

Women in Computer Science: The Carnegie Mellon Experience¹

Lenore Blum

Overview

In 1995, the Computer Science Department at Carnegie Mellon University (CMU) began an effort to bring more women into its undergraduate computer science (CS) program. At that time, just 7% (7 out of 96) of entering freshman computer science majors at Carnegie Mellon were women. Five years later, the percentage of women in the entering class had increased fivefold. In 1999, women were 38% of the incoming first-year computer science class (50 out of 130)²; in the fall of 2000, approximately 40% of the entering class were women. [See Table 1.]

Rather than an endpoint, the increasing number of women in the program signifies the beginning of a crucial period of transition for women in computer science at CMU. We are now faced with the challenge of ensuring that women and men in the program thrive. Starting in the academic year 1999-2000, there has been a concerted effort to foster a community committed to this process. We anticipate that the impact of these efforts will be truly transformative—not only by bringing more women into the computer science program, but by enhancing our position as a leader in the field, strengthened by the interests and concerns of a diverse student body.

Before outlining the factors that have been crucial to the success of our efforts thus far, it is worth noting that such dramatic increases in the number of women in computer science do not appear to be widespread. In fact, the widely cited statistics from the articles, “The Incredible Shrinking Pipeline”³ and “The Incredible Shrinking Pipeline Unlikely to Reverse,”⁴ indicate that the percentage of women entering computer science programs and careers in the US has declined precipitously during the past decade and suggest this is unlikely to change. Whether or not this conclusion is valid, it is the view of many observers in the field, and indeed was cited by Rita Colwell, Director of the National Science Foundation, in her keynote address at the Y2K Grace Hopper Celebration of Women in Computing.

Thus we see that the Carnegie Mellon experience may offer inspiration, ideas and concrete suggestions to others who wish to reverse this perceived trend.

¹ This chapter (to appear in *The Future of the University: The University of the Future*) is based on my Report to CMU President Jared Cohon on Year 1 Activities of the Women@SCS Advisory Council. Faye Miller assisted with the original report and also conducted the student interviews.

² One student interviewed said that her CS friends joke that the 1999 entering class broke the “girl to Dave” ratio in CS.

³ http://www.mines.edu/fs_home/tcamp/cacm/paper.html

“The Incredible Shrinking Pipeline”, Tracy Camp, Colorado School of Mines.

An edited version of this paper appears in *Communications of the ACM*, vol. 40, no. 10, pp. 103-110, Oct. 1997.

⁴ http://www.mines.edu/fs_home/tcamp/new-study/new-study.html

“The Incredible Shrinking Pipeline Unlikely to Reverse”, Tracy Camp, Colorado School of Mines, Keith Miller, University of Illinois at Springfield, Vanessa Davies, Colorado School of Mines.

The following have been crucial to the success of our efforts so far:

- A vision for the program articulated by key faculty and administrators stressing the belief that a more diverse program is good not only for potential students, but crucial to the intellectual health and future of CMU's computer science program as well as the entire field.
- A solid base of research from which to make change and educate faculty and students.
- Respected and experienced researchers, faculty and administrators at the helm of the effort, working to bring others on board.
- An articulate and committed group of women undergraduate and graduate students on who have gained the recognition and respect of the faculty and administration.
- A growing reputation of CMU as a place that wants women and values their presence.
- Support from the President of the University, that has enabled us to bring speakers to campus, organize events, workshops and outreach activities, provide funds for students to attend professional meetings and to assess the impact of our efforts.

In this chapter we document changes that have occurred during the past several years and we examine the reasons for the increase of women in our program. We also present and summarize the impact of activities designed to help create a community of women in computer science with the goal of enhancing the educational and social experiences of undergraduate and graduate students. We indicate some of the challenges and stumbling blocks we have faced and our plans for the future.

Admissions Statistics

The admissions statistics summarized in Table 1 indicate several important trends at different stages in the admissions process:

- A steady rise in the numbers of both male and female applicants to the undergraduate program over the past five years. This increase has been steeper for women than men. The number of women applying to the program has increased by more than 100%; the number of male applicants has increased by about 87%. Women were 11% of applicants in 1995 and 14% in 2000.
- A higher proportion of women applicants being accepted each year. Since 1995, 1 out of 3 female applicants has been accepted into the program. For men, 1 out of 4 applicants was accepted in 1995; in 1999, 1 out of 7.

- Increased yield among female applicants. Of those women admitted to the program, increasingly higher percentages are choosing to attend. The yield among male applicants has remained fairly constant.

Table 1. Carnegie Mellon computer science undergraduate admissions, by gender, 1995–2000

Year	Applied			Admitted			Enrolled			Yield (enroll/admit)	
	Total	Women (% of all applicants)	Men (% of all applicants)	Total (% of applied)	Women (% of female applicants)	Men (% of male applicants)	Total	Women (% of total enrolled)	Men (% of total enrolled)	Women	Men
1995	1484	160 (11%)	1324 (89%)	382 (26%)	54 (34%)	328 (25%)	96	7 (7%)	89 (93%)	15%	27%
1996	2182	231 (11%)	1951 (89%)	479 (22%)	87 (37%)	392 (20%)	142	23 (16%)	119 (84%)	23%	30%
1997	2222	248 (11%)	1974 (89%)	481 (21%)	87 (35%)	394 (20%)	136	18 (13%)	118 (87%)	19%	30%
1998	2364	274 (12%)	2088 (88%)	462 (19%)	96 (35%)	366 (17%)	140	27 (19%)	113 (81%)	28%	31%
1999	2680	342 (13%)	2334 (87%)	454 (17%)	122 (36%)	326 (14%)	130	50 (38%)	80 (62%)	41%	25%
2000	2876	404 (14%)	2472 (86%)	386 (13%)	158 (39%)	228 (9%)	132	51 (39%)	81 (61%)	32%	36%

Source: CMU Office of Admissions (May 18, 2000); updated CSD (Oct. 10, 2000).

Why the Increase?

We will now outline the efforts that helped bring about this increase, and discuss the factors that contributed to this change.

First, it may be helpful to say a few words about the history and structure of computer science at Carnegie Mellon. The Computer Science Department (CSD) and its Ph.D. program were inaugurated in 1965; the undergraduate major was not instituted until 1988 (first as a Math/CS major and then in 1992 as a CS major). Typically, students enter the computer science major as freshmen. In 1988, the Department evolved into the School of Computer Science (SCS), which now comprises seven departments (including the core CSD), centers, and institutes of education and research.⁵ Each of the divisions offers graduate programs; the CS undergraduate program remains housed in the Computer Science Department. For more information see: <http://www.cs.cmu.edu>

Research Basis to Support Change

During its first several years, the undergraduate computer science program was plagued by very low numbers of women – a trend common to most comparable Ph.D. granting computer science departments⁶. In 1995, when efforts were made to understand and

⁵ These are: The Center for Automated Learning and Discovery (CALD), The Computer Science Department (CSD) which houses the undergraduate program, The Entertainment Technology Center (ETC), The Human-Computer Interaction Institute (HCII), The Institute for Software Research, International (ISRI), The Language Technologies Institute (LTI) and The Robotics Institute (RI).

⁶ <http://cra.org/statistics>

The Computer Research Association “Taulbee Survey”.

change this problem, the number of women in the CMU undergraduate computer science program was negligible. There were just 7 women in the incoming class of 96 computer science majors.

Allan Fisher, then Associate Dean for Undergraduate Computer Science Education, spearheaded an intensive effort to understand and change the representation of women in the undergraduate program. He collaborated with Jane Margolis, a social scientist and expert in gender equity in education, on a research study aimed at deeply understanding the nature of the problem and establishing a sound base of knowledge from which to develop interventions. Funded by a grant from the Sloan Foundation, the project was based upon hundreds of interviews with both male and female CS students about their histories with computing, interests, motivations and aspirations, reasons for majoring in computer science at Carnegie Mellon, and their experiences in the undergraduate program. Conducted over a four-year period, the project was able to track many students throughout their time at Carnegie Mellon. By interviewing students once a semester over a period of years, the researchers witnessed the ups and downs of their experiences, and changes in attitudes over time. Most importantly, they were able to identify crucial periods in students' attachments to the field, and factors that contributed to or inhibited their ability to succeed.

The study yielded significant insights into the many layers of the problem, in terms not only of bringing women into computer science, but also of retaining them. Problem areas identified were:

- Experience gap.
- Confidence doubts.
- Curriculum and pedagogy.
- Peer culture.

The findings of this study have been well documented elsewhere⁷, and we will not go into detail about them here. Suffice it to say that the project set the stage for further efforts. The research was useful in developing a blueprint for action, confirming hunches, and serving as an informational resource for faculty and other potentially supportive parties.

Initiatives

As a result of these findings, several initiatives were developed.

Summer Institute for AP CS Teachers

Clearly the problem of few women entering the field of computer science is inherited. For example, in 1997 just 17 % of Advanced Placement (AP) computer science test

⁷ <http://www.cs.cmu.edu/~gendergap/>

Women in Computer Sciences: Closing the Gender Gap in Higher Education, Allan Fisher and Jane Margolis, School of Computer Science, Carnegie Mellon University.

takers were female, the lowest of any AP exam that year.⁸ This amounted to just a 1% gain in ten years. (Only about 12% of the more advanced AB computer science test takers have been female.)

In 1995, prompted by impending revisions in the AP CS exam, the National Science Foundation (NSF) issued a call for proposals to prepare high school teachers for the change. Allan Fisher saw this as a fortuitous opportunity to work with teachers to address gender gap issues while they were motivated to gain new expertise. Thus the Summer Institute for CS Advanced Placement Teachers (6APT) was conceived. With a grant from the NSF, Fisher ---together with Jane Margolis, computer equity expert Jo Sanders, and Assistant Dean for CS Undergraduate Education Mark Stehlik--- ran two weeklong sessions each summer during the years 1996, 1997, and 1998. The goal of the program was two-fold: 1) to prepare high school computer science teachers to teach C++, a major component of the revised AP CS exam, and 2) to talk to teachers about the gender gap in computing and what they could do about it.

During the course of the three summers, 240 teachers (approximately 16% of all AP CS high school teachers in the US) participated in the program on the CMU campus. Thus, it is likely that, both directly and indirectly, 6APT has played a significant role in the increased numbers of high school women considering majors in computer science --and at Carnegie Mellon, in particular. Indeed, anecdotal evidence from interviews with students supports this claim. For example, one first-year student interviewed directly linked her decision to apply and enroll at CMU with her AP CS teacher's experience at CMU's 6APT program. The teacher would make jokes in class, and wink at the student and say, "That's your school. They really want women." This teacher also showed off the web site containing pictures from 6APT and raved about the faculty met there. Other women students have relayed similar stories.

Preliminary data also confirms these findings. [See Table 2.] Indeed the percentage of women from the 6APT high schools entering our undergraduate program in 1999, and again in 2000, was 18%, compared to 0 in 1995. (Interestingly, the percentage of men coming from these schools increased significantly in the fall of 2000 as well.)

Table 2. CMU First-year CS Majors from 6APT High Schools

First-year students	1995	1996	1997	1998	1999	2000
Women from 6apt schools	0% 0/7	5% 1/20	12% 2/16	7% 2/27	18% 8/49	18% 10/54
Men from 6apt schools	19% 17/90 (from 7 schools; 6 from Thomas Jefferson HS)	12% 14/119	8% 9/110	14% 15/109	12% 10/83	23% 19/80

⁸ <http://www.collegeboard.org/press/senior97/table14.html>

Both the 6APT program and the research study have received considerable positive local and national press. In addition, AP teachers are more likely than typical high school teachers to belong to professional networks and thus have opportunities to disseminate their experience informally, as well as formally, to their peers. Thus, the reputation of CMU as a place that values and cares about female students is almost certainly a factor accounting for the increased numbers of women applying to our CS program.

Admissions

Around 1995, Raj Reddy, then Dean of Computer Science, articulated to the Director of Admissions his desire to attract students to Carnegie Mellon who demonstrated potential to be world leaders and visionaries in computer science. The CMU Admissions Office, which is responsible for all undergraduate admissions, responded to Reddy's vision by expanding the range of qualities they looked for in computer science applicants. In addition to demonstrated academic competence, the Admissions Office began giving more weight to non-academic factors, looking for applicants with leadership potential and a commitment to "give back to the community." These broadened criteria also became important in awarding financial aid.

About the same time, Allan Fisher also conveyed to the Admissions Office his goal of a gender-balanced program. One thing he felt important was to get the message out that "no prior programming experience is necessary" to enter the CMU computer science program. The image of a computer science student as someone (usually male) who has played with computers since early childhood is widespread. So, many prospective students assume that those with a more extensive computing background have a better chance of being admitted. Several women have said that when considering colleges, hearing Fisher's message encouraged them to apply to CMU.

A Supportive Community: The Women@SCS Advisory Council

The backbone of current efforts of ensuring a positive learning environment for women in the School of Computer Science is the Women@SCS Advisory Council. The Advisory Council was created in the fall of 1999 and has since met weekly during the academic year. Membership includes undergraduate students representing all four years and graduate representatives from the various departments within the School of Computer Science.⁹ Advisory Council meetings, and ensuing conversations, whether in person or virtual (the Council logs voluminous email correspondence), produce the Council's priorities and evolving agenda for action. A top priority is community building.

The Advisory Council was created by the confluence of events in the School of Computer Science. We had just witnessed a striking increase in the number of women in the first year class. Graduate women were organizing social events that would bring women in the

⁹ During its first year, eight undergraduate women, four graduate women, one faculty advisor, and one staff member served on the Advisory Council. Four additional students comprised the development team for the Women@SCS web site: <http://www.cs.cmu.edu/~women/>. In its second year, the Council grew considerably (e.g., in the fall of 2000, eight additional graduate students came on board).

graduate computer science programs together. An articulate and thoughtful group of undergraduate women were expressing their opinions about changes needed in the undergraduate program. I had just arrived at CMU with the view that by pulling together the many elements already in place, we could rather quickly create a comprehensive program to increase the participation of women in the CS pipeline. From longtime experience in this area, I also believed that the issues raised and changes proposed would make sense for, and benefit, the entire CS program. Key faculty and administrators were supportive of this direction. Thus, forming a Council that would bring together these positive forces seemed the natural way to start.

Activities and Initiatives of the Women@SCS Advisory Council

From the start, the Women@SCS Advisory Council has been a pro-active, action-oriented group. While many of its efforts were in fact recommended by the Fisher and Margolis research, its myriad of activities grew directly from discussions among its members about the needs of women in the program. The fact that the Council arose from within the School of Computer Science, involving “insiders” from all levels of the program, has been key to its success. Its efforts have been spurred on by people intimately familiar with the field, giving the group legitimacy.

In its first year, the Council had three primary goals:

- To foster a supportive peer environment and an academic and social community of women in all levels of the CS program.
- To communicate to faculty and administration the needs of women in the School of Computer Science, and to act as consultants, providing suggestions and information on how to improve the CS program.
- To organize outreach activities for girls and women at various levels in the hopes of increasing the numbers of women in the CS pipeline.

Here we outline some specific Council activities and initiatives designed to meet its goals. During the first year, major attention was paid to undergraduate concerns, particularly since we felt it critical to address pressing issues raised by the dramatic changes in the undergraduate student body.

Community-Building

The most extensive single activity of the Women@SCS Advisory Council has been the Big Sister/Little Sister program, which pairs upper-class students with first-year and sophomore CS majors. It was formed to strengthen the bonds of women in SCS and encourage a forum for discussion and support. Thirty-four students participated in the Big Sister/Little Sister program during its first year, 48 during the second year.

Other community-building activities have included: student-faculty dinners, undergraduate student dinners, dessert socials during exam periods and group outings (e.g. we organized a guided tour of the 2000 Carnegie International).

In addition to the social aspects of community building, Women@SCS events also focus on the professional. For example, the Council periodically sponsor panels with visiting women computer scientists on topics such as “Women's Career Choices: Costs and Benefits Along the Way” and “Grad School or Industry -- what should I do?” A tradition begun at the end of the first year is the “Passing the Torch Dinner” where seniors share their pearls of *wisdom*.

Consulting and the Curriculum

One of the most valuable roles of the Council has been to act as a resource and sounding board for the faculty and administration about issues affecting undergraduates.

These issues can be quite specific. For example, the Council provided feedback to the Associate Dean for Computer Science Undergraduate Education on his recruitment presentation to prospective CS major, met with course instructors to suggest improvements, and reviewed TA training videos.

But what is likely to have the most profound impact on the Department is the Council clearly pointing out that the CS undergraduate curriculum as currently construed serves male students far better than females.

The first two years of our undergraduate CS program is extremely technical with a heavy programming component. Many of the courses either assume students already know the requisite programming language or that they can pick it up on their own. One might describe these years as “boot camp” for computer science. It is not until the third year that our program becomes more flexible and students have the opportunity to be involved in multidisciplinary projects. The upside is that by the time our students are juniors, they pretty much have the technical ability do anything they choose. The downside is that many women feel discouraged well before this time.

In a “white paper” she circulated at a meeting with faculty, Ting-Chih Shih, an undergraduate Council member (and our webmaster) provides some perspective:

“Most men come into the computer science curriculum having had many years of experience in programming, exploring the hardware and the software of computers, and learning on their own. Most females start with little or no experience in computer science. Some females have in-class experience in programming during high school and liked it for its problem solving aspects and the joy of having programs work. Some men seem to be fascinated by the machine itself and being able to take control of the machine. But females seem to see the computer as a tool to achieve what they wanted to do and therefore do not get as much enjoyment going through the process of dealing with the machine.

“Upon entering college, females are faced with many more men who seem to have more experience and get better scores effortlessly. As a result, they start to doubt their ability to learn computer science. They begin thinking that leaning computer science takes innate talent and no amount of hard work will pay off...They start to lose confidence and forget their initial

interest in computer science. Statistics show that females with grades equal to or better than those of their male peers have less confidence.

“At Carnegie Mellon, females begin to lose confidence because introductory courses ... seem to work towards men’s advantage and make female students feel inferior.... The way lectures are presented seem to appeal to men more. In general, females feel that the birds-eye view of a problem and the end result are more relevant than the coding details in between. Some professors fail to emphasize the purpose and the end result of assignments. Students spend most of their time programming for assignments. Because male students have had more experience coding they finish assignments earlier without struggling as much as female students. Since, for most females, the hardest part about the courses is writing programs, they may think that computer science is just mastering how to program”

A more integrated approach to computer science, one that introduces multi-disciplinary possibilities earlier in the curriculum, would seem reasonable.

Information Dissemination: The Web Site and the Grace Hopper Celebration

The Council has been, and continues to be, a source of information about women in computer science for the campus community and the community-at-large. One of our first endeavors was to develop the Women@SCS web site (<http://www.cs.cmu.edu/~women>) with the goal of becoming a “destination” for people desiring information regarding women in computer science in general and at CMU, in particular. It is a “must see” to get a feel for the scope of our activities.

The CMU experience received national attention at the Year 2000 Grace Hopper Celebration of Women in Computing in Hyannis, Massachusetts with our standing room only panel (with the same title as this chapter). Eleven CMU students attended the conference. Five students¹⁰ participated on the panel sharing their perspectives and experiences together with Allan Fisher, Jane Margolis and myself. The students were runaway hits with their keen insights and great good humor. Their upbeat message to others, “Take one step at a time, and go for it!”

Recruitment and Outreach

The Council also reached out to prospective SCS students, informing them of Women@SCS activities and creating a welcoming environment. Activities have included panel discussions and social gatherings for prospective CS undergraduates during Sleeping Bag weekends, Open Houses for prospective SCS graduate students and informational letters sent to admitted students.

There is a large niche for activities geared towards engaging middle and high school girls in science and technology. We have participated in two such outreach activities:

- *Expanding Your Horizons* Conference for middle school girls. We developed a hands-on workshop where teams of girls built and programmed small robots. (Forty girls participated.)

¹⁰ Jorjeta Jetcheva, Brigitte Pientka, Lisa Nelson, Leah Miller and Tiffany Chang.

- *Take Our Daughters to Work Day.* Robotics graduate students gave demos of their projects to girls ages 7-12.

Impact

We are continuing to canvas students, faculty and the administration to assess the impact of Women@SCS activities and how we can be more effective.

Impact on Students

During the first year, Faye Miller, who had worked with Allan Fisher and Jane Margolis on their assessment, conducted interviews with 15 undergraduate women, via one-on-one interviews and focus groups.

Of the students interviewed, those on the Advisory Council appeared to benefit most, not only from the activities they participated in, but also from being on the Advisory Council itself. The experience of being sought out by faculty, truly listened to, and respected as experts on their own experiences, was one of the most profound effects of being on the Council:

“[Being on the Council] affected the way I viewed how the administration cares about the students, and ways to get things changed around the school. I didn’t have any idea it could have so much of an impact. I also didn’t realize how much of an impact I could have on my peers and freshmen.”

“Just getting involved in the committee has had a big impact -- you start knowing there are people you didn’t know existed before.”

“I planned the [student/faculty] dinner, and hearing that others got things out of it means a lot to me. It makes me want to do more, boosts my confidence in that area.”

During the first year, graduate women benefited less directly from their participation on the Council since efforts were focussed primarily on pressing issues affecting undergraduates. While graduate women were particularly integral to the Council’s outreach activities, graduate issues received much less airtime during meetings (and in this report).

The women not on the Council appeared to fall into two camps. There were those who were moderately interested in the Council’s activities, had attended some events, and generally thought the group valuable. Although these students had some knowledge of the activities organized by the Council, through e-mail and word-of-mouth, many were unclear about the range of goals of the Council. These are students who might be more active participants if they were more aware of the Council’s aims.

The other set of students had no interest in the activities organized by the Council. They said they didn't have any particular needs or problems that the Council could meet. They said they were comfortable with the gender ratio, and were reluctant to say that there was *anything* unique about being a woman in CS.

This quote from a graduate student, posted on a mailing list discussion about the creation of the Women@SCS Advisory Council, echoes succinctly what we heard some undergraduates say:

“When I first arrived at CMU, I didn't see much point in women-specific groups and activities – I didn't care if other women wanted to have them, but I didn't think they had much to offer me, and I definitely didn't want to be seen as part of any gender-defined opinion bloc. After six years here, though, my feelings have changed somewhat...”

However, when asked what their biggest issues are *as CS students*, the women we interviewed talked about the same things that women on the Council pointed to as gender-related -- self-esteem gap, experience gap, and being accused of “getting in because you're a girl.” Regardless of whether they identify themselves as interested in “women's issues,” many undergraduate women may have interests in some of the goals of the Women@SCS Advisory Council. We ought not to ignore them as potential participants.

Retention

In assessing impact, issues of retention must also be addressed. In the early years, attrition among women in computer science was high; more recently, the situation has been improving. [Table 3]. However, comparing male and female attrition rates is difficult, because the actual number of women, even just a few years ago, was so small. One woman transferring out might mean a loss of 10% of the women in that class. We are pleased that of the 50 women in the 1999 freshman CS class, 47 are enrolled as sophomores in the fall 2000. However, until the program stabilizes, we do anticipate additional transfers out of CS are likely.

Table 3. Transfers Out of Computer Science

Women

Cohort	Yr. 1			Yr. 2			Yr. 3			Yr. 4		
	Sem. 1	Sem. 2	% loss cumulative	Sem. 3	Sem. 4	% loss cumulative	Sem. 5	Sem. 6	% loss cumulative	Sem. 7	Sem. 8	% loss cumulative
1995	7	7	0%	6	3	57%	4	4	43%	4	4	43%
1996	20	19	5%	18	16	20%	13	13	35%	13	12	40%
1997	18	18	0%	17	16	11%	16	16	11%	n.a.	n.a.	n.a.
1998	27	25	7%	24	23	15%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1999	50	49	2%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Men

Cohort	Yr. 1			Yr. 2			Yr. 3			Yr. 4		
	Sem. 1	Sem. 2	% loss cumulative	Sem. 3	Sem. 4	% loss cumulative	Sem. 5	Sem. 6	% loss cumulative	Sem. 7	Sem. 8	% loss cumulative
1995	89	87	2%	81	78	12%	81	75	16%	73	73	18%
1996	115	110	4%	109	104	9%	101	93	19%	96	?	?
1997	118	115	2%	103	107	9%	98	?	?	n.a.	n.a.	n.a.
1998	113	109	3%	107	?	?	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1999	81	?	?	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: Carnegie Mellon University Planning Office, updated by the Computer Science Department.

(Note: Sometimes students re-enter the major after transferring out—thus, an occasional increase in numbers.)

While retention is certainly one of the goals of the Women@SCS Council, we concur with Peter Lee, Associate Dean for Computer Science Undergraduate Education:

[Retention] seems unnecessarily negative to me, and at any rate seems to aim too low. The goal, it seems to me, is to take advantage of the great recruiting success and produce a crop of graduating women who will be the future leaders, world-class scientists, visionaries, and captains of industry. . . .

Impact on the Faculty and Administration

There is a growing perception amongst the faculty and administration that the student body is “more interesting than ever before.” But also, awareness of pressing issues --- such as the curriculum, advising and climate--- appears to be increasing, particularly among core faculty involved in undergraduate teaching and key administrators.

Associate Dean Peter Lee consults frequently with Council members and has been a strong supporter and advocate of the Council’s role He has given various presentations (for example, at a faculty meeting and to the President’s Advisory Council for the School of Computer Science) articulating opportunities and challenges afforded by the increased numbers of undergraduate women and outlining what faculty can do

A significant new development is a comprehensive re-examination of the entire undergraduate computer science program. Currently, revisions are being instituted in the entry level programming sequence, building on earlier revisions instituted by Allan Fisher, to accommodate students with varying degrees of prior experience. Even more comprehensively, under the aegis of Peter Lee, four faculty committees have been convened with the mandate to examine and make recommendations to the Department on: 1) the early curriculum 2) metrics/benchmarking, 3) student life/research/advising, and 4) deep thinking (math/foundations). Chairs of these committees have met with the Council and are incorporating Council suggestions in their deliberations.

Finally, it is worth commenting on the relationship between the Fisher-Margolis gender studies and the changes we are witnessing, particularly amongst the faculty and administration. Clearly, the research directly informed the design of the high school teachers program (and recruitment information), which in turn dramatically impacted the CS enrollment statistics. It also directly informed the initial modifications of the first year curriculum as well as the faculty directly involved in the entry-level program. However, until quite recently, most other faculty in the Computer Science Department have been either unaware of, or only marginally interested in, the studies. Indeed, it has been the presence of the women themselves, their numbers and the publicity that has caused many faculty to take note and become motivated to look to the research for insights, explanation and guidance. The research now plays an invaluable role in validating experiences, identifying effects of differential experiences and the culture, articulating and pointing out resulting patterns of behavior (e.g. the inappropriate vs. appropriate “switcher”¹¹) and in guiding the creation of productive strategies for change.

Ongoing Activities and Next Steps

The scope of Women@SCS activities continues to grow as we meet new challenges and new opportunities present themselves. Current and potential activities include the following.

Documenting Changes in Climate and Culture

With the increase of women in computer science at Carnegie Mellon, we are starting to see changes in the students’ confidence levels and feelings of belonging. The three undergraduate presenters at the Grace Hopper conference, respectively a senior, sophomore and freshman during the Council’s first year, presented what amounted to a “Before, During and After” testimonial of the positive effects of the changes at CMU. The transition from the self-doubting “Why am I here?” reaction of a woman freshman in 1996 (who had four years of high school programming under her belt) to the “What’s the fuss? It’s just normal” reaction of a woman freshman in 1999 was striking, even for those of us intimately familiar with our program.

Thus, as we strive to move towards “critical mass” in computer science at CMU, it will be important --and fascinating-- to document changes in the climate and culture of computing, particularly, changes in attitudes and behavior of both women and men. Building on the earlier CMU studies we can now ask: What issues disappear, what persist, what new ones arise? And how do we deal with all this?

¹¹ In their working paper, “Women in Computer Sciences: Closing the Gender Gap in Higher Education” (<http://www.cs.cmu.edu/~gendergap/confidence.html>), Jane Margolis, Allan Fisher and Faye Miller discuss “the difficulty for women students to experience and hold on to “intrinsic interest” in computer science in an environment that can undercut their confidence, motivation and sense of belonging in the field. ...” Many women thus inappropriately switch out of computer science, not because they find their interest elsewhere, but rather because their initial high interest and enthusiasm for computing has waned due to “eroded self-confidence.”

As an example, the question of admissions criteria has been a volatile topic of discussion among students. Women students we interviewed frequently mentioned hearing from their peers that they “got in” to computer science only because they were female. As one student put it:

“I think there is some sense that girls got in because they are girls... It really undermines your self-esteem, it makes you question why you got in, like if you didn’t really deserve to get in, if you are not fully qualified, it makes you question your chances for success.”

Hopefully, as it becomes more “normal” for women to be part of the computer science community, this particular issue will disappear. Even so, a challenge for the faculty and administration will be to address admissions questions raised by students in a more direct way.

Bridging the Experience Gap

The experience gap between men and women entering the program has implications for the curriculum and for women’s sense of belonging and confidence. For example, women in our interviews suggested that the Women@SCS Advisory Council could organize workshops to teach UNIX (which is needed for certain classes but never taught) and answer questions that the women feel are “stupid” and so are embarrassed to ask of male peers or male TAs. We might consider additional TA training, or find alternative sources of help.

There has been some e-mail debate among faculty about what students should be taught, and what they need to learn on their own. The Dean writes:

“It is painful to watch new students tripping over the arcanae of UNIX. On the other hand they (recent CS alumni) thought a virtue of their CMU education was that they had ‘learned how to learn’ such ... without much help.”

Another faculty member replied:

“These are issues that lots of CMU students understand when they enter, and we currently expect the rest of them to pick it up on the street corner. The issue, of course, is less gender than it is prior experience and orientation toward tinkering with the system -- it’s just that those are substantially gender-correlated.”

Academic Advising

Some of the curricular and pedagogical difficulties are perpetuated partly because many CS faculty do not have ongoing contacts with undergraduate students outside their own courses. Faculty often are not aware of the undergraduate students’ whole program and

the competing demands on their time and mental and psychological energy.¹² Academic advisors get to know students in deeper ways than other faculty. In the undergraduate CS program, only two faculty members, Mark Stehlik and Jim Roberts, have substantial formal contact with students outside of classes. Informal mechanisms, such as periodic lunches and/or seminars as suggested by Peter Lee, could be instituted to provide faculty with more student contact and a deeper and more global understanding of both the curriculum and students' programs. The Women@SCS Advisory Council is ready to provide input and assistance with such endeavors.

Promoting Professional Development

One area we have only touched on, and would like to pursue in the following years, is student professional development. For example, there are opportunities on campus for undergraduates to obtain funding for research projects and there are forums for students to present their research to the larger community. Until now, male students have been the sole representatives of computer science at these forums. As more women go through our program we expect this to change. But also, the Council could take initiative to encourage and support women to pursue and present their research.

Addressing the Graduate Student Agenda

During the first year, major attention was paid to undergraduate concerns. As a consequence, although the graduate students played essential roles as mentors and advisors, their own needs and interests were not sufficiently met. Thus during the second year, the Council split into two groups, an undergraduate advisory board and a graduate advisory board, each with its own agenda and activities. Although each group now meets separately, both come together periodically, particularly to plan joint projects and events.

Professional issues are a major focus of the graduate student advisory board. Graduate students are eager to meet with and hear from accomplished women in the field. Thus, an important graduate student activity has been organizing meetings with visiting women computer scientists. A Distinguished Lecture Series is being planned.

Outreach: Girls, Technology and Education

New outreach opportunities present themselves all the time. For example, we have been asked by a local private girls' school to present a two-week mini-course for sophomores and juniors that would delve more into the intellectual aspects and ideas of computer science (rather than just programming). As of yet, we have not had the resources or time to respond to this request, but we hope to pursue this opportunity in the future. We already have a tentative blurb to advertise such a course to interested girls:

¹² In contrast, graduate students in the Computer Science Department are paired with advisors (in a formal "marriage ceremony") within a month of entering the program; they meet regularly with advisors thereafter. At the end of each semester, the entire computer science faculty gathers for 1-2 days (during the infamous Black Fridays) to evaluate each graduate student's progress to date and to compose individual letters applauding successes, stating concerns, and outlining expectations for the coming semester. Advisors are responsible for presenting their students' cases and are often given suggestions by the rest of the faculty on how to better advise their students.

What is Computer Science anyway? *No*, it is not word processing, it is not email and it is not surfing the web. *Yes*, it is the deep ideas, ingenuity and wild imagination that created all this and more! Experience the fun with some of the CMU women computer scientists who are creating the robots, wireless technology and search engines that for sure will be part of your future.

Along these lines, and inspired by the success of our workshop for middle school girls (“Is there a robot in your future?”), a subgroup of the Council has begun discussing the feasibility of a “Women@SCS Educational Games and Software Project.” Clearly, there is a need for high quality material that would be appealing to and valuable for girls. While some excellent material is starting to emerge, we feel in a unique position to contribute, given the enormous pool of talent, expertise, resources, skills and insights available at CMU. As part of this effort, we are planning a mini-conference on “Girls, Technology and Education.”

Forming an Alumnae Network and Expanding the Pipeline

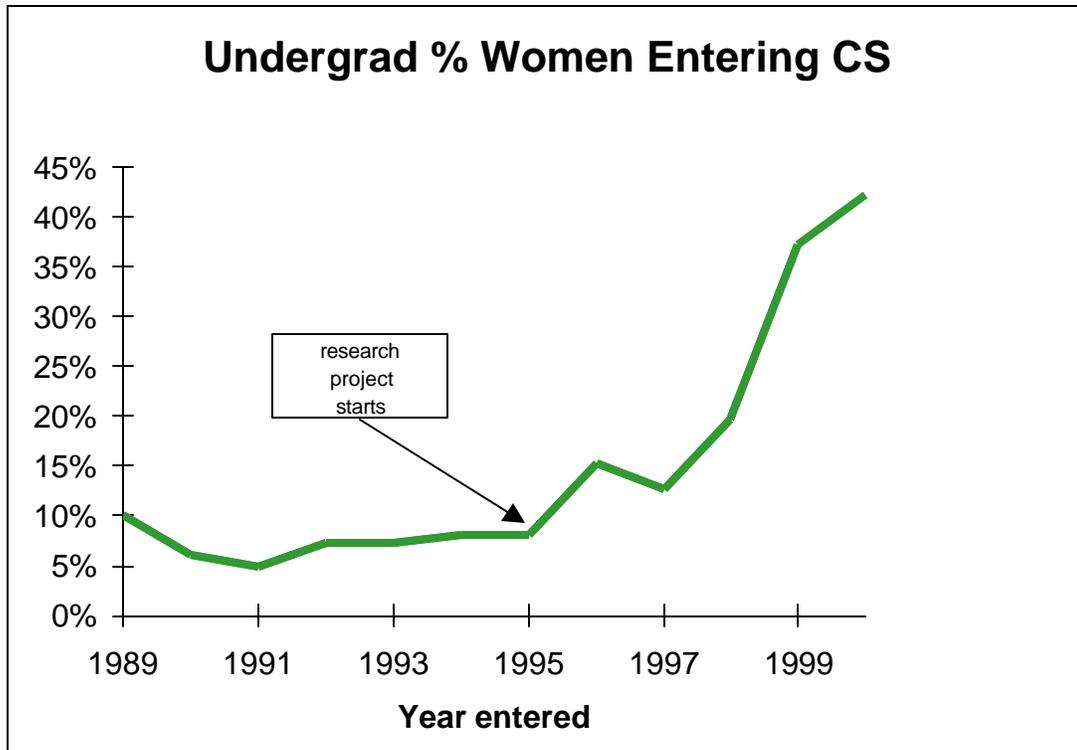
Finally, an exciting recent development is the formation of a nascent SCS alumnae network. Already we have alumnae representatives on the Council and an email list containing over 100 names. We expect that this group will become an increasingly important resource, particularly as more women graduate from our program. Indeed, by being a natural source of “role models” and mentors for our current students, our alumnae can serve to inspire and guide our students as they consider and move into careers in computer science, both within academia and beyond.

In Conclusion

Increasing and maintaining the presence of women in computer science at levels equal to men necessitates taking a hard look at, and changing, business as usual. In the past, the culture, environment and expectations of the undergraduate CS program have served to meet the needs of male students more than female students, although it certainly has not been optimal for many male students as well. Many of the changes we have been advocating, particularly regarding curriculum, advising and pedagogy, are not gender-specific, and can benefit all students in the program. Indeed, with our visibility and prestige, what we accomplish has potential to have widespread impact. The next several years at Carnegie Mellon are full of potential. We have made considerable strides. Presidential support has played a major role in enabling us to quickly implement new projects to foster community and to anticipate and constructively respond to problems and issues as they emerged. Sustaining momentum and moving ahead in directions we have outlined will require ongoing attention and commitment from the faculty and administration.

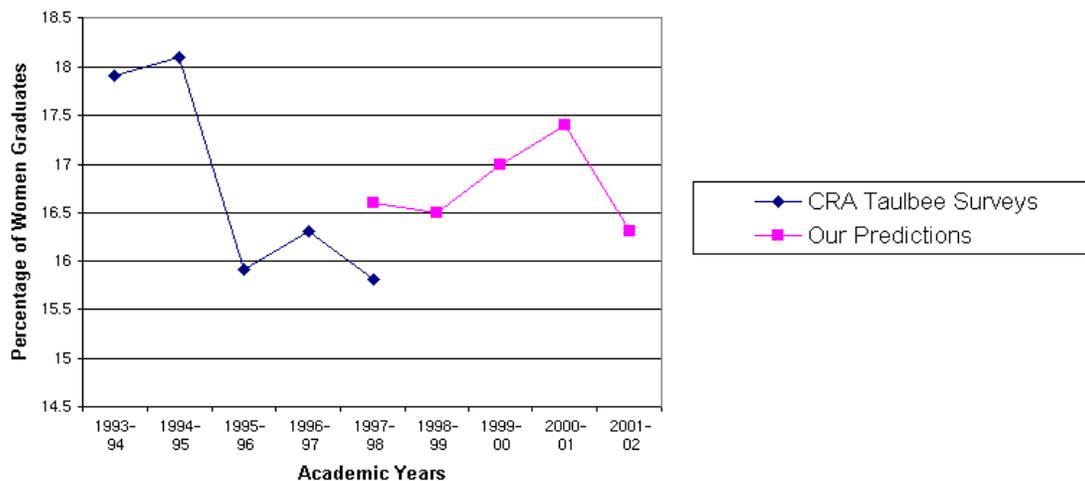
Women in CS Enrollment Trends

- **at CMU** (graph, courtesy of Allan Fisher)



- **Elsewhere** (from “The Incredible Shrinking Pipeline Unlikely to Reverse”)

Figure 3. Percentage of Women Earning Bachelor's Degrees -
CRA Taulbee Surveys and Our Predictions



Women@SCS Community



Undergrad Women@SCS Advisory Council and friends.



At Grace Hopper.
Top: Lenore, Jane, Belinda.
Bottom: Grace, Brigitte, Leah, Maayan, Jorjeta.



Time out at the Grace Hopper Celebration of Women in Computing, Cape Cod, September 2000.



Graduate Student Potluck (above) and Picnic (below).





Big Sister/Little Sister get-together