two results from this study which apparently indicated positive movement in the affirmative action area. The first was the increase in the percentages of women and minorities enrolled in, and minorities graduated from, computer science bachelor's programs. The enrollment figures would appear even more favorable if they could be viewed in terms of new students (freshmen) only. The data presented are totals across all enrolled students, and a strong affirmative action effort in a particular year would be spread out over four years' worth of undergraduates. The second positive result was the percentage of minorities en-

[7] $\chi_m^2$ = 20, $df$ = 4, $p$ < .01, $C$ = .108.
[8] $\chi^2$ = 54, $df$ = 6, $p$ < .01, $C$ = .288.
[9] Affirmative action programs include a formulation of appropriate goals, timetables, and means to improve the status of groups against which there has been discrimination. They ordinarily call for recruitment efforts above and beyond those required by equal opportunity, and include special support programs for women and minority groups after entry into a field. The development and evaluation of such programs for science and engineering fields is in its infancy.
[10] This recommendation was based on the evidence that across all disciplines there is now no gap between women and minorities presently qualified and those holding "ladder" positions on faculties. The data from this study also support this "no gap" reasoning, as women comprised 7% of the doctorates awarded and also 7% of the assistant professors in computer science.

rolled in and graduating from master's programs. The differences between percentages of minorities in bachelors, masters, and doctoral programs seemed to be caused by a relatively high percentage (9%) at the master's level. Thus it seems that affirmative action in recruiting minority graduate students has influenced this 9% figure which is approaching the figure of 17% of minorities in the population as a whole [1].

This survey covered enrollment and graduation statistics since 1971, and even though few statistically significant increases in percentages of women and minorities have occurred over this time period, it is possible to speculate that there has in fact been a significant increase since the late 1960s. One piece of available data which supports this hypothesis is the result of a survey of all women Ph.D.s graduated from computer science degree programs in the years 1964–1969 [7]. Women then made up only 3% of the Ph.D.s in computer science, while they comprised 7% of the Ph.D.s in the years 1971–1975.

### Discrimination

Although the percentages of enrolled and graduated women and minorities in Ph.D. programs may be described as deficient when compared to the representation of these groups at the bachelor's level, the question of discrimination is neither addressed nor suggested by those data. Two possible explanations for the underrepresentation are the lack of supply of qualified students and the lack of motivation or ambition on the part of qualified students. In the area of graduate student employment, however, a possibility of discrimination was suggested and should be the subject of further investigation. If it is assumed that the total population of women, minorities, and men who are enrolled into computer science graduate programs is a homogeneous pool (that is, that all students are equally qualified for and desirous of available jobs) from which to draw employees, then the significantly lower percentages of women and minorities employed as teaching and research assistants would suggest that discrimination in hiring does exist. Under the assumption of homogeneity, the differences in percentage of subgroups employed would be attributed to their membership in the subgroups and hence discrimination would be concluded.

However, differences in the percentages of women, minorities, and men employed in computer science graduate programs may be attributed to factors other than race or sex. It may be that women are more likely to attend graduate school without support, or that women and minority students are more often employed outside of the academic institution, or that minority members are less qualified on the average and are admitted into departments "with deficiencies." Data currently available are insufficient to evaluate these and other possible alternative explanations.

## 5. Future Plans

This study has focused its attention on students in computer science, and only minimally on faculty. A follow-up study is planned which will investigate comparative recruitment efforts, salary levels, teaching loads, and numbers of publications of women, minority members, and men on computer science faculties.


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