The Evolving Culture of Computing

Similarity Is the Difference 1

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Most studies of gender and computer science have been conducted (out of necessity) in gender-imbalanced environments. The findings often point to significant gender differences, leading the researchers to recommend strategies to meet these differences. One such recommendation is to adopt a female-friendly, contextual approach to curriculum development.²

In contrast, based on our recent and ongoing studies of undergraduate computer science (CS) students at Carnegie Mellon University, we hypothesize that in a more balanced environment, gender differences tend to dissolve. That is, the spectrum of interests, motivation, and personality types of men and of women becomes more alike than different. This leads us to be considerably more pragmatic in our recommendations for effective and positive change. Indeed, we believe that recommendations for curricular changes based on presumed gender differences can be misguided and may help reinforce, even perpetuate, stereotypes.

Here, we describe some of the changes in the culture of computing as our undergraduate CS environment has become more balanced in three critical domains: gender, the mix of students and breadth of their interests, and the professional experiences afforded all students.

BRIEF BACKGROUND FOR THE EVOLVING CULTURE

In 1995, just 7 percent (7 out of 96) of the entering freshmen CS majors at Carnegie Mellon were women. Since 1999, the percentage has increased nearly fivefold (on average, 45 out of 132), challenging trends across the country.³ Two major factors have contributed to the dramatic increase of women in CS at Carnegie Mellon: an outreach program for high school CS teachers that combined technical training with discussions of gender-gap issues and a broadened admissions policy (emphasizing diverse interests—along with high achievement in mathematics and science—and de-emphasizing prior programming experience). To meet the needs of students with varying backgrounds, multiple entry routes were built into the first-year programming sequence.⁴

The subsequent creation of the proactive student organization Women@SCS has been catalytic in building an environment in which the new student body can flourish.⁵ Women@SCS explicitly provides crucial educational and professional experiences generally taken for granted by the majority in the community but typically unavailable for the minority participants.⁶ Many of these experiences are casual and often happen in social settings. For example, in an undergraduate CS program, male students often have the opportunity to discuss homework with roommates, with friends late at night, or over meals. Course and job information and recommendations are passed down from upperclassmen, from fraternity files, or from friends. Women students, being in the minority, do not have access to—in fact are often excluded from—these implicit and important advantages. As one proceeds into the professional world, similar phenomena occur. These key actions, and implications for other venues, are discussed further at the end of this paper.

Our recent study, based on a set of interviews with seniors in the class of 2002⁷ may be viewed to a limited degree as a follow-up to the intensive longitudinal studies of CS students at Carnegie Mellon carried out by Jane Margolis and Allan Fisher between 1995 and 1999. Their studies, funded by the Sloan Foundation and discussed in

Unlocking the Clubhouse, were undertaken to help understand differences in male and female students' engagement (attachment, persistence, and detachment) with computer science, with a special focus on the gender imbalance in the field. A major goal was to devise and effect changes in recruitment, curriculum, pedagogy, and culture to encourage the broadest possible participation in the computing enterprise. Unlocking the Clubhouse paints a bleak picture for women in the undergraduate computer science program in the 1990s, one that still resonates with many CS programs across the nation. Margolis and Fisher note that for the most part, "women who were enthusiastic about computing find their confidence and interest extinguished in the college years." Consequently, many of the (few) women students who entered the program transferred to different majors within a year or two. 10

In addition, Margolis and Fisher note a strong gender difference in which male students focus more on programming and women more on the applications of computers. "Dreaming in code' has become one of our working metaphors, emblematic of a male standard of behavior in this computer-oriented world." Their findings influenced their curricular recommendations, in particular the contextualizing of computer science studies. ¹²

VOICES OF A CLASS IN TRANSITION

Our cohort, having entered the CS program in 1998, represented a unique class in transition. They were the last to have entered before there was anything close to a critical mass of women. By their senior year, all three classes following them had significant numbers of women students. Their unique positioning alone was enough to warrant some recording of their views before they disappeared into the world beyond Carnegie Mellon.

Our curiosity and expectations were tempered primarily by our understanding that students tend to work, socialize, and share the experience of student life with the class in which they enrolled, and by the fact that these students had been admitted under the old guidelines that were designed (consciously or not) to produce cutting-edge programmers for the technology workforce. Clearly, these guidelines would tend both to favor "geek" personality types¹³ and to support the well-documented geek culture of computing that was so prevalent here in years past.¹⁴

FINDINGS

Our 2002 glimpse of Carnegie Mellon's computing culture shows marked changes to the findings of Margolis and Fisher, along with several similarities. Since the students in our cohort were members of the last class to enter with relatively few women (indeed, two had been interviewed in the early studies), it is no surprise that some of their perspectives and experiences also echo earlier findings. The most prominent of these relate to maledominated classrooms, especially for upper-division CS courses in which many male engineering students enroll as well.

However, these marked changes interest us the most; they form the basis of our analysis and help shape our recommendations. We found many students who did not fit traditional CS gender stereotypes, men and women whose perspectives were often more alike than different, students who were well rounded (or at least aspiring to be so), students whose views of their field had broadened quite dramatically from seeing CS as "programming" to seeing the field as an exciting range of possibilities, and women who were enthusiastic and positive about their experiences as CS majors. In contrast to the findings about the adverse effects of the culture of computing on women students at

Carnegie Mellon,¹⁵ women students were seemingly flourishing as an integral part of the community. Some of the most interesting signs of transitional culture emerged from those women in our group who seemed to be constructing a new identity that was both "geeky" and feminine, while at the same time, men and women in our cohort were reevaluating and redefining what it means to be a computer scientist.

We have chosen to categorize the changes under themes that either were prominent in the questionnaire or emerged subsequently: stereotypes, programming versus applications, the expanding view of the field, and meeting the challenges of diversity.

STEREOTYPES

Although no interview question category specifically addressed the issue of stereotypes, all eleven of our categories had questions that elicited responses related to computer science gender stereotypes. We were struck by how frequently the seniors' responses did not fit traditional patterns. A woman senior voiced the same perception: "Some (women) were just as hardcore as the guys. And the guys, it's the same thing: some of them really want to spend all their time on the computer and not think about anything else, and some of them are really not like that, and [are] really interested in making it more appealing."

The picture of a narrowly focused computer science student did not emerge. To the contrary, we found students with a variety of interests and social circles both inside and outside of computer science, students who were involved in outreach activities and community service, students who enjoyed humanities as well as science classes, and students who were aware of the old "hacker" stereotypes and determined not to be like that. Our cohort included students who played the violin, wrote fiction, sang in a rock

band, participated in university team sports, enjoyed the arts, and were members of a wide range of campus organizations. We found that men and women alike appear to be moving toward a more well-rounded identity that embraced academic interests and a life outside of computing. Students described themselves as "individual and creative, just interesting all-around people," "very intelligent, . . . very grounded, not the traditional geek, . . ." "much more well rounded than people five or six years ago."

This is not to say that programming is a less important part of their world—it certainly is important and has to be. Nor is it saying that students who enjoy coding do not exist, but this interest seems to be placed within a broader context, with respect both to the field of study and to the participants. We found men and women who enjoy programming and the "geekier" aspects of computer science, and we found men and women who do not enjoy those aspects.

The image of "dreaming in code" as the dominant characteristic of male computer-science students is being challenged. "[The geeks] give a bad rap for everybody else," said one young man. Another claimed he and his friends "were as interested in things that had nothing to do with computer science" and in "trying to apply computer science to completely different things."

Contrary to the findings of earlier studies, our snapshot of students' perceptions reveals that the confidence of most of our cohort's women had increased by their senior year and had not been "extinguished." One woman made this very clear, "I see myself as one of the best of the best now."

The longest interview, with seemingly the most "sociably outgoing" student in the cohort, was with a young man who talked for over one and a half hours, while the

"geekiest" of students interviewed was a woman who recalled that as a child she had kissed the computer in much the same way as she would kiss a fond toy. This student had originally "wanted to fit the stereotype" but finally adopted a more self-assured attitude as she claimed some aspects of the geek stereotype but maintained a feminine identity: "You know, a girl can be good-looking and still be in computer science and still be smart, goddamnit." One student summed up the situation in this way: "There isn't a typical student anymore. There are some traits that you have to have. They have to know how to use computers, but there is such a range of students."

What seems clear is that these students were constructing a new image. We might speculate that the culture in which they spent more than three years of their studies, a culture with an increasingly diverse student body and that supported this diversity, had shaped their image of themselves. We might also speculate that such a transitional culture gave the men "permission" to explore their nongeeky characteristics and the women encouragement to be both feminine and computer focused. For the most part, our cohort was identifying with the "newer," more diverse aspects of the general student body while retaining some of the traditional aspects of CS students.

PROGRAMMING VERSUS APPLICATIONS

Margolis and Fisher note a strong gender difference in computer-science students' interests—male students focus more on programming and women more on the applications of computers. In contrast, this was one area in which our cohort exhibit strong gender similarities. Almost all students saw programming as one part of their interests and the computers as a "tool" for their primary focus, which was applications. For example, two men and two women who had maintained an interest in programming

expressed their continued interest in very similar ways; they particularly enjoyed being in control and making the computer do "what you want." But just as we found women who could be "geeky," we found men who seemed just as likely as women to appreciate computer applications and want more from the field than programming. One man acknowledged his own change of attitude: "I still find computers to be very interesting. But because the field of computer science has grown as I've learned more about it, it's no longer the computer itself and the programming that is interesting. It's what can be done with the programs that is now interesting. . . . The computer I see more as a tool now, as opposed to this neat toy." Another man claimed, "I like having the ability to create something useful that people can use to save them time, or to make doing something easier."

THE EXPANDING VIEW OF THE FIELD

From freshmen who viewed computer science "as writing programs, programs, and programs," we saw a shift to seniors who viewed it as "a whole lot of stuff!" They often struggled to define computer science in a way that encompassed their new understanding, "It's hard for me to define because there are many academic areas within computer science and I'm trying to . . . find a definition to encompass all of them."

Another example of how the view of the field crosses gender lines emerged when students were asked to define computer science. The most common theme to emerge—explicitly from the responses of five women and five men—is that computer science means "problem solving."

MEETING THE CHALLENGES OF DIVERSITY

Our current study focuses primarily on gender diversity in computer science, as did the

earlier Margolis-Fisher work at Carnegie Mellon. The number of underrepresented minority students in our program unfortunately has been on par with the low numbers in CS programs nationwide. For example, there were only three African American students (all male) and eight Hispanic students (one female) in the 2002 graduating class. Although these students were represented in our interview cohort, there were too few to make meaningful observations, except of course that this state of affairs is unacceptable.

Both men and women in our 2002 graduating cohort had heard (usually only through hearsay) that women were getting into the program simply because of gender, and this made everyone uncomfortable. For some men, it conflicted with their sense of fairness: women were somehow taking the places of better-qualified men. For these men, bringing in women meant lowering standards and having to make the program easier.¹⁷ Other men often observed that this was not true: "Almost all the women I'm friends with are extraordinarily intelligent. I mean the junior year I was talking about earlier [i.e., the first CS class that entered under the new admissions criteria and with the large increase of women students] kicks my butt in just about everything." Many women had developed strategies for working in a male-dominated situation and overall seemed ready to deal with any, and all, challenges: "At times it was frustrating and challenging. I felt like I had a lot of attention on me. . . . When I asked a question in class, people noticed because I was a woman." This same woman pointed out the positives of such a situation: "Well, the attention can always be a good thing. If you want a partner on a project, every guy will want to be your partner."

Many students, men and women, thought that women could add another dimension to the field and that their input was valuable: "It's a one-sided view if it's only

men. Women could add to the field from the women's perspective." "If half of society is discouraged from being a part of it, then we're missing out on a lot of great ideas." One man suggested, "I think that having more women would improve the quality for everyone." Some men showed a very sophisticated approach to having more women in the field: "Computing is going to be affecting our whole society and it probably makes a difference on who is giving input into this, but that's just from the societal point. As far as being fair, that should just be dependent on whether they are interested or not. I would hope that it could be that just traditionally the field hasn't attracted women because it hasn't exposed, hasn't properly recruited them, so let's give it a shot."

ACTIONS ESSENTIAL FOR CHANGE

In its structure, the Carnegie Mellon School of Computer Science (SCS) reflects and embodies the philosophy that computer science thrives on the interaction of diverse perspectives and expertise. Although the connection between this philosophy and having a diverse student body may not be apparent at first, these perspectives clearly mesh and can serve to support each other. This point is crucial: although the need and methods for change might be motivated by the interests and needs of an underrepresented group, it is our view that for programs to succeed and become part of the institutional fabric, ultimately they must mesh with the sensibilities of the institution, even serve to enhance the enterprise in general.

Here, we outline actions that have been key to changes at Carnegie Mellon and indicate how they might be adapted to other venues. It is important to note that these and subsequent developments have been undertaken with essential support from top administrators, including our university's president.¹⁹ Though our focus has been

primarily on increasing gender diversity in computer science, we believe that features of our program can be effectively adapted to increase the diversity of other underrepresented groups. Indeed, one of the most successful programs we know to increase diversity in computer science—directed by Richard Tapia at Rice University—incorporates philosophy and methods similar to ours.²⁰

Outreach in the form of summer workshops for high-school computer-science teachers

The workshops, held on our campus, had the dual aim of teaching new technical skills required for the CS advanced-placement (AP) tests and addressing gender-gap issues. Both directly and indirectly, these workshops played a significant role in increasing the number of high-school women considering majors in computer science. Given the general downturn of student interest in computer science, we believe that similar positive outcomes would accrue nationally if such programs were sponsored by colleges and universities on their campuses. 22

Changes in the admissions criteria to more closely reflect SCS goals and more rational prerequisites for success in the major

The new admissions criteria downplay prior programming experience and place high value on indicators of future visionaries and leaders in computer science. These changes are a direct result of the Margolis-Fisher studies, which show prior programming is not a predictor for success in the CS major at Carnegie Mellon, and of a vision for the School of Computer Science articulated by then dean Raj Reddy, who charged the admissions office to develop criteria that would select for future leaders in the field. One resulting criterion was "evidence of giving back to the community." Thus, in addition to opening doors to talented women students who may not have had prior computing experience, the

new admissions criteria open doors to a broader range of students, men and women. High academic standards (grades and test scores) remain unchanged.²³

At Carnegie Mellon, students enter the CS undergraduate program directly from high school. This provides certain advantages in achieving gender equity in CS over other undergraduate institutions where students choose their major during their sophomore year or later. Computer science departments at these institutions might examine unnecessary obstacles that may impede entry into their programs, take a broader view of the field, and proactively promote the field and their programs with exciting and informative campus events.

Providing effective access to the computer science curriculum in the form of various entry routes into the entry-level programming sequence

Many schools have found such phased entry, sometimes with peer-taught workshops, critical for attracting and supporting underrepresented groups in scientific and technical fields.²⁴ Another innovation is the Freshman Immigration course.²⁵ Here, faculty representing a broad range of CS fields discuss their research in a weekly seminar for all entering CS majors. Aside from regular course and curriculum updates, these entry-level changes have been the only major curricular changes in the Carnegie Mellon undergraduate computer science program.

Creating a professional organization and community for students to provide collegiality, role models, mentors, and leadership opportunities

When the number of women increased to near "critical mass"²⁶ the next challenge was to ensure an environment in which the women could flourish and be successful. In 1999, the student organization Women@SCS was created to meet this challenge. As we have

previously stated, Women@SCS explicitly provides crucial educational and professional experiences generally taken for granted by the majority in the community but typically not available for the minority participants.²⁷ It also gives voice to the community of women so that "critical mass" becomes more a question of visibility and effectiveness than one of numbers. Although some might describe Women@SCS as a "support group," this label suggests a limited and faulty understanding of its function. Indeed, its function, structure, and activities are deliberate—and labor intensive.²⁸ The organization has flourished, and its members have been featured on national television and in local and national newspapers. On campus, Women@SCS has become the largest and most active student organization in the School of Computer Science. As Women@SCS has become a respected part of the SCS "institution," the atmosphere for all students in SCS has greatly improved. Indeed, Women@SCS events, such as course advice sessions held just before the course-registration period each semester, are now welcomed by the whole student body.²⁹

The senior interviews indicate that both men and women saw the benefits of an organization like Women@SCS, even when they had not personally been involved in the activities: "They're pretty well organized and touch on other relevant issues that concern young female students at Carnegie Mellon. They organize a lot of activities and their Web site is very informative." One man said, "It seems to be quite a moving force," while another commented, "I'm pretty impressed with it, actually it seems like they're doing a lot. They're very active and up-to-date and it seems like a very solid organization although I don't know a lot about it." Many women pointed to the advantages of having more women friends and colleagues. One stated, "I find that we think more alike and it's

probably easier to work with female students," and another mentioned "there is also a greater sense of community than before."

We strongly believe building an energetic, action-oriented student organization with ongoing faculty and professional leadership and support is key to building a successful community of women in the computer sciences and a successful outcome for our students.³⁰ We encourage readers to browse the Women@SCS Web site to discover the full spectrum of resources and valuable outreach activities that the organization provides.³¹

CONCLUSION

From these interviews with our class in transition we identified significant changes to the findings of Margolis and Fisher, changes that lead us to question some of the accepted differences in the ways men and women relate to computer science. A principal finding of the Margolis-Fisher study (1995–1999) is that men tend to view the computer as an object of study, while women tend to view the computer as a tool.³² This has led to hypotheses and recommendations that to increase the participation of women in CS, curricular changes to emphasize real-world applications are necessary. Our findings lead us to question such recommendations. For example, it may or may not be a good idea to incorporate applications in a particular course; this depends on whether it makes sense for the subject matter, for the intellectual skills to be developed, or for pedagogical purposes.³³ We believe that changing curriculum as a means to promote gender equity helps reinforce, even perpetuate, stereotypes. It also puts the onus on the underrepresented group and can promote marginalization. Pragmatically, the process of revamping the curriculum is daunting; consensus for doing so to meet the perceived

needs of a particular group is nearly impossible.³⁴ Furthermore, as we observe within our changing student body and its evolving motivations and interests, some of these recommendations may even be misguided.

Our conclusion is that the observed gender differences from the 1995–1999 study tell more about the biases in our former admissions criteria (and a limited view of the undergraduate major) than about significant or intrinsic gender differences in potential computer scientists. During the years of the Margolis-Fisher study, the undergraduate CS major at Carnegie Mellon fed primarily into the booming high tech industry. With an admission rate of one for every ten applicants, the admissions criteria were set to select people who would become hot-shot programmers for the high-tech industry. It stands to reason that the high-school computer "geek" would have an admissions advantage. Women and men with potential to become computer science leaders but without demonstrated programming experience or commitment would have had little chance. The very few women who managed to get in had exceptional academic records. It is worth noting that this identification of computer science with programming is due mostly to a late twentieth-century phase in the field, an identification that unfortunately persists in the public's mind. Very few of the pioneers and current professors of computer science were "hackers." Many were motivated by their interest in logic and in understanding intelligence and problem solving. In the twenty-first century, with the increasing ubiquity of computing, women and men with this broader and deeper perspective are critical for the field and will drive its future.

With changes in the admissions criteria and subsequent changes in the overall student body, the manifest dichotomy observed by Margolis and Fisher is considerably

less apparent and becoming less so. Indeed, differences often show up more strikingly as intra-gender differences, and similarities show up as a spectrum of motivation and interests (from hacking to applications) among men and women.

For effective change, institutions must design programs that accord with their unique characteristics. We hope our example and findings will help inform others who work to increase gender equity in the computer sciences and provide some guidance as to what to expect from an environment and culture in transition.

NOTES

¹ Research for this study was supported by a grant from the Alfred P. Sloan Foundation.

² Jane Margolis and Allan Fisher, *Unlocking the Clubhouse: Women in Computing* (Cambridge, MA: MIT Press 2002); Allan Fisher and Jane Margolis, "Unlocking the Clubhouse: The Carnegie Mellon Experience," special issue: *Women in Computing, Inroads, SIGCSE Bulletin*, vol. 34, no. 2 (NY: ACM, 2002): 79-83. This special issue has the most comprehensive collection of articles on women and computing to date.

³ Widely cited statistics, from "The Incredible Shrinking Pipeline" (Tracy Camp, *Communications of the ACM*, vol. 40, no.10 (1997):103-10, http://www.mines.edu/fs_home/tcamp/cacm/paper.html) and "The Incredible Shrinking Pipeline Unlikely to Reverse" (Tracy Camp, Keith Miller and Vanessa Davies, 1999, http://www.mines.edu/fs_home/tcamp/new-study/new-study.html), indicate that the percentage of women entering CS and IT programs and careers in the United States declined precipitously during the past decade and suggest change is unlikely. According to the *New York Times*, 22 May 2003, the national average for women students in undergraduate programs in CS in the United States in 2003 was 15 percent.

⁴ Margolis and Fisher, *Unlocking*, 109-127, 130.

⁵ The Women@SCS website, http://women.cs.cmu.edu/, contains information about the organization and its many activities as well as resources for students and teachers. For discussion of its role in transforming the culture of computing see: Lenore Blum, "Transforming the Culture of Computing at Carnegie Mellon," *Computing Research News*, vol. 13, no. 5 (2001): 2, 6, 9, http://www.cra.org/CRN/issues/0105.pdf; Lenore Blum, "Women in Computer Science: The Carnegie Mellon Experience," *The Innovative University*, eds. D. P. Resnick and D. S. Scott (Pittsburgh, PA: Carnegie Mellon University Press, 2004) 111-29, http://www.cs.cmu.edu/~lblum/PAPERS/women_in_computer_science.pdf.

⁶ Carol Frieze and Lenore Blum, "Building an Effective Computer Science Student Organization: the Carnegie Mellon Women@SCS Action Plan," special issue: *Women in Computing, Inroads, SIGCSE Bulletin*, vol. 34, no. 2 (2002): 74-78, http://www.cs.cmu.edu/~cfrieze/paper.html.

The 2002 senior CS class had a total of 153 students (including thirteen fifth-year seniors) with twenty-four women (15.7 percent). Throughout the spring semester 2002, we conducted interviews with thirty-three of these students, seventeen women and sixteen men. (All twenty-four women in the class were invited to be interviewed as well as twenty-four randomly selected men in the class.) The interview questions (available upon request) were adapted as appropriate from the Margolis-Fisher questionnaire (Margolis and Fisher, *Unlocking*, 145-153). The questions were open-ended and meant to solicit perceptions and comments more than direct quantifiable information. As in the earlier studies, the interviews were transcribed and imported into NUD*IST (a qualitative analysis software package) to examine salient variables addressing issues of change. Researchers Elizabeth Larsen and Peggy Stubbs coded and analyzed the data using this tool; their results are presented in a companion paper (Elizabeth A.

Larsen and Margaret L. Stubbs, "The Evolving Culture of Computing: Undergrad Perceptions of Change and Gender by a Cohort in Transition at Carnegie Mellon University: Findings from Preliminary and Secondary Analyses of Interviews with Spring 2002 Seniors in the Computer Science Department" (Report to the Alfred P. Sloan Foundation, New York, 2003)). Although this research represents a qualitative, interview-based case study, we note that with open-ended questions and a small number of participants, the presence of as few as two or three similar responses takes on magnified significance.

⁸ Margolis and Fisher, *Unlocking*.

⁹ Margolis and Fisher, *Unlocking*, 5.

¹⁰ Margolis and Fisher, *Unlocking*, 90-91. Such transferring out has diminished considerably. For example, of the first large class of forty-nine women (of a class of 130) who entered the program in 1999, forty-three graduated from Carnegie Mellon (thirty-five from CS, two from information sciences, four from the business school, one from biology and one with a self-defined major), four are on leave (of these, three are expected to graduate in CS) and two withdrew.

Margolis and Fisher, *Unlocking*, 5.

¹² Margolis and Fisher, *Unlocking*, 52-54, 131-33, 140-41.

¹³ The word "geek" seems to have entered the vernacular in the 1990s as a label for computer obsessed individuals lacking social skills. Although the word "geek" is often used disparagingly, the moniker is also worn with pride among some members of the computing culture.

¹⁴ Lee. Sproull, Sara. Kiesler and David Zubrow, "Encountering an Alien Culture," *Journal of Social Issues*, vol. 40, no. 3 (1984): 31-48; Margolis and Fisher, *Unlocking*.

¹⁵ "Living among the Programming Gods: The Nexus of Confidence and Interest," Margolis and Fisher, *Unlocking*, 77-92.

¹⁶ We note that the 2002 entering CS class had nine African American students (three women) and ten Hispanic male students (in a class of size 133). Currently (for the academic year 2004–2005) there are fifty-three African American, Hispanic, and Native American undergraduate students in the CS program (eight women, forty-five men). Although underrepresented minority enrollment is growing campus-wide, there has been a recent precipitous drop in the overall number of students applying to CS nationwide—and at Carnegie Mellon—affecting newly recruited populations, with less stable roots in the field, even more. Some factors causing the general downturn seem to be: the dot-com bust, concerns about outsourcing, and the public image of computer science as programming. This downturn has sounded alarms within the CS community at large causing many CS departments and major professional societies to start looking for solutions. We believe that many of the successful strategies for recruiting and retaining women in CS can apply to recruiting underrepresented as well as majority students into the field. Clearly this is a situation to be followed.

¹⁷ These responses indicate the major "backlash" we had to address in the first years of the transition. They also indicate the need to educate the community in the early stages of any educational reform. At a special faculty meeting in January 2000, associate dean Peter Lee explicitly pointed to the challenges and opportunities afforded by our newly diversified student body. He outlined suggestions for faculty involvement that could assist in positive outcomes. Although these and related issues continue to be addressed on an "as needed" basis, we believe ongoing forums would be even more beneficial.

¹⁸ SCS departments and faculty represent fields ranging from core CS to robotics, human-computer interaction, language technologies, computation, neurobiology, and entertainment technology.

¹⁹ Joanne Cohoon stresses the importance of institutional support for effective change (J. McGrath Cohoon, "Toward Improving Female Retention in the Computer Science Major," *Communications of the ACM*, Volume 44, Issue 5 (May 2001): 108-114).

²⁰ Richard A. Tapia and Cynthia Lanius, "Underrepresented Minority Achievement and Course Taking: the Kindergarten-Graduate Continuum," http://ceee.rice.edu/Books/DV/continuum/.

²¹ The percentage of women from the participating schools entering our undergraduate CS program in 1999, and again in 2000, was 18 percent, compared to 0 percent in 1995. Unfortunately, at our own institution, the focus on gender in these workshops was discontinued after the original three summers. One apparent reason was that an early evaluation deemed this component unsuccessful in the *only* variable that was considered: Did the teachers attract more females to their classes after participating in the workshop? (Patricia B. Campbell, Lesli Hoey and Lesley S. Perlman, "Integrating gender equity training and teacher retooling for the high school computer science classroom (6APT): some results from the data," Campbell-Kibler Associates, Groton Ridge Heights, Groton, MA 01450 (2000); Jo Sanders, "Snatching defeat from

the jaws of victory: When good projects go bad. Girls and computer science," Paper presented at the annual American Educational Research Association meeting (April 2002),

http://edtech.connect.msu.edu/Searchaera2002/viewproposaltext.asp?propID=6997.) We believe this evaluation was seriously flawed: for example, high school teachers may not have much influence on who takes their classes; on the other hand, they may have considerable influence on students' choices of college and major (as our data indicates). In 2004, we reintroduced discussions of increasing diversity of underrepresented groups into the teacher workshops along with information about the breadth of CS (see: http://women.cs.cmu.edu/Teachers).

- High-school students and teachers tend to equate computer science with programming. Thus outreach programs clearly provide an opportunity to also include materials and start discussions that illuminate the broad range of areas and new directions comprising, and emanating from, computer science. Women@SCS students have designed outreach roadshows for a variety of audiences with these goals in mind (Adaptable presentations can be downloaded from the website: http://women.cs.cmu.edu/What/Outreach/Roadshow). This is just one more example of how programs designed to increase the participation of an underrepresented group can serve to enhance the field more generally.
- ²³ This is imperative to ensure that accepted students meet the challenges of a rigorous undergraduate program. Recent data show that gender parity now exists in high-school mathematics. Indeed, the number of girls taking AP calculus now exceeds the number of boys (Beatriz Chu Clewell and Patricia. B. Campbell, "Taking Stock: Where We've Been, Where We Are, Where We're Going," *Journal of Women and Minorities in Science and Engineering*, vol. 8 (2002): 255-84). Thus, if one removes prior programming as a criterion for entering a college CS program, the potential pool of female students increases dramatically. This highlights the critical importance of effective outreach activities.
- ²⁴ Lenore Blum and Steven Givant, "Increasing the Participation of Women in the Fields that use Mathematics," *American Mathematical Monthly*, vol. 87, no.10 (1980): 785-93.
- ²⁵ All freshmen CS majors take this course during the fall of their first year. The course meets once each week for an hour and a half. AS stated in the course description, during this time the students meet and hear from different members of the CS community who talk about their research in CS, past events, and future trends. The idea is to expand the students' concepts of what is available to them as students within the School of Computer Science. See: http://www.andrew.cmu.edu/course/15-128.
- ²⁶ In our context, we might say that "critical mass" is attained when being "other" is no longer a major defining or impeding quality; numbers alone are not necessarily the operative issue.
- ²⁷ A recent British think-tank publication broadly supports our emphasis on professional-community building arguing, as we do, that formal associations can provide support for women in ways informal networks have provided for men. Such "[networks add value in a variety of ways to women's working lives, from making professional contacts and gaining self-confidence, to finding new friends, learn new skills and accessing mentoring opportunities" (Helen McCarthy, *Girlfriends in High Places: How Women's Networks Are Changing the Workplace* (London: Demos, 2004), 19-20.
- ²⁸ Frieze and Blum, "Building."
- ²⁹ As additional evidence of the influence of Women@SCS on the entire SCS community, we have witnessed the establishment of two major community-wide endeavors initiated by student members of the Women@SCS Advisory Council: SCS Day (http://www.cs.cmu.edu/~scsday), an annual event that celebrates the diversity of skills and interests among our faculty, staff, and students, and the reintroduction of the Pittsburgh chapter of Computer Professionals for Social Responsibility (http://www.cs.cmu.edu/~cpsr/), a national public-interest alliance of computer scientists and others concerned about the effects of computer technology on society.
- ³⁰ Most schools rely on student run student organizations to provide peer support. However, without regular and ongoing faculty leadership and administrative and staff support, such groups tend to be episodic in their activities and influence—and thus are deemed "low-impact" and unsuccessful (Margolis and Fisher, *Unlocking*, 134). For such efforts to have high-impact and become part of the institutional fabric, it is critical that high level faculty be involved and that staff support be provided. This helps ensure organizational continuity and enables students to bubble with ideas that can be implemented using their energy wisely. For a toolkit of sample activities and suggestions, see Frieze and Blum, "Building," 74-78.

³¹ http://women.cs.cmu.edu/

³² Fisher and Margolis, "Unlocking," *Inroads*, 80.

SHORT BIOS AND CONTACT INFORMATION

Lenore Blum is Women@SCS (http://women.cs.cmu.edu/) Faculty Advisor and co-Director (along with Carol Frieze and Jeannette Wing) of the new Sloan funded Women@IT program. For over 30 years, Blum has created programs to increase the participation of girls and women in scientific and technical fields and co-founded many pro-active organizations such as the Math/Science Network and its Expanding Your Horizons conferences. She joined the Carnegie Mellon faculty in the fall of 1999 as Distinguished Career Professor of Computer Science where she is also co-Director (with Guy Blelloch) of the NSF-ALADDIN Center (http://www.aladdin.cs.cmu.edu/).

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Carol Frieze is Women@SCS (http://women.cs.cmu.edu/) Director and co-Director (along with Lenore Blum and Jeannette Wing) of the new Sloan funded Women@IT program. She brings to Women@SCS an interdisciplinary and diverse perspective, having taught Cultural Studies for four years while a graduate student in Carnegie Mellon's English Department, and having a previous background in inner-city London high school teaching and hospital teaching at the Royal National Orthopeadic Hospital School in England.

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³³ Contextualizing a course designed to promote abstract and analytical thinking would have to be done with considerable caution not to undermine the kind of skills such a course intends to develop. On the other hand, adding applications to a course may make perfect sense from the perspective of the field irrespective of gender. For example, Lenore Blum is co director of the ALADDIN Center which promotes synergy between algorithm theory and practice (http://www.aladdin.cs.cmu.edu/). The genesis of this center came from Professor Guy Blelloch's graduate course Algorithms in the Real World designed for theoreticians to see how their work is being used in practice (http://www.cs.cmu.edu/~guyb/realworld.html).

³⁴ We are in no way implying that the undergraduate CS curriculum as it currently stands needs no revision. To the contrary, effectiveness and relevancy, both with regard to the curriculum and to the way the field is portrayed, are critical if the field is to attract the creative minds necessary for it to thrive in the future. But to do so for the perceived needs of a particular group rather than within a broader context is fraught with problems.