Social Change Research and the Gender Gap in Computer Science

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INTRODUCTION

At Carnegie Mellon University, home to one of the top computer science departments in the country, only 7% of the students in the entering computer science class in 1995 were women. By the fall of 2000, that proportion had risen to 42%. While the percentage of women entering has declined slightly, likely reflecting the bursting of the Internet bubble, Carnegie Mellon’s female computer science enrollment remains at about 30%, far higher than the average among research departments of computer science. Today, in 2005, the Carnegie Mellon School of Computer Science, with its increased number of female students, is a changed place. What sparked this development?

The story of the research that served as a catalyst for these increased numbers can be found in our book Unlocking the Clubhouse: Women in Computing (Margolis & Fisher, 2002). In this book we lay out the blueprints—the walls, doors, and windows—of the “boys’ clubhouse” of computing education. We describe some specific institutional changes, enacted both by us and by others at Carnegie Mellon, which resulted in increasing the recruitment and retention of women students. These changes range from rethinking admissions criteria; contextualizing computer science (“computing with a purpose”); paying attention to students’ experiences and the department culture; accommodating a wide range of previous computing experience; recognizing that women and students who do not fit the prevailing norm are disproportionately affected by problems like poor teaching, unapproachable faculty, or hostile peers; providing students with a broader picture of what it means to be in computer science, other than the hacker stereotype; outreach to high schools; and the formation of a vibrant women’s organization.

In this article we offer reflections about some of the critical factors that contributed to our research becoming an instrument for social change. We provide some “lessons learned” for other institutions that are thinking about addressing the gender gap in their computer science departments. While the Carnegie Mellon developments began with a body of research, we do not believe that extensive research is necessary for all institutions. However, it is important to understand the local situation well enough to customize a general set of strategies. While people rightfully want to learn from successful initiatives, and not “reinvent the wheel,” the constitution of each department—its history, the culture, the demographics, the leadership, the pressure points, what is known and not known about the experiences for women students—will differ from institution to institution. In most cases, but not all, initiatives can be modeled after existing programs by understanding the commonalities and differences between the situations. To achieve this, some straightforward data gathering, as opposed to in-depth research, is usually called for.

Here we present brief summaries of “lessons learned” from our research on the gender gap in computing. We believe that what we learned applies to planning an intervention as well as to conducting research.

ADDRESSING THE PROBLEM

• Understand Your System and Know Your Numbers: While lessons from other settings and other “diversity projects” can be instruc-
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tive, the critical question is how this all applies to your own institution. The management tru-
ism that “you can’t improve what you do not measure” applies here. Where is the bottle-
neck in your department? Is it in admissions? Is it in retention? When are people being lost? 
How many women students are in the department? How many women faculty? How does 
this compare to other technical departments in your institution? What are the retention rates of 
women in computer science? What have the trends been? What is the culture of your de-
partment? How do women experience the department? And, where are the relevant points of 
intervention within your department? 
Local information is also critical to community 
engagement. While information about the gen-
der gap from other places can be imported, 
especially when you have a “convinced audi-
ence,” there is nothing like shining the light on 
your own backyard, and providing evidence 
from your own students, to make an institu-
tional community take notice. The Carnegie 
Mellon research was based on some 300 
Carnegie Mellon student interviews, over a 4-
year period of time with a core sample group of 
50 male and 50 female computer science stu-
dents. We also conducted observations of com-
puter science classes, and held interviews with 
computer science administrators and faculty. 
We lived in the department (Allan as Associate 
Dean of Undergraduate Education and Jane as 
Visiting Research Scientist) and were familiar 
with it from the inside.

Leverage Interdisciplinary Expertise: Our 
research was conducted by an interdisciplinary 
team. Jane is a qualitative researcher with a 
background in Education and Women’s Stud-
ies. Allan is a computer scientist and at the time 
of our research was Associate Dean of Under-
graduate Education in the Carnegie Mellon 
School of Computer Science. While we origi-
nally referred to our research partnership as an 
“insider-outsider” collaboration (with Allan as 
the insider and Jane as the outsider), we quickly 
realized that since we were studying the dy-
namics of the gender gap in computer science, 
both perspectives were at the core of the 
problem. Neither perspective was on the mar-
gins. Each of us had a key to the puzzle that the 
other lacked. This both equalized our collab-
oration and opened up the range of issues that 
could be investigated. Our collaboration ex-
plored the traditionally unspoken issues that 
impact women’s experiences such as confi-
dence, sense of belonging, and different male 
and female motivations for studying computer 
science.

Listen to Students Holistically: It was stu-
dents’ experiences (and our eagerness to hear 
from women’s perspectives) that led us to the 
trouble spots in the department. But, to learn 
about those experiences we had to construct 
an interview guide that allowed us to learn 
more than the “party line,” and more than what 
was “safe” to talk about. We also needed to 
construct a process that allowed interviewees, 
speaking in confidence to third parties, to talk 
about topics not commonly discussed in com-
puter science culture. Open-ended questions 
that encourage interviewees to describe and 
shape their own accounts of their experiences 
(such as “Can you tell me the story of you and 
computers?” or “Can you tell me about your 
decision to major in computer science?”), rather 
than choosing amongst pre-selected generic 
answers, were critical to this process.

Take the Long View vs. a Single Snapshot: 
We conducted multiple interviews with our 
sample of students, following some students 
over a four-year period of time. This longiti-
dinal approach allowed us to take more than just 
landmarking stories. The multiple interviews allowed us to observe the evolution of students’ relationship to com-
and Carol Frieze have been able to use other sources of support to investigate ongoing cultural changes within the department since. We emphasize again, though, that large-scale research is not required for effective interventions—but tracking the numbers is.

• **Understand the Dynamics:** One of our interview questions was: “Can you describe your fellow computer science students?” Male and female students gave similar descriptions of their colleagues: myopically obsessed, living and breathing computers 24/7, emerging occasionally from behind the computer with a “monitor tan.” Students’ responses to this “geek mythology” were interesting. Despite the fact that both male and female students had similar descriptions of their fellow computer science students, about two thirds of the women and one third of the men explicitly dissociated themselves from the stereotype: “But that’s not me.” Yet the widely held perception of computer science students as being interested in nothing but computing became a set of expectations against which students judged themselves. Listening to the students tell of their experiences, we heard how each student’s self-evaluation becomes a critical part of his or her sense of belonging in computer science. We heard how the obsessed computer whiz kids became the reference group—a frame of reference for each student’s self-assessment. As a result, some students felt a good fit between their preferences and this model of what it is like to be a computer science student and others did not. Women fell disproportionately into this latter category.

We then saw how this sense of being outside of the norm makes women students especially vulnerable to other injuries such as poor teaching, inhospitable learning environments, and unhelpful instructors. When compounded by feeling outside the norm, seemingly small and sometimes unintended slights often are magnified. All of these chip away at a student’s confidence. This, in turn, often leads to a loss of interest in the discipline. We saw once-enthusiastic students, mostly female, in a descending spiral of eroding interest and confidence, driven by negative comparisons to peers and by a variety of environmental insults.

One key observation on these influences is something that we have come to view almost as the First Law of Educational Diversity: in a situation with in-groups and out-groups, “everything bad happens worse” for the members of the out-groups. Because of doubts about fit, comparisons with members of the in-groups, and the feedback between confidence and interest, bumps in the road—poor teaching, lack of advising, weed-out experiences, and so forth—disproportionately create disaffection and attrition among the out-groups. Note that a corollary of this observation is that many effective interventions in favor of diversity are good for all students.

**SHAPING A RESPONSE**

• **Make a Leadership Commitment:** Because the initial impetus for this project came from Allan, who was an “insider” with authority over the undergraduate program, there was an unusual level of legitimacy associated with this research. It has been all too common for gender investigations to be marginalized and not taken seriously. Because of Allan’s position in the department and the fact that the project was part of the department (with a department office and a title granted to Jane as Visiting Research Scientist), a legitimacy was bestowed on the project that we believe helped facilitate information gathering and cooperation from different members of the community. This commitment was continued after our departure from the scene by Lenore Blum, who has had extensive experience in gender projects, and Peter Lee, Allan’s successor as Associate Dean, with support from University leaders as well.

• **Focus on the Bottlenecks:** At Carnegie Mellon, we were “losing women” in two main ways: at admission time, where all three of application, acceptance, and matriculation rates were lower for women than for men; and in the early years of the curriculum, where nega-
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tive experiences and a sense of “lack of fit” created disproportionate attrition among women. In other settings we have seen, introductory courses, processes for choosing one’s major, and “weed-out” courses have posed bottlenecks. We believe it is critical to monitor such bottlenecks over time, and to focus interventions there.

- **Attend to the Basics:** A few powerful heuristics apply to almost all settings. Programs should provide mentoring and community, multiple pathways into the curriculum for students with differing levels of experience, a high-quality and positive learning environment, and should develop a culture that supports and celebrates multiple approaches to the study of computer science.

- **Paint a Broad Picture of Computer Science:** Most CS faculty think of computer science as a dynamic, multi-disciplinary field that combines aspects of mathematics, engineering and science and has application in nearly every field of human endeavor. However, many prospective students, including some of the most enthusiastic, inherit from high school and society a narrow notion of computer science as focused on computers and on coding. Addressing this ongoing legacy is a key challenge for the computing community. Further, the introductory sequences of traditional curricula often reinforce narrow images of the field, by focusing primarily on equipping students with the programming tools they will use in later, more diverse courses. Carnegie Mellon’s response to this issue has included the addition of an “immigration course” introducing new students to the breadth of the field. Other institutions have developed introductory courses that use integrative projects, that focus on principles over programming, or that link computer science to applications, to help to broaden students’ vision.

- **Catalyze and Support Women’s Community:** Upon her arrival at Carnegie Mellon in 1999, Lenore Blum led the creation of Women@SCS, an organized group of women in computer science. A professional group like this plays several important roles. Perhaps foremost, it provides an environment for women to experience being female computer scientists together with others, without feeling the need to “learn to speak ‘boy’” (as eloquently phrased by Anita Borg) in order to be in the field. In this vein, it provides a venue both for professional development experiences and for mutual support. The most successful instances of such groups seem to combine substantial student leadership with ongoing faculty support. Beyond its direct impact on its membership, a women’s group increases the visibility and influence of women in the larger community. At Carnegie Mellon, the women’s group has developed representation on standing committees, has organized events for the entire community, and has developed a variety of recruiting and outreach activities—even assisting in the creation of women’s groups at other institutions.

**SUSTAINING PROGRESS**

- **Leverage Critical Mass and “Virtuous Cycles”:** At Carnegie Mellon, changes in admission policy (removing previous computing experience as a preference factor, and emphasizing leadership potential in addition to numeric predictors) were an important factor leading to the increased enrollment of women. With more women classmates, female students no longer felt as isolated. And, as these talented and able women students had more of a presence in the department, faculty and administrators began to recognize how the increasing numbers of women in the program made the program even stronger and enhanced its competitive advantage. This, in turn, helped to make the environment ever more appealing to women students.

- **Watch the Student Experience Like a Hawk:** In most academic settings, especially in large institutions, key interactions with students are factored across multiple organizations: admissions, academics, student affairs, housing, career counseling, and so forth. Each of these areas presents opportunities to foster or weaken a student’s affiliation with a discipline. We believe it is critical to work cross-
functionally both to provide students with positive experiences and to head off the oversights that can miss such opportunities or, worse yet, drive students away. While Carnegie Mellon’s reputation and recruiting power played a key role in the rapid increase in the involvement of women in computing, we believe that the university’s culture of working across organizational boundaries was also an essential factor; at various times, we were able to work closely with admissions staff, other colleges, the student affairs office, and others to address specific issues.

• **Adapt:** Especially in a field like computing, with its rapid technological change and dynamic business cycle, change is a constant. The students whom we first studied were among the first generation to grow up with personal computers as a pervasive presence in the home; ten years later, a new generation has grown up with the Internet and all it implies. Ten years ago we saw the first inklings of the Internet boom, and now we have been through boom, bust, and consolidation. As we write this, perhaps the key human resource challenge to the discipline of computing in the developed countries is the public perception that “all the computing jobs are going offshore” to the developing world.

Just as the external environment changes, communities change. Lenore Blum and Carol Frieze have observed a shift in the Carnegie Mellon computer science student culture, in which both men and women are likely to take a broad and connected view of the field, and in which the traditional gender stereotypes of computing are largely defused. In light of internal and external changes, it is necessary to adapt dynamically to new sources of challenge and advantage.

**CONCLUSION**

Our research challenges the assumptions we often heard (and still hear): that women are less suited than men to do computer science, or that the subject is “just boring” for women and girls. Instead, our research shows the weighty institutional influences that steal women’s interests in computer science away from them. It is critical to recognize the “First Law” effect, that women and other students who do not fit the prevailing norm are disproportionately affected by problems within the “computer science pipeline.”

The goal should not be to fit women into computer science as it is usually conceived and taught. Instead, as we suggest in *Unlocking the Clubhouse*, “a cultural and curricular revolution is required to change [the culture of] computer science so that the valuable contributions and perspectives of women are respected within the discipline.” Ultimately, this revolution serves not only the interests of the women involved, but those of the discipline itself.

**REFERENCES**


