
Leveraging an Alternative Source of Computer Scientists: Reentry Programs

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"I went back to school after having been a housewife for a number of years. It was not easy, but I figured that if I could do it, so could many other women, and I wanted to make that option available to them. We need to bring women and underrepresented minorities into our field at all levels, which means that we need to have a significant number of women and minorities receiving computer science degrees from the top schools, of which UC Berkeley is clearly one."

—Dr. Barbara Simons, Co-founder

Introduction

Much has been written about the "leaky pipeline" of women in computer science (CS), with the percentage of women decreasing as one moves from lower levels, such as college, to higher levels, culminating in full professorship. While significant attention focused on keeping women from leaving the pipeline, there is also an opportunity to bring women into the pipeline through non-traditional programs, instead of requiring that everyone enter at the undergraduate level. Both Mills College, a small liberal arts institution for women, and UC Berkeley, a large research university, established programs in the 80's to increase the number of women in computer science by tapping non-traditional students.⁽¹⁾ Both programs share the core value of accommodating older students lacking technical backgrounds. The two programs have produced similar results: graduate degrees earned in computer science by students who would not have qualified without these programs, professional employment in the computer science field by women and minorities, and a recognition that this population represents a rich source of talent for our nation.

The CS Reentry Program at Berkeley: Background

In 1982, few women enrolled in CS doctoral programs at Berkeley. Then, as now, women comprised the largest pool of underutilized workers to meet the need of a technologically trained labor force. Two female graduates of Berkeley, Dr. Paula Hawthorn and Dr. Barbara Simons, noticed that the number of new women graduate students was decreasing rather than increasing with each new entering class.

"We learned that as the enrollment pressure on the department built up, the prerequisites for acceptance into the EECS grad-

uate program became more stringent, so that people who had not followed a standard math/engineering program of study, practically from junior high school had a hard time being accepted into the EECS graduate program. We wanted to give 'non-standard' students, like ourselves, a better chance."

—Dr. Paula Hawthorn

They proposed the creation of a "Reentry Program."⁽²⁾ Instigated by these proactive alumnae, the Berkeley CS faculty agreed to open a new pathway to graduate study for women and underrepresented minority students in 1983. The remarkable fact is that Berkeley faculty championed this program, which added students to an overcrowded program without increasing resources for the department. In the early 80's, computer science classes were so crowded that the university barred outside students from enrolling; the Reentry Program gave participants seats in the classroom, a crucial entrée. Directed toward very bright students who had concentrated in subjects other than computer science at the baccalaureate level, the Computer Science Reentry Program offered a concentrated and compressed education in upper division computer science courses. A committee of computer science faculty and staff⁽³⁾ set policy for this experiment and defined admissions criteria. Due to the passage of Proposition 209 in California, which prohibits programs providing educational benefits based on gender or ethnicity, Berkeley's CS Reentry Program ended in 1998. However, the spirit of the Reentry Program lives on, both through the contributions and through influence of its graduates, and through the lasting effect of the presence of older women and minority students for over fifteen years on the computer science culture at Berkeley.

CS Reentry at Berkeley: Program Description

"We were very clear that we did not want to create a certificate program, nor did we want to give the reentry students watered down courses. Therefore, we required that they take the regular undergraduate courses, and we had as the stated goal of the program their acceptance into some computer science graduate program."

— Dr. Barbara Simons

Berkeley's stated goal was ambitious: to enlarge the pool of women and minority computer scientists qualified for university and college research and teaching positions. The university created admissions criteria to seek applicants who held discernible promise for success in competitive graduate programs in computer science. The admissions requirements, thus, included a full year of college calculus, introductory computer programming, discrete mathematics, and an excellent score on the Graduate Record Exam (GRE) general test. Computer science faculty at Berkeley evaluated all applications with an eye to the candidate's graduate school potential and admissibility.

When in the CS Reentry Program, students enjoyed neither graduate nor undergraduate student status, nor did they earn a degree or certificate. The Reentry Program offered a period of safe transition in which participants acquired a computer science undergraduate core education. The environment created by supportive staff and advisors affirmed their graduate school aspirations. To keep the cost very low, since most students quit their jobs to attend, Reentry students received a one-third subsidy for their tuition. Students enrolled side by side with undergraduate majors, in regular upper-division computer science classes, taught by regular faculty. The program requirements aimed to replicate a very streamlined version of the computer science major at Berkeley: All students took Programming Languages, Data Structures, Digital Design, Operating Systems and computer science Theory. Many students, who spent an average of two years in the program, also undertook undergraduate research projects mentored by computer science faculty, or more advanced classes in computer science. Berkeley faculty known to be sympathetic to the experiment individually advised the Reentry students on their program of study, monitored progress, and wrote letters of recommendation for graduate school. Access to campus resources such as the library, career center and health center as well as focused academic support in the form of staff advising and tutorials, were negotiated. The Computer Science Division provided substantial resources, such as computers, equipment loans, and a special lounge for the students. Women graduate student volunteers initiated tutorials on the GRE computer science Subject Test, and gave strategic advice. Many corporations contributed cash to the Reentry Program, which gave it more stature in the campus engineering community.

The Berkeley Reentry Program Legacy

"The reentry program was perfect for someone like me, with a degree in classics but years of programming experience. Without the reentry program, top graduate schools would never have considered my application, and getting into a good school was of course crucial in my becoming a professor myself."

— Professor Nina Amenta, UT Austin

By what metric do we measure the effectiveness of the Berkeley Reentry Program? A concrete measure of success was the number of students admitted to competitive computer science graduate programs. Students gained admission to Berkeley, MIT, Stanford, UCLA, UC Davis, UC Irvine, UC Santa Cruz, Oregon Graduate Center, Ohio State University, University of Texas at Austin, and the University of Washington. A second measure is the number of advanced degrees earned. Of the 156 students who entered the CS Reentry Program, ten students have received Ph.D. degrees in computer science (nine women and one minority male). Seventeen students are still in the doctoral pipeline, pursuing a Ph.D. in computer science. Four of those still in the pipeline are women very close to obtaining doctoral degrees at Berkeley. One of the first Reentry students Professor Nina Amenta, is now a tenure-track faculty member at UT Austin. Dr. Amenta took computer science classes through Reentry, and earned a Ph.D. in CS Theory at Berkeley. She sums up the program's critical impact:

"Even with the reentry program behind me graduate school was really challenging, not only intellectually - I didn't have the years of math that most of the other students had - but emotionally - it takes a big mental shift to see yourself as a scientist. Getting a push in the right direction from the reentry program made all the difference."

At least 39 of the Reentry students have earned Master's degrees in computer science, reports Barbara Hightower, Administrator of the CS Reentry Program from 1993-98. One of the many successful MS graduates, Ginger Ogle currently works as a research group leader for the California Digital Library Project at UC Berkeley. Among those who did not complete the program are a number of highly successful computer scientists, software engineers, and entrepreneurs. More intangibly, each of the 156 students who entered the CS Reentry Program, regardless of whether they earned a graduate degree subsequently or not, derived a significant educational benefit: access to upper division computer science classes in one of the top three programs in the country.

Longer Term Effects

"A significant contribution of the Reentry Program for me was the creation of a rudimentary 'old girls network.' The connections I established with other women while in the Reentry Program 10 years back now go way beyond the hand-

holding and fretting we did back then... It is hard for me to imagine how to lure more women into CS without some sort of network like this in place at a fairly high level. The women who went through the Reentry Program in the 80's and early 90's are now starting to appear at these higher levels, and they will invite other women in the door and help them up the stairs."

— Ginger Ogle, UC Berkeley

The quantifiable results of Berkeley's Reentry Program include computer science degrees earned and professional positions attained in the field of Information Technology. These professionals bring the benefit of a broader background to the field of computer science. More subtle effects, though, include a higher degree of sensitivity to women students, as evidenced by the Parent Policy, support for the graduate and undergraduate women's groups, and active recruitment of women into the program. Berkeley's culture did change by the Reentry Program; it became more receptive to the talents of older students and those with undergraduate degrees in fields as diverse as theater design and German literature. The network to which Ginger Ogle alludes above continues to grow and sustain many women computer scientists. Despite its formal termination, as Ogle proclaims, "Reentry Lives!"

Mills College Certificate Program: New Horizons

"Before entering the ICS program I worked at unfulfilling jobs. Since graduating from the ICS program I have worked as a Systems Analyst and community college instructor. Now I love going to work."

— Constance Conner, Instructor
City College of San Francisco

Recognizing that some women develop an interest in computer science after graduating college, Professor Lenore Blum founded the New Horizons certificate program in 1984 at Mills College for women and men with bachelor's degrees in other fields.⁽⁴⁾ The program prepares women with bachelor's degrees in other fields for careers or graduate school in computer science. IBM contributed \$20,000 toward the founding of the program.

The New Horizons curriculum consists of eight undergraduate computer science courses, typically taken two per semester while a student also holds an outside job and fulfills family responsibilities. All New Horizons students take the following six courses (similar to the Berkeley Reentry core curriculum): Discrete Mathematics, Data Structures and Algorithms, Introduction to Computer Science, Computer Concepts and Intermediate Programming, Programming Languages, and Introduction to Computer Architecture. Students take at least two elective courses. Popular choices are Artificial Intelligence, Networks, Operating Systems, and Theory of Algorithms.

Twelve men and 46 women have earned the MA in Interdisciplinary Computer Science degree through January

2002. Only 7 students were awarded the New Horizons certificate, because most people do not request it unless they leave without the MA. Many New Horizons students left without actually receiving the certificate, instead going into other graduate programs or industry. We do not regard leaving without the certificate as failure if a student has met her needs. For example, a student who had an undergraduate degree in American Studies recently left the program to begin the doctoral program in computer science at MIT. Other doctoral programs to which New Horizons students received admission include the Universities of Washington, California at Davis, and Virginia. Except when lured away by industry, our students tend to be successful in graduate school.

Interdisciplinary Computer Science at Mills

Recognizing that there was value not only in transitioning into computer science but also in building on other areas of education and experience, Mills developed a Master of Arts degree in Interdisciplinary Computer Science (ICS). Unlike the New Horizons program, which has no prerequisites, students are required to have completed a year of discrete mathematics and a year of object-oriented programming to enter the ICS program. Typically, students take these courses either at a community college or through the New Horizons program. The ICS program requires a greater breadth and depth of computer science coursework: two upper-division classes and eight graduate-level classes. Students are also required to take technical communication and a course in a different discipline to prepare them for writing a thesis combining computer science with another discipline. Table 1 shows popular subject areas: as the bottom thesis title suggests, these areas overlap. A complete list of theses (and other information about the program) appears online at <<http://ics.mills.edu>>.

Area	Number of theses	Example Thesis Topics
Music	7	Real Time Rhythmic Editing Tool for Score Publishing (Koon Yong Chew, 1991)
Economics	6	Omphalos: A Prototype System to Evaluate Health Maintenance Organizations (Mana Alemu, 1988)
User Interface Design	3	Earcon Design Considerations for Home Automation Systems (Eiko DoEspintoso, 2001)
Education	11	The Design, Implementation, and Evaluation of Mathematics Software with Interactive Video (Elizabeth Kelley Quigg, 1989)

Table 1: Interdisciplinary Computer Science thesis areas

Unlike the New Horizons certificate, the intent of the ICS degree is terminal, although one graduate went on to earn a Ph.D. in cognitive science and now does research in user interfaces at IBM Watson. Although statistics on careers of graduates are incomplete, five graduates teach computer science at Bay Area community colleges. Many graduates are employed in industry, often in multimedia or educational software, including Apple, IBM, Microsoft and Sun, as well as smaller companies.

Invited Papers

Gearing Mills Programs to Women

One feature of the Mills programs that women find particularly attractive is that currently three out of four full-time faculty are women. Most of the students are women. Classes are small, usually 10-20 students, and collaboration is encouraged. More intangibly, the environment is nurturing. While at some larger schools professors brag about teaching to the top ten percent of the class or of weeding out students, Mills aims to help each student get all she can out of each course. One of the authors (Ellen Spertus) received her bachelor's, master's, and doctoral degrees from MIT before teaching at Mills so has seen both ends of the competitive/nurturing spectrum. At Mills, students ask questions if they do not understand something, while MIT students tend to keep quiet if they do not understand. Mills students address professors by their first names and discuss extra-curricular matters with them; it is not uncommon to see students' children in labs and occasionally in classrooms. At MIT, one rarely sees children. The point of this comparison is not to argue that Mills is a better environment than MIT or other research universities but that it is a *different* environment, which some students, particularly women, find more pleasant and conducive to learning, particularly as they are entering computer science.

A disadvantage of the Mills approach is that teachers trying not to lose the weaker students sometimes hold stronger students back. Another is that the department's small size limits the breadth and depth of courses and research. While faculty members in computer science at Mills are involved in three NSF-funded research projects, not all research areas are represented. Mills increases students' research opportunities through collaborations with local universities, such as UC Berkeley; government laboratories, such as Lawrence Livermore; non-profit organizations, such as Chabot Space and Science Center and the Institute for Women and Technology; and corporations, such as IBM and Sun.

Future Directions

The passage of Proposition 209 in California caused the UC Berkeley Computer Science Division to phase out the CS Reentry Program. Even though in 2001 the Regents of the University of California formally renounced Proposition 209, state law continues to bar programs such as the Reentry Program in public institutions that provide an educational benefit based on gender or ethnicity. Berkeley's challenge, therefore, is to find ways to attract and admit talented reentry students, who previously might have come through the Reentry Program, directly to the graduate program.

In recent years, Berkeley and Mills have been able to work together to serve students better than either could alone. In the summer of 2001, a Mills student was selected for the SUPERB summer 2001 program at Berkeley, an NSF

Research Experiences for Undergraduates site. Currently, two Mills students and one recent graduate are involved in research at UCB. Further, Mills is participating in the Berkeley's Virtual Development Center⁽⁵⁾, focusing on technology for disabled women. The Berkeley-Mills partnership allows women to enter computer science in a female-oriented nurturing environment, and then to transition into participation at a top-tier research university. That women have succeeded at this transition shows the value of having multiple entry points into the pipeline. As Barbara Simons states:

"We started working on the program because we observed that many young women did not consider engineering technical programs as an option when they were making decisions in their undergraduate years. Unfortunately, that is still the case, especially regarding computer science. It's clear that there were and still are a lot of older women who have the ability to be good computer scientists."

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Reference

- [1] Montano, G., Virtual Development Center, *inroads (the SIGCSE Bulletin)*, vol. 34, no. 2, 2002.

Endnotes

- (1) This idea built on important experiments of the 1970's. Prompted by a 1976 Congressional authorization, NSF initiated Career Facilitation Projects at various universities to convert or update women trained in one field for employment or graduate study in a different science or engineering field. Some of these programs focused on computer science. For a complete evaluation report by Alma Lantz and Linda Ingison, see: "Programs for Reentry Women Scientists" in *Women and Minorities in Science*; S. Humhreys, Ed., Westview Press, 1982.
- (2) Hawthorn and Simons purchased wine and cold cuts to entice Berkeley faculty to attend a meeting at which they presented the new program.
- (3) Computer Science Professors Eugene Lawler, Domenico Ferrari, Dean Karl S. Pister, and other faculty championed the program with great dedication.
- (4) Mills is a women's college at the undergraduate level. Its more advanced programs are coeducational, although still designed to meet women's needs.
- (5) Information on IWT Virtual Development Centers appears in this special issue [1]. More information on the Berkeley VDC can be found at <http://buffy.eecs.berkeley.edu/Programs/VDC.html>